FISH NUTRITION IN PRACTICE

BIARRITZ, FRANCE

JUNE 24-27, 1991

ABSTRACTS

RÉSUMÉS DES COMMUNICATIONS

IV INTERNATIONAL SYMPOSIUM ON FISH NUTRITION AND FEEDING

IV ème SYMPOSIUM INTERNATIONAL SUR LA NUTRITION DES POISSONS

IV International Symposium on Fish Nutrition and Feeding

IV Symposium International sur la Nutrition des Poissons

FISH NUTRITION IN PRACTICE

June 24-27, 1991

Casino Bellevue, Biarritz

Organized by

Laboratoire de Nutrition des Poissons

INRA

Station d'Hydrobiologie

64310 Saint Pée-sur-Nivelle

With the financial support from

Ministère de l'Agriculture

The European Economic Community (FAR)

Région Aquitaine

Local organizing committee :

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Prof R.P. Wilson Mississippi State Univ, MS, USA

Programme at a glance

June 23, 1991 Sunday afternoon / *Dimanche après-midi*

Venue / *Lieu* : Hôtel Mer et Golf, Biarritz

16:00 onwards Registration/ *Inscription*
18:00 - 20:00 Informal Get Together / *Pot de bienvenue*

June 24, 1991 Monday morning / *Lundi matin*
Venue / *Lieu* : Casino Bellevue, Biarritz

08:00 - 09:00 Registration / *Inscription*
Mounting of Posters / *Affichage des Posters*
09:00 - 09:30 Opening / *Ouverture*

Welcome Address **S. Kaushik** / INRA
M. Collet / Ministère de l'Agriculture
A. Rérat / Vice President IUNS, INRA

Oral and Poster Sessions

Venue / *Lieu* : Casino Bellevue, Biarritz

Monday, June 24th Oral Sessions 1 to 3
Civic Reception at the Town Hall

Tuesday, June 25th Oral Sessions 4 and 5
Poster discussions

Wednesday, June 26th Oral Session 6
Excursion to St Jean de Luz
Banquet Dinner

Thursday, June 27th Oral Sessions 7 and 8

June 24, 1991 Monday morning / *Lundi matin*

Sessions 1 & 2 Nutrition and Broodstock Management

Chairperson : Dr B. Jalabert Rapporteur : Dr F. Bergot

09:30 Genotypes and Nutrient Utilization
Austreng E.R. and Storebakken T.

10:00 Astaxanthin : An effective dietary component for red seabream broodstock.
Watanabe T.

10:30 - 11:00 Coffee Break / *Pause Café*

11:00 Growth and energy substrate utilization in three rainbow trout strains and their crosses from hatching to market size.
Médale F.

11:15 Influence of temperature and dietary lipid origin on fatty acid composition of spermatozoan plasma membrane phospholipids in rainbow trout : Effect on sperm cryopreservation tolerance.
Labbe C., Loir M., Maisse G. and Kaushik S.J.

11:30 Sexual maturation in Atlantic salmon : Effects of feeding regime and dietary energy.
Vabeno A. and Storebakken T.

11:45 Lipid transport in Atlantic salmon (*Salmo salar*) : Effects of diet and sexual maturation.
Lie O., Sandvin A. and Waagbo R.

12:00 Effect of feeding regime and feed composition on first sexual maturation in farmed Atlantic Cod (*Gadus morhua*).
Lehmann G.B., Holm J.C., Karlsen O. and Rosenlund G.

12:15 Dietary vitamin C and reproductive performance in Cod (*Gadus morhua*): broodstock nutritional status, vitellogenesis and chemical composition of eggs.
Sandnes K., Rosenlund G. and Waagbo R.

12:30 Dietary vitamin C and reproductive performance in Cod (*Gadus morhua*): biological effects on eggs and larvae.
Mangor-Jensen A., Haaland H., Holm J.C. and Jorgensen L.

12:45 - 14:00 Lunch at Casino Bellevue / *Déjeuner*

June 24, 1991 Monday afternoon / *Lundi après-midi*

Session 3 Nutrition and Health

Chairperson : Prof J.E. Halver Rapporteur : Dr K. Sandness

14:00 Role of micronutrients in immune response and disease resistance in fish.
Lall S.P.

14:30 Role of dietary protein on immunocompetence in rainbow trout (*Oncorhynchus mykiss*).
Kiron V., Fukuda H., Takeuchi T. and Watanabe T.

14:45 Health implications of dietary carbohydrates in white sturgeon.
Hung S S.O. and Fynn-Aikins F.K.

15:00 Influence of dietary vitamin B6 on immune response and disease resistance in Atlantic salmon (*Salmo salar*).
Albrektsen S., Sandnes K., Glette J. and Waagbo R.

15:15 Efficacy of L-ascorbyl-2-sulfate in rainbow trout.
Halver J.E., Felton S. and Palmisano A.

15:30 - 16:00 Coffee Break / *Pause Café*

16:00 Utilization of different levels of ascorbyl monophosphates by rainbow trout (*Oncorhynchus mykiss*).
Cho C.Y. and Cowey C.B.

16:15 L-ascorbyl-2-phosphate-Mg as a vitamin C source for the Japanese Flounder (*Paralichthys olivaceus*).
Teshima S.I., Kanazawa A., Koshio S. and Itoh S.

16:30 Dietary vitamin C, immunology and disease resistance in Atlantic salmon (*Salmo salar*).
Waagbo R., Glette J., Raa-Nilsen E. and Sandnes K.

16:45 Vitamin nutrition and fish immunity : Influence of antioxidant vitamins (C and E) on immune response of rainbow trout (*Oncorhynchus mykiss*).
Verlhac V., N'Doye A., Gabaudan J. and Deschaux P.

17:00 Dietary calcium source affects growth and bone mineralization of Channel Catfish.
Gatlin D. and Scarpa J.

17:15 *Relation alimentation-hypoxie-digestibilité-furonculose experimentale chez la Truite Arc-en-ciel.*
Neji H., Naimi N., Lallier R. and de la Noue J.

18:00 Reception at the Town Hall by the Mayor of Biarritz
Réception à la Mairie de Biarritz

June 25, 1991 Tuesday morning / *Mardi matin*

Session 4 Nutrition, Metabolism and Growth

Chairperson : Dr K. Dabrowski Rapporteur : Dr G. Corraze

09:00 Metabolism of protein in coldwater fish with reference to flesh quality
Cowey C.B.

09:30 Taurine synthesis in rainbow trout fed diets supplemented with sulfur amino acids.
Yokoyama M.

09:45 Nutritional status and muscle and adipose tissue characteristics.
Fauconneau B.

10:00 Protein turnover as a modulator of food conversion efficiencies in fish.
Houlihan D.F., Pannevis M., Heba H. and Mccarthy I.D.

10:15 Compensatory growth in Atlantic Cod.
Jobling M.

10:30 - 11:00 Coffee Break / *Pause Café*

11:00 Metabolic effects of feeding rate in rainbow trout.
Storebakken T., Hung S.S.O., Walzem R.L. and Plisetskaya E.M.

11:15 Optimum ratio of medium chain triglycerides to pollack liver oil in diets on lipid accumulation of ayu (*Plecoglossus altivelis*).
Nakagawa H. and Kimura T.

11:30 Gill lipid metabolism in pantothenic acid-deficient rainbow trout (*Oncorhynchus mykiss*).
Masumoto T., Hardy R.W. and Stickney R.R.

11:45 Effect of dietary lipids on the fatty acid composition in tissues of gilthead bream.
Kalogeropoulos N., Alexis M.N. and Henderson R.J.

12:00 Diel cycle in *Oncorhynchus mykiss* using demand-feeder and held in different photoperiod regimes : circadian pattern of food-demand, liver composition and plasma hormone concentrations.
Boujard T. and Leatherland J.F.

12:15 Correlation between appetite and plasma thyroid and growth hormones and plasma metabolite levels in rainbow trout.
Farbridge K.J. and Leatherland J.F.

12:30 - 14:00 Lunch at Casino Bellevue / *Déjeuner*

June 25, 1991 Tuesday afternoon / *Mardi après-midi*

Session 5 Nutrition and Waste Management

Chairperson : Prof. A. Matty Rapporteur : Dr F. Médale

14:00 Digestibility of feedstuffs in the context of waste management by nutritional strategies.
Cho C.Y.

14:30 Energy and nitrogen balance studies in fish.
Heinsbroek L.T.N., Tijssen P.A.T., de Jong G. and Flach B.

14:45 High energy diets to Atlantic salmon : effects on pollution.
Johnsen F., Hillestad M. and Austreng E.

15:00 Biological availability of phosphorus in fish meal for Atlantic salmon.
Lall S.P. and Keith R.A.

15:15 Periodic feeding of low-phosphorus diet and phosphorus retention in rainbow trout (*Oncorhynchus mykiss*).
Hardy R.W., Fairgrieve W.T. and Scott T.M.

15:30 - 16:00 Coffee Break / *Pause Café*

16:00 - 17:30 **Discussion of Posters** Sessions 1 to 4

18:00 - 19:30 Buffet dinner at Casino Bellevue

19:30 - 20:30 **Discussion of Posters** Sessions 5 to 8

June 26, 1991 Wednesday morning / *Mercredi matin*

Session 6 Larval and Crustacean Nutrition

Chairperson : Prof. S. Meyers Rapporteur : Dr H. Alami-Durante

09:00 Essential phospholipids of larval fish and crustaceans.
Kanazawa A.

09:30 Biochemical aspects of the early life history of yellow perch.
Dabrowski K., Culver D.A., Brooks C.L. and Voss A.C.

09:45 Effects of cod liver oil on growth and survival of cyprinid larvae.
(Effet de l'huile de foie de morue sur la survie et la croissance des larves de cyprinidés).
Radunz Neto J., Charlon N., Escaffre A.M. Corraze G. and Bergot P.

10:00 Supplementation of dry diets for whitefish larvae.
(Supplementation des régimes artificiels pour les larves de corégone).
Escaffre A.M., Charlon N., Alami-Durante H. and Bergot P.

10:15 *Bacillus* Sp. spores as food additive for the rotifer *Brachionus plicatilis* : improvement of their bacterial environment and their dietary value for larval Turbot *Scophthalmus Maximus* L.
Gatesoupe F.J.

10:30 - 11:00 Coffee Break / *Pause Café*

11:00 The effect of dietary enzymes with age on protein and lipid absorption and deposition in *Sparus aurata* larvae.
Kolkovski S., Tandler A. and Kissil G.Wm.

11:15 The effect of dietary lecithin and exogenous lipases on fatty acid incorporation in the tissue lipids of *Sparus aurata* larvae.
Koven W.M., Kolkovski S., Tandler A., Kissil G.Wm. and Sklan D.

11:30 N-3 HUFA requirement for larval gilthead bream (*Sparus aurata*).
Rodriguez C., Perez J., Izquierdo M.S., Mora J., Lorenzo A. and Fernandez-Palacios H.

11:45 Feeding Stimulants in Marine Fish Larvae.
Doving K.B. and Knutsen J.A.

12:00 Enhancement of PUFA and alpha-tocopherol levels in *Penaeus indicus* broodstock diets : Effect on biochemical composition of organs and tissues.
Cahu C., Villette M. and Quazuguel P.

12:15 Protein requirements following an optimum dietary energy to protein ratio for *Penaeus vannamei* juveniles.

Cousin M., <u>Cuzon G.,</u> Blanchet E., Ruelle F. and Aquacop

12:30 - 14:00 Lunch at Casino Bellevue / *Déjeuner*

June 26, 1991 Wednesday afternoon / *Mercredi après-midi*

14:00 Excursion to St Jean de Luz

19:30 **Banquet Dinner** at Château de Brindos

Presentation of "*Makhila d'Honneur*" as a gift of recognition to

Dr Colin B. Cowey, Aberdeen, Scotland & Guelph, Canada
Dr John E. Halver, Seattle, Washington, Usa
Dr Takeshi Nose, Tokyo, Japan

Past Chairmen of the IUNS Sub Committee on "Fish Nutrition and Production"

June 27, 1991 Thursday morning / *Jeudi matin*

Session 7 Tropical Aquaculture Nutrition

Chairperson : Dr S. Viola Rapporteur : Mr J. Lazard

09:00 *Particularités des besoins alimentaires des poissons tropicaux d'eau douce.*
Luquet P.

09:30 Does a digestive active bacterial flora exist in fish ?
Lesel R.

09:45 The protein sparing effect of synthetic lysine in practical carp feeds.
Viola S. and Lahav E.

10:00 Bioenergetics of grass carp *Ctenopharyngodon idella* (Val.) : protein turnover in relation to ration and diet quality.
Carter C.G., Houlihan D.F., Brechin J. and McCarthy I.D.

10:15 Nutritional and functional constraints of utilizing plant based fish feeds in tropical small-scale aquaculture systems.
Yakupitiyage A.

10:30 - 11:00 Coffee Break / *Pause Café*

11:00 Replacement of fishmeal by grease meal in a grow-out diet for *Lates calcarifer*.
Orengo H., Thouard E., Nedelec G., Cuzon G., Cousin M., Bennett A. and Ruelle F.

11:15 The effects of varying dietary phytic acid, calcium and magnesium levels on the nutrition of common carp (*Cyprinus carpio*) : histopathology and mineral bioavailability.
Hossain M.A. and Jauncey K.

11:30 The effect of dietary L-carnitine on the growth and growth efficiency in juveniles of the African catfish (*Clarias gariepinus* Burchell 1822) in relation to dietary lipid levels.
Torreele E., van der Sluiszen A. and Verreth J.

11:45 The influence of dietary energy levels on the induction of hepatic mixed function monooxigenase by PCB in Tilapia *O.Niloticus* x *O.Aureus*.
Shiau S.Y. and Chen S.Y.

12:00 *Adaptabilité de differents aliments et fertilisants aux conditions particulières des élevages d'Oreochromis niloticus en étangs dans le milieu rural Ivoirien.*
Morissens P.

12:15 Aquaculture nutrition and feeding in developing countries : A practical approach to research and development
Tacon A.

12:30 - 14:00 Lunch at Casino Bellevue / *Déjeuner*

June 27, 1991 Thursday afternoon / *Jeudi après-midi*

Session 8 Ingredient Quality and Nutrient Bioavailability

Chairperson : Dr A. Tacon Rapporteur : Dr G. Choubert

14:00 Importance of nutrition research on the development of the US catfish industry.
Wilson R.P. and Lovell R.T.

14:30 Report on the new NRC bulletin on nutrient requirements of fish.
Wilson R.P. and Lovell R.T.

14:45 Effect of calcium and phosphorus on zinc availability to rainbow trout.
Satoh S., Porn-Ngam N., Takeuchi T. and Watanabe T.

15:00 Freshness of fish for fish meal - Effect on growth of salmon.
Pike I.H.

15:15 Growth rate of Atlantic salmon (*Salmo salar*) fed fish meal with varying content of water soluble protein.
Mundheim H. and Opstvedt J.

15:30 - 16:00 Coffee Break / *Pause café*

16:00 Soybeans for Atlantic salmon (*Salmo salar* L.).
Krogdahl A. and Olli J.

16:15 Digestibility of native starches of different botanical origin by rainbow trout.
Bergot F.

16:30 The utilization of dietary carbohydrate in cod (*Gadus morhua*) : response to feeding and starvation.
Hemre G.I., Lie O. and Sundby A.

16:45 Responses of Atlantic salmon (*Salmo salar* L.) to intakes of raw and extruded wheat.
Arnesen P. and Krogdahl A.

17:00 Soybean molasses impairs growth and nutrient utilization in Atlantic salmon (*Salmo salar* L.).
Olli J.J. and Krogdahl A.

17:15 **General Discussion and Conclusive Remarks**

Posters Sessions 1 and 2

Effects of temperature and dietary lipid origin on female broodstock performance and fatty acid composition of the eggs in rainbow trout.
Corraze G., Larroquet L. and Kaushik S.J.

Differences in growth rate and fat deposition in three strains of rainbow trout.
Corraze G., Larroquet L. and Médale, F.

Effects of dietary n-3 fatty acids and vitamin E on egg quality of Atlantic salmon (*Salmo salar*).
Waagbo R., Sandvin A., Sandnes K. and Lie O.

Sex influences on glucose utilization in the mature sea bass (*Dicentrarchus labrax* L.).
Sanchez-Muros M.J., Garcia-Rejon L. and de la Higuera M.

Dietary and sex influences on fructose bisphosphatase kinetics in sea bass breeding-season.
Garcia-Rejon L., Sanchez-Muros M.J. and de la Higuera M.

Individual variation in growth, food consumption and retention efficiency in rainbow trout (*Oncorhynchus mykiss*).
McCarthy I.D., Carter C.G. and Houlihan D.F.

Effect of dietary protein levels in diets for turbot (*Scophthalmus maximus* L.) to market size.
Danielssen D. and Hjertnes T.

Posters Session 3

A comparison of two vitamin C polyphosphate products in salmon.
Roem A.J. and Oines S.

The effect of different dietary levels of vitamin C on the immune response of Atlantic salmon (*Salmo salar* L.).
White A., Hardie L.J., Fletcher T.C., Secombes C.J. and Houlihan D.F.

Effect of stress on the symptoms of ascorbic acid deficiency in turbot (*Scophthalmus maximus*).
Gouillou-Coustans M.F. and Guillaume J.

Effects of diets containing oxidized fat or lacking vitamin E in seabass. (*Incidence chez le bar, Dicentrarchus labrax, d'aliments contenant des lipides oxydés et carencés ou non en vitamine E.*)
Stephan G., Messager J.L., Baudin-Laurencin F. and Lamour F.

Vitamin E concentrations in farmed Atlantic salmon (*Salmo salar* L.) tissue.
Roy W. and Matty A.J.

Digestive enzyme levels in farmed Atlantic salmon (*Salmo salar*) : effects on nutritional state, pancreas disease and enzyme inhibitors.
Mitchell A.I., Pringle G.M., Callanan K.R., Dawson A. and Houlihan D.F.

Posters Session 4

Effect of frequency of feeding of diets with different protein content on the fractional protein synthesis and degradation in the liver and muscle of rainbow trout (*Oncorhynchus mykiss*).
Peragon J., Ortega-Garcia F., Barroso J., de la Higuera M. and Lupianez J.A.

Size and meal timing effect on body composition in rainbow trout.
Boccignone M., Forneris G., Salvo F., Ziino M. and Leuzzi U.

Meal timing and feeding level effect on performances in rainbow trout.
Zoccarato I., Boccignone M., Palmegiano G.B., Anselmino M., Benatti G. and Leveroni S.

The effect of temperature and dietary protein content on the metabolic utilization of the diets by rainbow trout.
Oliva-Teles A. and Rodrigues A.M.

Variations quantitatives des proteines, lipides et cendres somatiques chez le gardon capturé à differentes saisons dans une retenue mésotrophe.
Parent J.P., Ferroni J.M., Bau F. and Vellas F.

Teneur en acides aminés du soma à differentes saisons chez deux espèces sauvages : la perche (Perca fluviatilis) et le gardon (Rutilus rutilus).
Parent J.P., Ferroni J.M., Escorihuela D. and Vellas F.

Neutral amino acid transport by marine fish intestine.
Balocco C. and Boge G.

Intermediary metabolism response of the European eel to dietary protein to lipids ratio.
Suarez M.D., Hidalgo M.C., Sanz A., Garcia-Gallego M., and de la Higuera M.

Effect of long-term starvation on the NADPH production systems in several different tissues of rainbow trout (*Oncorhynchus mykiss*).
Barroso J., Garcia-Salguero L., Peragon J., de La Higuera M. and Lupianez J.A.

Comparative study of two liver enzymes involved in peroxisomal lipid metabolism in halibut, salmon and trout.
Ruyter B., Christiansen E.N., Rortveit T. and Thomassen M.S.

Effects of different dietary treatments, starvation and exercise on fat content in Atlantic salmon (*Salmo salar*).

Bencze A.M., Wathne E. and Thomassen M.S.

In vitro and in vivo desaturation and elongation of linoleic and linolenic acid by the European eel (*Anguilla anguilla* L.).
Pacolet W., de Dyn R., Fontaine F., Moshage H., De Schrijver S., Yap S. and Ollevier F.

Flesh color assessment of salmonids.
Christiansen R., Torrissen O.J., Struksnaes G. and Esterman R.

Effects of polyunsaturated fatty acids and vitamin E on flesh pigmentation in Atlantic salmon (*Salmo salar*).
Christiansen R., Waagbo R. and Torrissen O.J.

Astaxanthin and canthaxanthin as pigment sources for salmonids ?
Torrissen O.J. and Christiansen R.

Tissue distribution of ^{14}C-astaxanthin in the Atlantic salmon (Salmo salar) determined by autoradiography.
Torrissen O.J. and Ingebrigtsen K.

Interaction between astaxanthin and vitamin A in Atlantic salmon.
Storebakken T., No H.K. and Choubert G.

Absorption and blood clearance of carotenoids in mature female rainbow trout (*Oncorhynchus mykiss*).
Guillou A., Choubert G. and de la Noue J.

Transport of canthaxanthin in serum of rainbow trout (*Oncorhynchus mykiss*).
Choubert G., Milicua J.C., Gomez Martinez R., Sance S., Petit H., Negre-Sadargues G., Castillo R. and Trilles J.P.

Posters Session 5

Optimum feeding rates for striped bass fingerlings at 20°C.
Hung S.S.O., Hallen E.F. and Conte F.S.

Diurnal feeding rhythms in Atlantic salmon parr.
Rawlings C. and Talbot C.

Self-selection of a diet covering zinc needs in the trout.
Cuenca E.M., Diz L.G. and de la Higuera M.

Effects of feeding strategies on the utilization of different carbohydrates by rainbow trout fingerlings.
Hung S.S.O. and Storebakken T.

Effect of feeding stimulants on feed choice of rainbow trout.
Koskela J. Pirhonen J. and Virtanen E.

Incorporation de quelques probiotiques dans l'alimentation du juvenile de bar (*Dicentrarchus labrax*).
Metailler R. and Hollocou Y.

Effect of virginiamycin and related factors on growth, body composition and plasma growth hormone levels of rainbow trout.
Cravedi J.P., Lebail P.Y., Blanc D. and Kaushik S.J.

Application of a settling column system to studies of digestibility in the eel.
Bazoco J., Garcia-Gallego M., Suarez M.D., Sanz A. and Cardenete G.

Fecal collection methods for determining phosphorus digestibility in rainbow trout.
Brown P.B.

Influence of different binders on dietary availability of nutrients in the trout (*Oncorhynchus mykiss*).
Morales A.E., Cardenete G., Sanz A., Akharbach H. and de La Higuera M.

Studies on the use of dietary energy by gilthead seabream (*Sparus aurata* L.) juveniles.
Vergara J.M. and Jauncey K.

Effect of dietary protein to lipid ratio on growth and chemical composition of chinook salmon (*Oncorhynchus tshawytscha*) in sea water.
Silver G., Higgs D., Dosanjh B., Mckeown B., Deacon G. and French D.

Freshwater fish as a source of w3 polyunsaturated fatty acids and their application to human nutrition.
Steffens W., Wirth M., Mieth G. and Lieder U.

Influence of different carbohydrates on digestibility, growth and carcass composition of carp (*Cyprinus carpio* L.).
Schwarz F.J. and Kirchgessner M.

Growth and body composition of turbot in relation to different protein / fat ratios in the diet.
Andersen N.G. and Alsted N.S.

Effects of dietary protein and fat levels in dry feed for juvenile Halibut (*Hippoglossus hippoglossus* L.).
Hjertnes T., Gulbrandsen K.E. and Opstvedt J.

High energy diets : Excellent Growth, but what about Fish Quality ?
Einen O. and Roem A.

Aliments extrudés en élevage intensif : effet du rapport protéine/énergie sur les performances d'élevage, la qualité de la chair et sur les rejets piscicoles.
Robert N., Le Gouvello R., Mauvio J.C., Aguirre P. and Kaushik S.J.

Posters Session 6

Preliminary data on semi-synthetic diets for crucian carp larvae.
Szlaminska M., Escaffre A.M., Charlon N. and Bergot P.

The use of protibel as a substitute for casein in artificial diets for larvae and juveniles of the African catfish, *Clarias gariepinus*.
Pector R., Caers G., Blommaert V., de Schrijver R. and Ollevier F.

Age course of energy assimilation and conversion for growth in carp larvae fed different food.
Kamler E.

Effect of various lipid enrichment in rotifers on development of first feeding turbot.
Kjorsvik E., Olsen Y., Rosenlund G. and Vadstein O.

Comparison of three kinds of rotifer enrichments for turbot larval culture.
Robin J.H., Le Gall M.M. and Le Delliou H.

Nutritional value of rotifers fed different enrichment diets.
Hernandez Cruz C.M., Fernandez-Palacios H., Izquierdo M.S., Robaina L., Vergara Martin J.M., Salhi M. and Fernandez-Palacios J.E.

Essais de sevrage du loup (Dicentrarchus labrax) avec différents aliments équilibrés.
Melotti P., Amerio M., Gennari L., Novelli A., Roncarati A. and Garella E.

Feeding practices in sea bass (*Dicentrarchus labrax*) during weaning and ongrowing onto sevbar.
Person le Ruyet J.

Mise au point d'une technique de mesure de l'ingeré chez le jeune alevin de bar (Dicentrarchus labrax) à l'aide d'iodure d'argent marqué.
Langar H. and Guillaume J.

The effect of algal addition on lipids and fatty acid content of turbot larvae.
Reitan K.I., Rainuzzo J.R., Oie G. and Olsen Y.

Posters Session 7

Riboflavin requirement of fingerling red hybrid tilapia grown in seawater.
Lim C., Leamaster B. and Brock J.A.

Evaluation of suitability of mixed feeding schedules in two Indian major carps, catla (*Catla catla*) and rohu (*Labeo rohita*).
Nandeesha M.C., de Silva S.S. and Krishnamurthy D.

Effect of environmental temperature and feeding rate on growth, food utilization and body composition of common carp (*Cyprinus carpio* L.) fry.
Hasan M.R. and Macintosh D.J.

Growth response of *Tor khudree* to silkworm pupae incorporated diets.
Shyama S. and Keshavanath P.

Evaluation of silkworm pupae meal as dietary protein source for catfish (*Heteropneustes fossilis*).
Hossain M.A., Islam M.N. and Alim M.A

A preliminary study on use of poultry offal meal as dietary protein source for the fingerling of Indian Major carp *Labeo rohita* (Hamilton).
Hasan M.R.

Energy substrates utilization by a tropical air-breathing catfish *Hoplosternum littorale*.
Moreau Y., Medale F. and Luquet P.

Dietary requirements of milkfish (*Chanos chanos* Forskal) for essential amino acids.
Coloso R.M. and Borlongan I.G.

Essential fatty acid requirement of juvenile seabass.
Wanakowat J., Boonyaratpalin M., Watanabe T., Pechmanee T. and Yashiro R.

Effect of thiamine, riboflavin, pantothenic acid and inositol on growth, feed efficiency and mortality of juvenile seabass.
Boonyaratpalin M. and Wanakowat J.

Posters Session 8

Quantitative lysine requirement for Atlantic salmon.
Anderson J.S., Lall S.P., Anderson D.M. and McNiven M.

Zinc requirement in Atlantic salmon (*Salmo salar*) fry.
Maage A., Lorentzen M., Bzornevik M. and Julshamn K.

The effects of varying dietary phytic acid, calcium and magnesium levels on the nutrition of common carp (*Cyprinus carpio* L) : Growth and food utilization.
Hossain M.A. and Jauncey K.

Effect of graded levels of dietary ascorbic acid on mineralization of calcium and phosphorous in rainbow trout *Oncorhynchus mykiss*.
Akand A.M., Sato M., Yoshinaka R. and Ikeda S.

Effects of dietary calcium soaps on growth and body composition of juvenile sea-bass (*Dicentrarchus labrax* L).
Lanari D., Ballestrazzi R., Tulli F. and Tibaldi E.

Effect of the replacement of the inorganic zinc of the diet by zinc/methionine on vegetable and animal protein utilization by rainbow trout.

Gomes E.

Effet de l'incorporation d'une dose élevée de sel dans l'aliment sur le transfert en mer de la truite fario (Salmo trutta).
Arzel J., Metailler R, Boeuf G, Baudin-Laurencin F, Barone H. and Guillaume J.

The contribution of supplementary sea water on the mineral balance in Atlantic salmon alevins.
Torrissen O.J. and Shearer K.D.

Norseamink(R) and Norse Lt-94(R) - special product fish meals in dry feed for Atlantic salmon (*Salmo salar*).
Pedersen T.M., Mundheim H. and Opstvedt J.

The growth response of turbot (*Scophthalmus maximus*) and wolf fish (*Anarchichas lupus*) on two different qualities of fish meal.
Oines S. and Moksness E.

Nutritional value of shark meat incorporated in rations for turbot (*Scophthalmus maximus*).
Coelho J.F.S., de Pinho M.M.S., Afonso I.C.M. and Da Silva L.M.M.

Partial substitution of fishmeal with different meat meal products in diets for seabream (*Sparus aurata*).
Davies S.J., Negas I. and Lintu S.M.

Evaluation of four semi-purified protein sources for use in juvenile Atlantic salmon (*Salmo salar*) test diets.
Shearer K., Christiansen R., Daae B. and Torrissen O.,

Nutritive utilization of earthworm protein by fingerling rainbow trout (*Oncorhynchus mykiss*).
Cardenete G., Garzon A., Moyano F. and de la Higuera M.

Evaluation of soyabean and lupinseed meals as protein sources for juvenile gilthead bream (*Sparus aurata*).
Robaina L., Izquierdo M.S., Moyano F.J., Vergara Martin J.M., Fdez-Palacios H., Hernandez Cruz C.M., Salhi M. Fdez-Palacios J.E.

Nutritive evaluation of sunflower meal as a protein source for rainbow trout.
Cardenete G., Morales A.E., de la Higuera M. and Sanz A.

Effect of cooking/extrusion of three legume seeds on growth and food utilization by rainbow trout.
Gouveia A., Oliva-teles A., Gomes E. and Rema P.

A comparative study of the nutritive utilization of dietary carbohydrates by eel and trout.
Garcia-Gallego M., Bazoco J., Sanz A. and Suarez M.D.

Utilisation de levures dans l'alimentation du juvenile de bar (Dicentrarchus labrax).
Metailler R. and Huelvan C.

Sessions 1 et 2 : Nutrition and Reproduction

Oral presentations / communications orales

GENOTYPES AND NUTRIENTS UTILIZATION.

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ASTAXANTHIN : AN EFFECTIVE DIETARY COMPONENT FOR RED SEABREAM BROODSTOCK.

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In the series of studies on red seabream *Pagrus major* broodstock nutrition, it was found that spawning and quality of eggs greatly improved on replacing the control fish meal diet with frozen raw krill shortly before or during spawning. The dietary quality of raw krill was attributed to the incorporation of polar or nonpolar lipids from its fat-soluble fraction. The main component of the fraction was phosphatidyl choline in the former and astaxanthin in the latter. Further, the control diet supplemented with astaxanthin purified from a synthetic source was fed to the broodstock. The result revealed that supplementation of 2 mg of astaxanthin to the fish meal diet enhanced the quality of eggs, indicating that the effective component of the nonpolar lipid fraction in raw krill was astaxanthin. The role of phosphatidyl choline in broodstock nutrition is to be clarified.

GROWTH AND ENERGY SUBSTRATE UTILIZATION IN THREE RAINBOW TROUT STRAINS AND THEIR CROSSES FROM HATCHING TO MARKET SIZE.

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The aim of the work was to investigate the possible relationship between growth performance, energy expenditure and metabolic utilization of endogenous or dietary substrates in fish.

The studies were conducted with rainbow trout from a diallel cross breeding. The three parental strains (labelled "COR", "GAT", "SY") were known to have different growth rates.

Growth performances and feed efficiency were followed from hatching to market size. Nitrogen and energy budgets were studied at different stages of life through indirect calorimetric measurements.

The weight of SY ova was significantly lower (70mg) than those of COR and GAT ones (80mg). Weight of newly hatched larvae was proportional to eyed ova weight. One month after hatching, weight of fry born of female COR was the highest and there were no difference of weight between fry from female GAT and from female SY. Four months after hatching, the effect of ova size had disappeared. Fry of strain GAT had the lowest weight and those of strain COR the highest while voluntary food intake was the same.

In fish of strain COR, mainly in cross CORxCOR, endogenous nitrogen losses and the part of energy supplied by body protein were lower than in other strains. This characteristic remained until market size.

From the fifth month, all fish were reared together (water temperature : 17°C) and specific growth rates of all crosses were similar. There was no significant difference between strains regarding energy expenditure and metabolic utilization of dietary nutrients. In fish of strain SY, which had an intermediary weight, digestibility of dietary protein and lipid was low but voluntary food intake was higher than in other strains.

While the three strains are distinguished by early growth, the differences in growth rates do not seem to be related to changes in energy expenditure.

THE INFLUENCE OF BOTH TEMPERATURE AND DIETARY LIPID ORIGIN ON FATTY ACID COMPOSITION OF SPERMATOZOAN PLASMA MEMBRANE PHOSPHOLIPIDS IN RAINBOW TROUT. EFFECT ON SPERM CRYOPRESERVATION TOLERANCE.

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Cryopreservation of salmonid sperm has almost been mastered but some difficulties remain due to the great heterogeneity in ejaculate quality (between males and for a single male during its breeding season). We have already demonstrated the chief role of plasma membrane quality in sperm cryopreservation tolerance. The aim of this study was to investigate to what extent two different rearing temperatures (8°C and 18°C), each combined with two diets, one supplemented with corn oil and the other with cod liver oil, can influence lipid composition of the plasma membrane and sperm ability to fertilize after thawing.

Rainbow trout, 1 year old and 100g in weight, were submitted to one of the temperatures and one of the diets. The experiment lasted one year during which animals went through their first sexual cycle and reached maturity (became spermiant). Semen of these now 1kg trout was collected regularly during a two month period. A small volume was frozen and the remaining semen sample was used to isolate high purity plasma membrane by nitrogen cavitation. Lipids were extracted, cholesterol and phospholipid were evaluated and phospholipid fatty acids were analysed by gas chromatography.

There were no differences in the membrane cholesterol/phospholipid ratio. However, the fatty acid composition was altered. Cod liver oil increased the n-3/n-6 ratio compared to corn oil whereas the latter induced a greater PUFA/MUFA ratio. There is no significant influence of the temperature on these ratios but some differences appeared in the fatty acid species.

The fertilizing ability of thawed sperm with respect to these lipid modifications was investigated.

SEXUAL MATURATION IN ATLANTIC SALMON : EFFECTS OF FEEDING REGIME AND DIETARY ENERGY.

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The combined effects of dietary composition and feeding strategy on growth and sexual maturation were investigated in an experiment with two year old atlantic salmon (*Salmo salar*) in the sea. Dietary composition were LF (54% protein/14% fat) vs HF (50% protein/21% fat) and feeding strategy C (continuous feeding) vs S (no feeding during February and March). There were 3 pens pr treatment.

Average body weight at start in December was 1.2 kg and the body weights increased by 140-200% during the experimental period which lasted for 8 months. Both fat level and feeding strategy significantly affected the growth of the fish and at the end HF-fish weighed 11% more than LF-fish. After the starvation period, S-fish showed significantly higher relative growth than the C-fish. Despite of that, C-fish weighed 9% more than S-fish at slaughtering. Feed fat level and feeding strategy also significantly affected the body composition of the fish.

Percent sexual mature fish ranged from 8-15% and sexual maturation only occured in male fish. LF versus HF significantly reduced sexual maturation by 26% and S versus C by 28%. For growth and maturation rate there were no significant interactions between dietary composition and feeding strategy. Lower sexual maturation rate in the LF and S groups of fish gave better slaughter quality and better price. Because of higher slaughter weight, the combination HF/C gave the best total economical result.

LIPID TRANSPORT IN ATLANTIC SALMON (Salmo salar) : EFFECTS OF DIET AND SEXUAL MATURATION.

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Atlantic salmon were fed three different levels of n-3 polyunsaturated fatty acids (PUFA) in the diet, each diet with a low and a high content of Ó-tocopherol. The fish were fed the experimental diet from smolt until sexual maturation.

For examination of the transport of lipids during maturation, serum from females was sampled and the different lipoproteins were isolated. The fatty acid composition of the main lipid classes and the content of Ó-tocopherol of the different lipoproteins were determined.

The results will be presented and discussed in view of diet composition and sexual maturation.

EFFECT OF FEEDING REGIME AND FEED COMPOSITION ON FIRST SEXUAL MATURATION IN FARMED ATLANTIC COD (*Gadus morhua*).

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Cod (*Gadus morhua*) is a potential species for aquaculture. However, the high growth rates due to the intensive feeding applied, often result in early maturation. Thus in order to make cod farming profitable, early maturation must be avoided.

Studies on salmon show that the onset of maturation is dependent on several factors among which the physiological status of the fish, including growth rate and fat reserves, seems to play an important role.

The effect of feed energy content and feeding regimes on maturation in first year spawners of cod has been studied. The diets used were either a high energy (24 MJ/kg d.w.) moist feed based on capelin or a low energy (15 MJ/kg d.w.) dry feed (Tess Marin, Skrelling, Norway).

The diets were either fed to satiation or half that amount. The experiment lasted for 15 months (Feb.-June) and sexual maturation was followed ultra sonically in individually tagged fish.

The results show that the amount of maturating fish can be reduced from 100% to 40% using a low energy feed and reduced feeding during the autumn months.

DIETARY VITAMIN C AND REPRODUCTIVE PERFORMANCE IN COD (*Gadus morhua*) : 1. BROODSTOCK NUTRITIONAL STATUS, VITELLOGENESIS AND CHEMICAL COMPOSITION OF EGGS.

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As part of an extensive program with the aim to improve marine fish fry production, the present study was carried out to evaluate the significance of dietary vitamin C in cod broodstock feed related to egg quality and fry production.

Cod were fed diets containing 0, 50 and 500 mg vitamin C per kg dry feed from September 1990 to January 1991. Samples of broodstock fish were collected monthly. Vitamin C was analysed in liver and ovaries, total protein and protein bound phosphorous were analysed in serum, and growth parameters (including organ indices) and hematology were recorded.

Eggs were collected from spawning cod intervals from January to May 1991, and analysed for vitamin C. The dietary vitamin C content clearly affected the vitamin C content in the ovaries. Broodstock nutritional status and egg composition will be presented. The significance of dietary vitamin C in the broodstock diets on biological egg and fry quality parameters will be presented elsewhere.

DIETARY VITAMIN C AND REPRODUCTIVE PERFORMANCE IN COD (*Gadus morhua*) : 2. BIOLOGICAL EFFECTS ON EGGS AND LARVAE.

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Three cohorts of adult cod were four months prior to spawning fed diets containing respectively 0, 50 and 500 mg vitamin C per kg dry feed. Sibling egg groups were collected several times during the spawning season and incubated in a hatchery.

Mitotic symetry and chorion strength of the eggs during the first hours after fertilization were registered for evaluation of egg quality. Vital parameters as fertilization percentage and survival rate throughout yolksac stage were observed. The eggs were characterized with regard to free amino acids which have been shown to be a major nutritional component for the fish embryo during the egg and yolksac stage. After completion of the yolk absorption, the start feeding performance of larvae was registered. The diets and the broodstock feed as well as vitamin C content in eggs will be presented elsewhere.

Session 3 : Nutrition and Health

Oral presentations / communications orales

ROLE OF MICRONUTRIENTS IN IMMUNE RESPONSE AND DISEASE RESISTANCE IN FISH.

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With the worldwide expansion of aquaculture production and higher risk of aquatic organisms to infectious diseases, there is growing realization that nutrition may significantly influence immune function and disease resistance of fish. This paper reviews recent work on alteration in immune response associated with selected micronutrient deficiencies and examines the potential of predicting risk of infection based on immunological abnormalities.

Infection, nutrition and immunological interactions are poorly understood in fish and many studies relate to deficiencies and excesses of vitamin C. The comparative nutrition of fish and mammals in relation to the effects of excessive intake of ascorbic acid and vitamin E on immune response and disease resistance is discussed. Generally, experiments designed to determine the nutrient requirements of fish have studied the role of vitamins and trace elements in the cellular and metabolic process without any consideration for immune response parameters. Selected immunocompetence tests used to determine the physiological requirements of certain nutrients in warm blooded animals, which may have potential applications in fish nutrition research, are emphasized.

ROLE OF DIETARY PROTEIN ON IMMUNOCOMPETENCE IN RAINBOW TROUT *Oncorhynchus mykiss*.

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The role of dietary nutrients in the health of fish is an area of recent research. A variety of nutritional factors govern the physiological status and the immunological responsiveness of the fish. This study reports the effect of dietary protein on antibody production and the response to pathogenic challenge in rainbow trout.

Adult rainbow trouts reared on a non-protein diet and graded protein diets (20, 35 & 50%) were tested for antibody production against *Aeromonas salmonicida*. The diets were offered for three months, whereafter the fish were immunized with formalin-killed bacteria. The antibody titres were measured three weeks later by enzyme-linked immunosorbent assay.

Fry of the same species, reared on similar diets for a month were put on infectivity trials against Infectious Hematopoietic Necrosis Virus. Survival rate was considered as the indicator of disease resistance.

The probable influence of dietary protein on fish health is reported here.

HEALTH IMPLICATIONS OF DIETARY CARBOHYDRATES IN WHITE STURGEON.

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Juvenile white sturgeon (*Acipenser transmontanus*) were fed 8 weeks of diets containing 27% of different carbohydrates. The ability of sturgeon to utilize these dietary carbohydrates, based on the percent energy retained, was glucose = maltose > sucrose = dextrin = raw corn starch > lactose = fructose = cellulose. Sturgeon fed the glucose or maltose diets, however, had a significantly ($P<0.05$) higher levels of plasma triacylglycerol and liver glycogen. Sturgeon fed the sucrose, lactose, or fructose diets, on the other hand, showed a significant increase in the luminal water in the distal intestines similar to the diarrhea observed in the lactose intolerance in some higher vertebrates. Sturgeon fed diets containing different levels of glucose (0-35%) for 8 weeks showed higher plasma triacylglycerol levels when the dietary glucose was 21% or more. Significantly higher levels of liver glycogen were also observed in sturgeon fed diets with 7% or more of glucose.

Normal plasma glucose levels (81-114 mg/100ml) were observed in sturgeon fed diets with 27% of different carbohydrates or 0 to 35% of glucose. This is different from the very high plasma glucose levels in sturgeon after they were force-fed with 167 mg/100 g body weight of glucose or maltose. Maximum plasma glucose levels of 347 and 270 mg/100 ml were observed in sturgeon which had been force-fed with glucose or maltose, respectively.

INFLUENCE OF DIETARY VITAMIN B_6 ON IMMUNE RESPONSE AND DISEASE RESISTANCE IN ATLANTIC SALMON (*Salmo salar*).

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Atlantic salmon were fed a dry pelleted diet supplemented with 0, 10, 20, 40, 80 and 160 mg/kg pyridoxine.HCl. After 6 weeks on the respective diets, 30 fish from each feeding group were vaccinated against cold water vibriosis with formaline killed *Vibrio salmonicida* (Norbio A/S, Norway). Twenty fish were sham injected with the vaccine medium only. Four weeks later, the fish were revaccinated according to the same treatments.

Antibody production, serum hemolytic complement activity and lysozyme activity were analysed in individual blood samples. The activity of isolated head kidney macrophages was studied. Liver and muscle vitamin B_6 level were analysed, and at the end of the experiment other tissues like spleen, kidney and head kidney were analysed as well. ASAT enzyme activity was analysed in muscle and liver tissue. The effect of vitamin B_6 on disease resistance of Atlantic salmon was investigated in a separate challenge experiment. Fifty fish from each dietary group were cohabitantly challenged with *Aeromonas salmonicida*, and survival was recorded.

The effect of vitamin B_6 on specific and unspecific immune response and disease resistance will be presented according to analyses.

EFFICACY OF L-ASCORBYL-2-SULFATE IN RAINBOW TROUT.

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Replicate lots of rainbow trout, *Oncorhynchus mykiss*, 70g IBW, fed diet H440 with L-ascorbic acid (C_1) or L-ascorbyl-2-sulfate (C_2) as vitamin C sources were sacrificed on Days 5, 15, 21.

Fecal wastes, blood and liver tissues were extracted with 5% TCA centrifuged, filtered and assayed for C_1 and C_2 in an improved HPLC assay procedure using Bondapak C_{18} columns in series and both electrochemical and UV detectors. The mean absorption coefficient for C_2 was 0.7. Discrete quantities of both C_1 and C_2 were found in blood of C_2 fed fish indicating absorption and conversion of some C_2 into C_1.

Replicate lots of rainbow trout, 70g iwt, were converted into seawater, held in tanks, and fed H440 with C_1 or C_2 at equimolar concentrations. Diet was made once per month, frozen, transported and thawed as needed for the diet trials. No significant differences in growth, diet conversion, PER or NPU were detected between lots fed the C_1 or C_2 treatments in seawater as the fish grew 6 months and 6 fold increase in weight. No scurvy signs were detected in either groups during the period.

When fish have gained 10 fold increase in weight, liver and carcass analysis indicated storage levels of C_1 and/or C_2 in tissues.

UTILIZATION OF DIFFERENT LEVELS OF ASCORBYL MONOPHOSPHATES BY RAINBOW TROUT (*Oncorhynchus mykiss*).

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Ascorbic acid is the most labile vitamin in fish feeds. It has been used at high dose levels to ensure that a minimal (required) level persists during manufacture and storage. Recently stable forms of ascorbic acid have become commercially available. One of these is ascorbyl monophosphates (AMP) which is thought to be very bioavailable and stable in the presence of heat and moisture.

Two monophosphate salts (-Mg and -Na) of ascorbic acid were supplemented to a steam-pelleted practical diet at levels of 10, 20 and 40 mg ascorbic acid (AA) equivalent per kg of diet. The experimental diets were fed to a group of rainbow trout (3g IBW; 94 fish/60L tank; 3 replicates/diet) for 20 weeks in flow-through water system (15°C).

Live weight gain (LWG), feed efficiency (FE=gain/feed) and mortality were determined every 4 weeks. All treatments except negative control (NC; no supplementary ascorbic acid) performed as well as positive control (PC; supplementary 500 mg AA) throughout experiment period. For the first 12 weeks, all groups grew well although NC gained about 10% less weight than the other groups. During the last 8 weeks mortality increased gradually in the NC group despite the fact that they all looked "normal". By 20 weeks mortality had reached 100%.

Surprisingly, apart from a few instances in the NC group, no scoliosis or lordosis were observed. Histopathological examination of dead fish diagnosed mild depigmentation, fin erosion and anemia, none of these symptoms was sufficiently severe to cause death. Live weight gain averaged 110g and FE 1.2 in groups other than the NC group during the 20 week study. These data represent a good growth performance ; all fish were in healthy and lively condition.

It was concluded that, under the culture conditions employed, vitamin C supplementation in the form of either AMP-Mg or -Na in salmonid diets need be no more than 10mg AA equiv. (Partial fiscal support and supply of equipment from Showa Denko K.K., Japan is acknowledged).

L-ASCORBYL-2-PHOSPHATE-MG AS A VITAMIN C SOURCE FOR THE JAPANESE FLOUNDER (*Paralichthys olivaceus*).

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A relatively stable form of vitamin C, L-ascorbyl-2-phosphate-Mg (APM), was tested for efficacy as a vitamin C source in the Japanese flounder *Paralichthys olivaceus*. In the present study, two feeding experiments were conducted in a flow-through system at 19-22°C. In experiment 1, the fish, weighing about 3g, were fed 2 casein-based diets containing 788mg Ca ascorbate/100g or no supplemental AA for 90 days.

The fish receiving the diet without supplemental AA retarded growth and resulted in total mortality within 45 days, whereas that receiving the diet containing Ca-ascorbate grew up about 50g in body weights after 90 days. In experiment 2, the fish, weighing about 43g, were fed 5 test diets containing graded levels of APM (0, 1, 3, 6 and 10mg/100g diet) for 98 days. The basal diet was a casein-white fish meal (1:1) based diet. There were no significant difference in body lengths and survival rates after 98 days among the experimental groups except that receiving the diet without supplemental vitamin C. Whereas, higher weight gain (%) and feed conversion efficiency were obtained on the diets containing 6mg or more of APM per 100g. The results indicated that a supplement of about 6 to 10mg APM was sufficient to support good growth and survival of the Japanese flounder. The present study thus showed that APM can be effectively utilized by the Japanese flounder as a good replacement for L-ascorbic acid.

DIETARY VITAMIN C, IMMUNOLOGY AND DISEASE RESISTANCE IN ATLANTIC SALMON (*Salmo salar*).

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Presmolt Atlantic salmon were fed experimental feeds added graded levels of ascorbate-2-monophosphate, equivalent to 40, 400, 2000 and 4000 mg ascorbic acid/kg for 6 months.

During the experiment the liver ascorbic acid concentration was recorded.

Disease resistance parameters measured were hematology, antibody production after vaccination, assay of macrophage activity, serum hemolytic complement and lysozyme activity and finally challenge with *Aeromonas salmonicida*.

The results will be presented and discussed in view of the ascorbate-2-monophosphate levels in the feed and the levels of ascorbic acid found in the liver.

VITAMIN NUTRITION AND FISH IMMUNITY : INFLUENCE OF ANTIOXIDANT VITAMINS (C and E) ON IMMUNE RESPONSE OF RAINBOW TROUT (*Oncorhynchus mykiss*).

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Comparative trials were run to determine the immunomodulatory effect of a high dietary dose of vitamin C, as ascorbate-2-monophosphate calcium salt or vitamin E, as d-1-Ó-tocopherol acetate on cellular and humoral immune responses of rainbow trout.

Vit.C-deprived and non-deprived trout were fed vitamin C at 1000, 200 and 0 mg/kg of diet for at least 10 weeks and total seric complement activity, phagocytosis and lymphocyte proliferation were monitored. Humoral response was investigated in a curative study where deficient fish were fed ascorbate-2-monophosphate at 1000, 100 and 0 mg (ascorbic acid equivalent)/kg of diet and vaccinated against enteric redmouth disease. In another experiment, rainbow trout were fed a semi-purified diet supplemented with vitamin E at 450, 45 and 0 mg/kg of diet. After 100 days of experimental feeding antibody response was followed, for 9O days, after vaccination against enteric redmouth disease. A time-related study was run on lymphocyte proliferation.

Vit.C supplementation increased complement level and phagocytosis of latex beads by peritoneal macrophages. Phagocytosis only was impaired in deficient fish. Although supplemented fish developed a higher average in lymphocyte proliferation induced by concanavalin A, variation was not significant when compared to those fed the normal dose. Antibody response was impaired in deficient fish. Statistical analysis run on the area under the curves of individual kinetics did not show any difference between the two doses of APCa but the initiation of the response seemed to be more rapid in highly supplemented fish.

Vit.E supplementation enhanced antibody response while antibody titres were lowered in fish fed no vitamin E. Mitogen-induced proliferation was stimulated by supplemental dietary vit.E with 3 of the 4 mitogens tested at days 60 and 90. Fish fed no vit.E had lower stimulation index with all mitogens tested but not at all sampling times.

These results demonstrated a modulatory effect of vitamin E on

specific immunity while vitamin C seemed to have more influence on nonspecific response.

DIETARY CALCIUM SOURCE AFFECTS GROWTH AND BONE MINERALIZATION OF CHANNEL CATFISH.

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In previous experiments to determine the dietary calcium requirement of channel catfish (*Ictalurus punctatus*) in hard (>100 mg/L as $CaCO_3$) and soft (<1 mg/L as $CaCO_3$) water, it was observed that growth was progressively reduced by increasing levels of dietary calcium (supplied as $CaCO_3$). Therefore, the present study was conducted to determine the effects of different calcium levels and sources on growth and bone mineralization of channel catfish. A basal egg-white diet containing 0.02% Ca was supplemented with 0.5 and 2.0% Ca from $CaCO_3$, 2.0% Ca from $CaCl_2$, or 2.0% Ca from $CaHPO_4.2H_2O$ and fed to triplicate groups of fingerling channel catfish (initial weight 1.7 g/fish) in aquaria receiving a constant supply of water with hardness of 100 mg/L as $CaCO_3$. At the end of 8 weeks, growth and feed efficiency of catfish was significantly ($P<0.05$) affected by dietary calcium level and source. Fish fed diets containing $CaCO_3$ had the lowest weight gain and feed efficiency which decreased as dietary calcium increased from 0.5 to 2.0%. The diet containing 2.0% Ca from $CaCl_2$ produced similar fish performance as the diet containing 0.5% Ca from $CaCO_3$. The basal diet without calcium supplementation produced higher growth and feed efficiency values than all diets containing $CaCO_3$ or $CaCl_2$; however, the diet containing 2.0% Ca from $CaHPO_4.2H_2O$ produced significantly higher values than all diets. The various calcium sources and levels also produced responses in bone mineralization that were similar to the growth and feed efficiency data. Bone ash, calcium and phosphorus levels were significantly reduced in fish fed diets containing $CaCO_3$ and $CaCl_2$; whereas, fish fed $CaHPO_4.2H_2O$ had the highest levels. These results indicate that dietary calcium source and level can influence growth and bone mineralization of channel catfish even in water containing adequate levels of calcium.

RELATION ALIMENTATION - HYPOXIE - DIGESTIBILITE - FURONCULOSE EXPERIMENTALE CHEZ LA TRUITE ARC-EN-CIEL.

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Dans le but d'étudier les variations du coefficient d'utilisation digestive apparente des nutriments (CUDA) chez des poissons infectés (*A. salmonicida*), avec et sans stress (hypoxie à 60%), et de démontrer qu'un régime alimentaire adéquat (à base de protéines d'origine animale) accroîtra la résistance des poissons au stress et à la furonculose, nous avons procédé à des infections expérimentales par bain chez des truites (*O. mykiss*) de 150g. Les poissons ont été nourris avec deux régimes alimentaires, isocaloriques et isoprotéiques, à base de protéines animales ou végétales. Pour chacun des régimes, deux conditions d'oxygénation (normoxie et hypoxie) ont été étudiées. En l'absence d'infection par *A. salmonicida* et en situation de stress d'hypoxie, la prise alimentaire a diminué chez les poissons nourris avec le régime végétal; cette diminution ne fut que transitoire chez ceux nourris avec le régime animal. En revanche, après infection, la prise alimentaire a diminué chez tous les poissons indépendamment du régime et de l'oxygénation. Pour les deux régimes, l'hypoxie n'a pas entraîné de changement significatif ($p>0,05$) du CUDA de l'énergie, de la matière sèche et des protéines. Le CUDA de plusieurs acides aminés participant à des processus de production d'énergie a cependant augmenté de façon significative ($p<0,05$). Chez tous les poissons infectés, le CUDA de la plupart des nutriments a diminué significativement ($p<0,05$), surtout pendant les moments critiques de l'infection, avec retour progressif à la normale par la suite. Enfin, chez les poissons stressés et nourris avec le régime animal, une plus grande disponibilité digestive du tryptophane révèle que ces poissons auraient mieux résisté au stress d'hypoxie; une résistance à l'infection par *A. salmonicida* est aussi possible.

Session 4 : Nutrition Metabolism and Growth

Oral presentations / communications orales

METABOLISM OF PROTEIN IN COLD WATER FISH WITH REFERENCE TO FLESH QUALITY.

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Growth consists mainly in deposition of protein. Many attempts have been made to improve dietary protein utilization by increasing the amount of non-protein energy in the diet. These efforts have been attended by some success although usually at the expense of an increasingly fatty carcass. The combination of an increase in water temperature with an increase in dietary lipid tends further to spare dietary protein but again leads to elevation of carcass (mainly visceral) fat. On average only about 35% of ingested protein is retained in the body - a value similar to that pertaining for mammals and birds. In fish many of the catabolic losses of amino acids likely result from elevated tissue levels arising from the assimilation of diets containing high concentrations of protein. Some may arise as a consequence of protein turnover but it is not easy to see why this process, as such, should lead to irrevocable losses of amino acids. In any event, fractional rates of protein synthesis and breakdown in fish muscle (overwhelmingly the largest reservoir of proteins in the body) appear to be about an order of magnitude lower than those in mammalian muscle. There is some evidence from *in vitro* experiments in mammals that leucine exerts a proteogenic effect in muscle, but attempts to repeat this effect in trout *in vivo* were not successful. Branched chain amino acid (BCAA) metabolism may differ between fish and mammals; there is little evidence for a BCAA antagonism in fish, high dietary concentrations of leucine given to trout did not depress either weight gain or plasma concentrations of the other BCAA, also deamination of BCAA is not confined to muscle in trout. The indications are that catabolism of some other amino acids in fish muscle may differ appreciably from that in mammalian muscle. For example, glutamine is exported postabsorptively from mammalian muscle to gastro-intestinal tract and kidney but appears to be preferentially oxidized in the red muscle of fish. These differences will be discussed in the context of protein deposition in fish.

TAURINE SYNTHESIS IN RAINBOW TROUT FED DIETS SUPPLEMENTED WITH SULFUR AMINO ACIDS.

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Taurine plays important roles in physiological management of fish such as osmoregulation. It is well known that taurine is a final metabolite of sulfur amino acids, methionine and cysteine, and the amounts of urinary excreted taurine reflect the amino acid composition of dietary protein source in mammals. However, information on sulfur amino acid metabolism as well as taurine biosynthesis in fish is very limited.

In order to elucidate utilization of dietary sulfur amino acids in fish from the view point of taurine biosynthesis *in vivo*, a feeding study was conducted using rainbow trout. The fish were fed the diets supplemented with different levels of L-methionine and L-cystine to casein-base-diet for 15 days, and both the free amino acid composition in the tissue and the levels of excreted taurine were determined.

The fish fed the diet supplemented with 1% methionine to 50% casein diet accumulated methionine and cystathionine in tissues, although the fish fed 1% cystine supplemented diets did not. Taurine was accumulated in the tissues of fish fed cystine supplemented diets. Also, taurine excretion was observed only in the fish fed cystine supplemented diet.

These results suggest that dietary methionine can be converted to taurine less effectively than dietary cystine in rainbow trout.

NUTRITIONAL STATUS AND MUSCLE AND ADIPOSE TISSUES CHARACTERISTICS IN RAINBOW TROUT (*Oncorhynchus mykiss*).

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Experiments were conducted in rainbow trout reared in two of our experimental facilities (Donzacq and Lees-Athas, INRA, France) differing by their water temperature characteristics (respectively 18°C and 8°C all over the year). The distribution of white and red muscle fibres sizes and that of dorsal and abdominal subcutaneous adipose cells sizes were analysed by quantitative histology and compared with chemical composition of fish fillets.

In fasted fish of 250g Body Weight (one week fasting), the size of white muscle fibres and adipocytes were higher in fish reared at 8°C than at 18°C. These differences were related with higher fat content in the viscera and in muscle. The relative percentage of small diameter fibres in white muscle was also higher at 18°C than at 8°C. Few differences were observed in sensory evaluation of fish flesh quality.

In fish of 600g BW, fed since 8 months on an experimental diet based on fish meal and supplemented either with cod liver oil or corn oil, no significant differences due to temperature were observed in the distribution of white muscle fibres size or adipose cells size. The size of red muscle fibres was however lower in fish reared at 8°C that in that reared at 18°C. This could be related to the activity of fish. No significant differences were observed due to the experimental diet used except for the size of abdominal subcutaneous adipocytes which were higher in fish fed corn oil diet compared to that of fish fed cod liver oil diet. The dorsal subcutaneous adipose tissue was not affected by the diet. Thus, the sensitivity of the two adipose tissues studied to diet manipulation could be different at that stage.

These results obtained on cells and fibres size distribution could be related to changes in hypertrophic growth of adipose tissues and of muscle (effect of diet, effect of temperature) but also to changes in hyperplasic growth of these two tissues (effect of temperature).

PROTEIN TURNOVER AS A MODULATOR OF FOOD CONVERSION EFFICIENCIES IN FISH.

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This paper sets out to test the hypothesis that food conversion efficiencies in fish are related to the extent of protein turnover in the tissues. If the energetic cost of protein synthesis in fish accounts for a high proportion of the standard oxygen consumption then the proportion of the synthesised protein which is retained as growth could act as an important modulator of energy expenditure. The efficiency of retention of synthesised protein can be calculated from the ratio of growth rate divided by protein synthesis rates. The efficiency of retention of synthesised protein is not a fixed value; as protein synthesis rates increase with increasing growth rates in fish, the efficiency of retention increases as growth rates increase.

The hypothesis has been tested in three conditions : juvenile Tilapia, from a comparison between Tilapia and goldfish and from the relationship between food conversion efficiency and protein retention efficiency of individual rainbow trout.

High growth rates of juvenile Tilapia are brought about by high retention efficiencies (>50%). Increases in body mass are accompanied by weight specific reductions in growth rate, protein synthesis and oxygen consumption. Scaling relationships are important in protein retention efficiencies.

Higher growth rates in Tilapia compared with goldfish when maintained at the same rations are correlated with higher retention of synthesised protein in the former species.

Individual rainbow trout with high food conversion efficiencies have been found to have high retention of synthesised protein.

These results have (inter alia) the following implications : reduced protein turnover rates may have trade-offs in adaptation to environmental stress and longevity. Diet design, feeding regimes and hormonal treatment aimed at reducing protein turnover may result in improved food conversion efficiencies.

COMPENSATORY GROWTH IN ATLANTIC COD.

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Following a transition from restricted feeding to conditions in which feed supply is not limiting, fish and other animals display marked increases in growth rates. Growth rates achieved during the short period of compensatory (or catch-up) growth may be considerably higher than those displayed by individuals held continuously on adequate rations. During periods of compensatory growth, animals may become hyperphagic and food conversion efficiency may also be improved. In domestic animals and birds it has been demonstrated that the composition of the weight gain differs between animals showing compensatory and normal growth patterns. The differences in deposited tissue composition may, in part, explain why food conversion efficiencies differ in compensatory and normal growth, but it has also been suggested that the improvements in conversion observed during compensatory growth may be the result of a temporary uncoupling of anabolic and catabolic processes.

Results of previous studies have suggested that the Atlantic cod has a pronounced ability to show compensatory growth following a period of food restriction. The work to be presented describes results of experiments carried out in order to investigate the nature of compensatory growth in cod under farmed conditions.

METABOLIC EFFECTS OF FEEDING RATE IN RAINBOW TROUT.

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Triplicate groups of individually tagged yearling rainbow trout (*Oncorhynchus mykiss*) with an average initial body weight of 0.5kg were fed four different rates (0.0, 0.3, 1.0 and 2.0% body weight/day) in a 6-week experiment. Significant ($P<0.05$) increases in average weight gains and feed efficiencies were observed in trout with increasing feeding rates. Except carcass fat and visceral protein contents, increasing feeding rates had no effects on the body composition. Significant increases, however, were observed in liver to body weight ratios and in liver lipid contents with increasing feeding rates. Liver hexokinase (EC 2.7.1.1) activity showed an increase below, and ß-D-glucose $NAD(P)^+$1-oxidoreductase (EC 1.1.1.47) activity an increase similar to liver weight increases. Malic enzyme (EC 1.1.1.40), glucose-6-phosphate dehydrogenase (EC 1.1.1.49) and 6-phospho-gluconate dehydrogenase (EC 1.1.1.44), on the other hand, showed preferential increases in activities above those that can be accounted for by increased liver weights. Plasma protein, insulin, glucagon and glucagon-like peptides were increased with increasing feeding rates, but plasma glucose and growth hormone were not. Determination of growth and metabolic responses on individually tagged trout provides additional information on the effects of social interactions within a group of fish.

OPTIMUM RATIO OF MEDIUM CHAIN TRIGLYCERIDES TO POLLACK LIVER OIL IN DIETS ON LIPID ACCUMULATION OF AYU, *Plecoglossus altivelis* (PISCES).

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Ayu is one of the most important freshwater fish in Japan. Increase in production of cultured ayu is accompanied by degradation of fish quality. It is said that excessive lipid accumulation causes deterioration of carcass quality in ayu. Effect of feeding medium chain triglycerides (MCT) has been found in ayu and tilapia in reference to improvement of carcass quality. Therefore optimum ratio of MCT and ordinary dietary lipid which mainly consists of pollack liver oil (PLO) should be established.

Ayu were fed with composed diets supplemented with different ratio of MCT/PLO (0/0, 0/4, 1/3, 2/2, 3/1 and 4/0) at a level of 4% dietary lipid. The effects of the dietary lipids were evaluated by biological characteristics and body constituents in connection with lipid accumulation.

Growth and feed efficiency were superior at the ratio of 1/3 and 2/2, respectively. MCT were not deposited in the fish. Accumulation of lipid in muscle was the lowest at 4/0. Total triglycerides accumulated in muscle, liver and intraperitoneal fat body were suppressed at 2/2, 3/1 and 4/0. Following the feeding experiment, the fish were starved for 14 days in order to determine mobilization of lipid reserves. While feeding MCT suppressed lipid accumulation, lipid mobilization was not activated by MCT.

Combination of MCT and PLO (2/2) would improve carcass quality without impairment of growth and feed efficiency in the fish.

GILL LIPID METABOLISM IN PANTOTHENIC ACID-DEFICIENT RAINBOW TROUT (*Oncorhynchus mykiss*).

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Groups of post-juvenile rainbow trout (*Oncorhynchus mykiss*) were fed two semi-purified diets, one complete and the other deficient in pantothenic acid, for 28 weeks, during which time the average weight of the trout fed the complete diet increased six times. After 28 weeks of feeding, fish fed the pantothenic acid-deficient diet showed clinical signs of deficiency, including reduced growth, anorexia, and gill hyperplasia. Samples of gill tissue were removed from fish in each dietary group, and the polar and neutral lipids were extracted. Each fraction was further analyzed for lipid class and fatty acid composition. Remaining rainbow trout were subjected to a 24-hour seawater challenge, after which blood samples were taken for measurement of hematocrit and plasma sodium levels. No significant differences were found between trout fed the complete or pantothenic acid-deficient diet in the lipid classes of either the phospholipid fraction or the neutral lipid fraction extracted from the gills. Fatty acid composition of the various fractions was also similar between dietary treatment groups. Despite gill degeneration, pantothenic acid-deficient fish were able to regulate their internal osmolarity during the seawater challenge. Significant differences in hematocrit values were observed between the two groups of fish in freshwater, but this difference was reduced after exposure to saltwater. Based on the results of this study it is clear that gill hyperplasia associated with pantothenic acid deficiency in rainbow trout is not a result of altered membrane lipid composition in the gills. Further, pantothenic acid deficiency did not affect osmoregulation in fish exposed to a 24-hour seawater challenge, possibly because malfunction of gill osmoregulation may be compensated for by other osmoregulatory organs in pantothenic acid-deficient rainbow trout.

EFFECT OF DIETARY LIPIDS ON THE FATTY ACID COMPOSITION IN TISSUES OF GILTHEAD BREAM (*Sparus aurata*).

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Six purified diets supplemented with 12% lipid from soybean oil (SBO) and cod liver oil (CLO), their levels changing in a reciprocal way, were fed to gilthead bream (*Sparus aurata*) having initial weight of 1g, for five months. The fatty acid composition of neutral lipids and phospholipids (polar lipids) from muscle and liver as well as the fatty acid pattern of perivisceral fat were studied.

The fatty acid profiles of neutral lipids of muscle and liver as well as those of perivisceral fat were generally similar. Fatty acid profiles of liver and muscle phospholipids were different, the liver containing more saturates and w3 fatty acids and less monoenes, dienes, w3 and w6 fatty acids than muscle.

The fatty acid classes in all tissues studied were significantly correlated with dietary levels with the exception of w9 fatty acids in all tissues and the saturates and monoenes in liver phospholipids.

The EPA and DHA levels in liver phospholipids approached a maximum after a 6% fish oil inclusion in the diet while in muscle phospholipids their levels increased linearly remaining always lower than the respective liver levels.

The results are discussed in relation to the fluctuating water temperatures which cultured gilthead bream face during their culture and their expected inability to elongate and desaturate dietary fatty acids.

DIEL CYCLE IN *Oncorhynchus mykiss* USING DEMAND-FEEDER AND HELD IN DIFFERENT PHOTOPERIOD REGIMES : CIRCADIAN PATTERN OF FOOD-DEMAND, LIVER WEIGHT, LIVER GLYCOGEN CONTENT AND PLASMA T_3, T_4 AND CORTISOL CONCENTRATIONS.

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Diel cycle of feeding was studied in fingerling *Oncorhynchus mykiss* held at 7-8°C in groups of 30 individuals, under a 16L:8D or 12L:12D photoperiod, using self-feeders connected to a computer. Regardless of the photoperiod, more than 98% of the feeding demand occurred during the light phase. Under 16L:8D and 12L:12D, respectively 42 and 48% of the daily feeding demand occurred during the 4 hours following dawn. During the rest of the light phase, the feeding demand was about 5% of the daily demand per hour, with a slight peak (6%) during the half hour of artificial dusk. In such lighting/feeding conditions, all the metabolic and endocrinologic parameters measured showed significant (ANOVA) circadian variations. Regardless of the photoperiod length, the most important changes were observed between the end of the dark phase and 4 hours after dawn, with a 20% decrease of the hepatosomatic index and a 110% increase of the serum T_4 concentration. At the same time a 33% increase of serum T_3 concentration was observed under 12L:12D but not under 16L:8D. Plasma cortisol concentration showed a 170 and 125% increase respectively under 12L:12D and 16L:8D at 8:00 h, and undetectable values after dusk, i.e., at 22:00 h, for most of the fish sampled. A 130% increase of liver glycogen concentration was also observed 4 hours after dawn, but due to a high inter-individual variation this last parameter was only significant if the data collected during the light phase were pooled. The respective roles of light and feeding as synchronizers of the studied parameters remain to be tested.

CORRELATION BETWEEN APPETITE AND PLASMA THYROID AND GROWTH HORMONES AND PLASMA METABOLITE LEVELS IN RAINBOW TROUT.

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The physiological events that link food intake (appetite) with the neuroendocrine processes that control satiety have yet to be identified in fish. Some evidence points to a role of the thyroid hormones (THs) and growth hormone (GH) in the process since plasma concentrations of these hormones are affected by ration size, and the secretion of these hormones has a circadian pattern that suggests an appetite-related function.

The present study was undertaken to investigate the correlation between plasma TH and GH levels and appetite in rainbow trout. Fish were fed to satiety on 5 days of the week (3 times each day) and deprived of food for 2 days; they were maintained under this feeding regime for 9 months, during which time measurement was made of feeding rate on different days of the week. Fish were sampled from before the morning feed on days 1, 2 and 3 following the two fast days. Plasma GH levels were measured by homologous ELISA, plasma TH levels by RIA, and plasma glucose and non-esterified fatty acid (NEFA) levels by appropriate enzymatic protocols.

Food consumption was highest on day 1 and lowest on day 2. Plasma T3 and NEFA levels were similar on all three sampling days, plasma GH levels were lower and plasma T4 levels higher on day 2, while plasma glucose levels were higher after refeeding. The significant changes in plasma GH and T4 levels, concomittant with the reduced appetite of trout on day 2 suggests that the two events may be related. This agrees with other data that indicate a TH role in energy repartitioning during fast periods, and an initial elevation (possibly associated with high appetite levels), followed by a sustained fall in plasma GH concentrations during prolonged fasts, possibly associated with energy sparing strategies.

Session 5 : Environmental effects

Oral presentations / communications orales

DIGESTIBILITY OF FEEDSTUFFS IN THE CONTEXT OF WASTE MANAGEMENT BY NUTRITIONAL STRATEGIES.

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Ingested feedstuffs must be digested prior to utilization by the fish and these digested protein, lipid and carbohydrate provide energy and such essential nutrients as amino acids, fatty acids and glucose. Therefore digestibilities of feedstuffs indicate the "potentially available" energy and nutrients for maintenance, growth and reproduction by the animal. At the same time these also determine indigestible nutrients which are solid waste output and account for major portion of aquaculture wastes.

Hence prior to any attempt to formulate diets for fish, it is then prime necessity to determine apparent digestibilities coefficients of ingredients as measure of availability of energy and nutrients and also expected waste out-put from the diets. In the context of fish nutrition, digestibility coefficients are little affected by biotic and abiotic factors and these coefficient values of individual ingredients are additive (Cho and Kaushik, 1985), so that the final content of digestible energy and nutrients and output of solid waste from a diet can be predicted from the digestibility coefficients of either a diet or sum of the ingredients in the diet along with amount of feed fed.

The estimation of aquaculture wastes by these nutritional procedures is simpler, less costly and more accurate than widely employed chemical measurement of water quality in the effluent. The conventional chemical approach, based on water quality analyses of the effluent, can only provide data on the concentration of soluble and suspended solid, not total solid wastes, in a given water volume at a given time. These are merely qualitative data far removed from quantitative estimation.

From apparent digestibility of feed and comparative carcass analysis, coupled with measurements of feed intake and growth, it is possible to determine the proportions of nutrients retained in fish and

excreted as solid and soluble wastes. The model of this nutritional approach can be utilized to predict quantitative and qualitative waste outputs from aquaculture operations. It provides a basis for eliminating tedious, costly and inaccurate limnological procedures and evolving ways to mitigate these effects.

ENERGY AND NITROGEN BALANCE STUDIES IN FISH.

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Research on energy and nitrogen metabolism of fish mostly consists of studying experimentally induced variations in components of the energy and nitrogen budgets. Normally intake, digestibility and retention of E and N and heat production are measured. Because these budgets are often not complete and also to study the daily variation in E and N metabolism, in dependence of the feeding regime, the balance respirometer described by Heinsbroek *et al.* (1991) was expanded with a continuous flow analyzer for on-line measurement of CO_2, NH_4-N and NO_x-N excretion.

Recovery tests, in which known amounts of $CaCO_3$ and NH_4Cl were added, showed that about 90% of the CO_2 was recovered. Nitrogen recovery was 100%. About 10-15% of the added NH_4-N was recovered in the form of NO_x-N.

Two experiments were conducted to test the respirometer with fish. In the first experiment with eel, *Anguilla anguilla*, at 25°C, still 35% of the N budget was missing, and CO_2 production was underestimated. In the second experiment, eel, *A. anguilla*, and carp, *Cyprinus carpio*, were compared at 20°C. In this experiment also the production by the fish of ureum-N and dissolved organic N was determined. Recovery of both gross energy and -nitrogen was found to be higher than 95% in this experiment.

HIGH ENERGY DIETS TO ATLANTIC SALMON. EFFECTS ON POLLUTION.

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High energy diets for Atlantic salmon are characterized by high fat levels and use of fish oils as the main energy source. The carbohydrate levels are reduced to the minimum necessary to produce feed particles with high physical quality. The protein levels are aimed to be optimal, and thus the feed proteins are mainly utilized for anabolic processes in the fish.

Diets containing 22 and 30% fat were compared in an experiment with Atlantic salmon in a landbased facility in production scale. The 30% fat diet was made by coating of the 22% feed by fat which means a dilution of the basic nutrient content of the particle.

The testing facility was 4 tanks of 250 m^3 containing 15000 Atlantic salmons per tank which grow from 200g to 1150g.

The feeds were fed isoenergetic following the std feed tables for Atlantic salmon.

The apparent protein digestibility was improved with increasing levels of fat in the diets.

The fish grow according to the energy content in the feed. This means that the feed conversion was improved by approximately 10% using the 30% fat diet.

The reduction in pollution load using the 30% fat diets were 35%, 35% and 25% for nitrogen as ammonia, phosphorus and organic matter, respectively.

Use of high energy diets seems to offer an opportunity for significant reduction in pollution from fish farms. The potentials when compared with lower quality feeds may be even bigger than measured in this experiment.

BIOLOGICAL AVAILABILITY OF PHOSPHORUS IN FISH MEAL FOR ATLANTIC SALMON.

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Most studies on the biological availability of phosphorus from various feed ingredients in fish are based on digestibility and growth measurements. Preliminary studies conducted on the digestibility of fish meal showed a wide range of digestibility values (50-84%) among various fish meals produced in Canada. There was no correlations between growth and digestibility data. Apparent digestibility data has limited use unless corrections are made for endogenous phosphorus excretion. Further studies on phosphorus bioavailability methodology involve estimation of net phosphorus utilization and plasma alkaline phosphatase assays.

Bone ash was the most sensitive practical criteria for evaluating dietary phosphorus sources and it was more accurate than body weight and apparent digestibility values. The advantages of other methods are discussed and quantitative data on the biological availability of herring, capelin, menhaden and whitefish meals are summarized. Although, the total phosphorus content of these meals ranged from 1.6 to 3.8%, their biological availability ranged from 60-75%. Herring and capelin meal showed higher values than menhaden and whitefish meals. The application of phosphorus bioavailability data in reducing phosphorus excretion by dietary manipulation is discussed.

PERIODIC FEEDING OF LOW-PHOSPHORUS DIET AND PHOSPHORUS RETENTION IN RAINBOW TROUT (*Oncorhynchus mykiss*).

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Two semi-purified diets, one complete and the other deficient in phosphorus, were fed for eight weeks to groups of juvenile rainbow trout (*Oncorhynchus mykiss*). Groups of fish were fed either the phosphorus-sufficient or the phosphorus-deficient diets alone, or together in various combinations during each two-week feeding period. The combinations consisted of feeding the phosphorus-sufficient diet 50, 33, 20 and 10 percent of the feeding days, with the phosphorus-deficient diet being fed on the other days. At the end of eight weeks, all groups of fish were switched to the phosphorus-sufficient diet for three additional weeks. Fish were removed from each dietary treatment group for whole body proximate and elemental analysis at the beginning of the feeding trial, at two week intervals during the first eight weeks of feeding, and at weekly intervals during the final three week feeding period. Clinical signs of phosphorus deficiency appeared in the groups of fish receiving only the phosphorus-deficient diet after five weeks of feeding, and included lethargy, reduced growth, anorexia, and dark coloration. Fish fed the phosphorus-sufficient diet 10% of the feeding days showed signs of deficiency after 7 weeks. None of the other dietary treatment groups exhibited clinical signs of phosphorus deficiency. Periodic feeding of the low-phosphorus diet reduced whole body phosphorus levels in the fish at rates proportional to the total phosphorus fed during the eight week trial. Whole body levels of phosphorus increased in all dietary groups during the three-week repletion period, except in the group receiving the phosphorus-sufficient diet continuously. The results of this study provide information on rates and consequences of reduction of whole body phosphorus in rainbow trout, and indicate that periodic feeding of phosphorus-deficient diets might represent one means of reducing phosphorus levels in hatchery discharge water.

Session 6 : Larval and Crustacean Nutrition

Oral presentations / communications orales

ESSENTIAL PHOSPHOLIPIDS OF LARVAL FISH AND CRUSTACEANS.

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Some phospholipids in the diets had been found to be indispensable for sustaining growth and survival of larval fish and crustaceans. The larvae suffered high mortality when fed on diets without phospholipids. The feeding trials were conducted to examine the effects of supplemental phospholipids on growth and survival of the larval rock bream, *Oplegnathus fasciatus*, Japanese flounder, *Paralichthys olivaceus*, and prawn, *Penaeus chinensis*. The larval fish and prawn had high growth and survival rates when given the diets with soybean lecithin including 1.5-2.0% phosphatidylcholine + phosphatidylinositol.

Phosphatidylethanolamine improved slightly growth and survival. Soybean lecithin was effective in improving growth and survival of the larvae, but also promotive at the juvenile and young stages.

Why are phospholipids essential nutrients for fish and crustacean larvae ? Experiments with ^{14}C labelled lipids to clarify the mechanism by which dietary phospholipids enhance the growth of the fish and crustaceans were conducted. Results demonstrated that phospholipids are required for the transport of dietary lipids, particularly cholesterol and triglycerides in the body. On the other hand, *Macrobrachium rosenbergii* were maintained with diets supplemented with and without soybean lecithin. However, no significant differences were detected in either the weight gain or mortality rate of the prawn.

BIOCHEMICAL ASPECTS OF THE EARLY LIFE HISTORY OF YELLOW PERCH.

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Larval yellow perch (*Perca flavescens*) raised in ponds or in tanks were sampled at one week intervals for one month, and then less frequently to relate changes in fish biochemical content to the ontogeney of anatomy, diet, and physiology. Observations on the differentiation of the stomach and pyloric caeca of the intestine were related to fish age and size. Preliminary analyses of diets indicated that zooplankton (cyclopoids and cladocerans) as well chironomids were eaten in pond reared fish. Lipids and fatty acids were analysed in yellow perch eggs, juvenile fish, and in zooplankton. Among the polar lipids in perch eggs, the serine phosphoglyceride fraction contained unidentified fatty acid of carbon chain longer than 22 C, docosahexaenoic (22:6n3) and eicosapentaenoic (20:5n3) acids constituted 9.4 and 4.3% of neutral lipids and 19.6 and 3.8% of phospholipids, respectively, in perch eggs. Amino acids were found to contribute to 64.3-79.7% of dry matter in larval perch. The proportions of several essential amino acids increased (lysine from 6.91 to 9.09; methionine from 2.38 to 4.03; arginine from 2.83 to 4.06%) as perch increased in mass from 1 to 25.3mg wet weight. Early ontogenic changes in ascorbic acid and vitamin E concentrations were also analysed. Complex anatomical changes are indeed matched by biochemical changes, influencing the nutritional needs of developing fish.

EFFET DE L'HUILE DE FOIE DE MORUE SUR LA SURVIE ET LA CROISSANCE DES LARVES DE CYPRINIDES.

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Trois expériences de 28 jours ont été réalisées avec des larves de carassin (exp.1 et 2) et de carpe (exp.3) recevant des aliments artificiels à base de levure et de caséine et supplémentés avec des quantités différentes d'huile de foie de morue (HFM). Les 3 expériences comportaient un régine témoin (80% de levure) avec une teneur de 0,4% en acides gras (AG) de la série (n-3), sous forme de 18:3, procurant une survie finale de 90 à 95%. Les produits PS (poids moyen final en mg x survie finale) obtenus avec cet aliment étaient de 269, 297 et 272, respectivement pour les exp. 1, 2 et 3. Les régimes expérimentaux contenaient chacun 75% (exp.1), 20% (exp.2) et 10% (exp.3) de levure. Dans l'exp.1, le produit PS a diminué de 182 à 111 quand la teneur en AG (n-3) de l'aliment a été augmentée de 0,4% (0% d'HFM) à 1,6% (5% d'HFM). Dans l'exp.2, le produit PS a diminué de 151 à 55 quand la teneur en AG (n-3) a été augmentée de 0,4 (1,2% d'HFM) à 1% (3,3% d'HFM). Dans l'exp.3, le produit PS a augmenté de 77 à 165 quand la teneur en AG (n-3) a été augmentée de 0,1% (0% d'HFM) à 0,4% (1,2% d'HFM).

Les résultats suggèrent que les besoins en AG (n-3) des larves de carassin et de carpe sont relativement faibles et correspondent environ à 0,4-0,5% de la matière sèche de l'aliment.

SUPPLEMENTATION DES REGIMES ARTIFICIELS POUR LES LARVES DE COREGONE.

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Des larves de corégone (*Coregonus shinzi palea*) ont reçu pendant 35 jours des aliments artificiels à base de levure et de foie de boeuf supplémentés ou non en huile de foie de morue (H), en mélange minéral (M) et en mélange vitaminique (V). Dans une 1ère expérience, avec des aliments contenant de la levure IFP, les niveaux de supplémentation (en H, M et V respectivement) étaient : 0/0/0, 5/0/0, 0/5/0, 0/0/5, 5/5/5 et 10/10/10. Dans une 2ème expérience, avec des aliments contenant de la levure Protibel, les supplémentations testées étaient : 0/5/5, 5/0/5, 5/5/0, 5/5/5, 10/5/5, 5/10/5 et 5/5/10. Dans les deux expériences, les moins bons résultats de survie ou de croissance ont été obtenus avec les aliments supplémentés en H et peu ou pas supplémentés en V (5/0/0, 5/5/0 et 10/5/5). Les meilleurs résultats ont été observés avec les supplémentations 10/10/10 (1ère expérience) et 0/5/5 (2ème expérience). Il est conclu que la supplémentation vitaminique est utile dans les aliments de démarrage pour les larves de corégone. La supplémentation en huile de foie de morue (5 ou 10% de la matière sèche) a un effet défavorable qui peut être cependant corrigé par l'apport vitaminique. L'apport minéral ne semble pas un facteur limitant.

Bacillus sp. SPORES AS FOOD ADDITIVE FOR THE ROTIFER *(Brachionus plicatilis*) : IMPROVEMENT OF THEIR BACTERIAL ENVIRONMENT AND THEIR DIETARY VALUE FOR LARVAL TURBOT, *Scophthalmus maximus* L.

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Bacillus IP 5832 spores, used as probiotics for livestock, were introduced into the culture medium of rotifers at the rate of 4000 Colony Forming Units (CFU) $.ml^{-1}.day^{-1}$. The rotifers filtered more than 90% of the spores in 1h, and their associated flora was deeply altered. After 5 days of culture, *Vibrio* sp. was dominant in the control rotifers (59% of the total colonies), whereas the flora of spore-fed rotifers was very diversified (13% of *Vibrio* sp.). Few *Bacillus* colonies were counted in turbot larvae, but their mean weight at day 10 was significantly improved with the spore-fed rotifers (0.47, 0.62 and 0.56mg in 3 consecutive experiments, versus 0.43, 0.57 and 0.42mg for the control groups, respectively. The survival rate of turbot at day 10 was also improved when an opportunistic strain of the family *Vibrionaceae* was encountered (15% versus 4% in experiment 2 and 59% versus 29% in experiment 3). This was confirmed by an experimental infection since day 8 with the opportunistic strain (31% of survivors from day 8 to day 10 with spore-fed rotifers, versus 10% in the control group). No further improvement of the growth or survival rate of turbot was observed when *Artemia* were fed with the spores. It was concluded that the dietary value of rotifers should not be restricted to nutritional aspects, since bacterial additives and associated flora might show a deciding effect in turbot larval rearing.

THE EFFECT OF DIETARY ENZYMES WITH AGE ON PROTEIN AND LIPID ABSORPTION AND DEPOSITION IN *Sparus aurata* LARVAE.

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The success of microdiets presently used in cultivation of marine fish larvae is limited as they only serve as partial replacements for live food. This limited success is thought to be associated with the fish poor digestive ability due to an undeveloped digestive tract. In a previous study we reported enhanced assimilation and growth in *Sparus aurata* larvae which were offered a microdiet supplemented with digestive enzymes. The present study was designed to test the effect of exogenous digestive enzymes on the assimilation of lipid and protein in larval *Sparus aurata*.

Larval gilthead seabream, 20-45 days old, were fed ^{14}C labelled microdiets containing commercial pancreatic enzymes at different concentrations (0,0.1 and 0.05g/100g dry weight). rates of assimilation of dietary polar and neutral lipids and protein in the larvae were determined using a labelled diet.

The results show that the supplementation with digestive enzymes enhanced the diets assimilability in general by 30%. The addition of 0.05% pancreatin resulted in a significantly ($p<0.05$) higher proportion of neutral lipid being assimilated by the larvae. The label accumulated predominantly in the neutral fraction one hour after feeding whereas the phospholipid fraction demonstrated the highest radioactivity after 8 hrs. The rate of lipid assimilation far exceeded that of protein but was negatively correlated with age. In contrast protein assimilation in the presence of the exogenous enzymes was independent of larval age. Finally growth on the pancreatin microdiets was significantly higher than the enzyme deficient diet but markedly less than fish offered live food.

In summary, the data suggest the inclusion of exogenous digestive enzymes in microdients to improve digestibility in *Sparus aurata* larvae.

THE EFFECT OF DIETARY LECITHIN AND EXOGENOUS LIPASES ON FATTY ACID INCORPORATION IN THE TISSUE LIPIDS OF *Sparus aurata* LARVAE.

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The essentiality of n-3 HUFA for marine fish larvae may not be fully expressed, in microdiets, when added in the form of oils. This may be a result of larvae inefficiently absorbing dietary fatty acids due to a developing digestive tract. The present study tested the effect of dietary lecithin and exogenous lipases on the incorporation of fatty acids into the tissue lipids of gilthead seabream larvae (*Sparus aurata*).

Two of four microdiets were prepared by the addition of oleic acid (^{14}C) in a FFA form to diets containing 5% cuttlefish liver oil (CLO) or 5% soybean lecithin. Triolein (^{14}C) was similarly incorporated in two other diets identical in lipid (4% cuttlefish liver oil, 1% soybean lecithin) and component composition but differed in that one received a supplement of 0.05% porcine lipase. The effect of these diets was tested by following the incorporation of the label (cpm/mg larvae DBW) in the neutral and phospholipid fractions of seabream larvae at four different ages (22, 28, 32 and 45 day old fish).

A significant ($p<0.05$) effect of dietary lecithin on the incorporation of labelled FFA in both larval neutral and phospholipid fractions was demonstrated at all ages. This was particularly pronounced during the early stages of development (day 22) where fish fed the lecithin supplement showed a 575% increase in label incorporation compared to the diet containing oleic acid (^{14}C) in CLO. This boosting effect diminished with age but was still significant at day 45 (117% increase). In addition, the label was considerably higher in the phospholipid fraction compared to the neutral lipid reflecting the high demand for membrane synthesis during a period of rapid growth rate. In contrast, the supplementation of lipases showed a clear effect only in older fish where 45 day old larvae fed the lipase diet demonstrated a 242% increase in radioactivity in their tissue lipids. This delayed lipase response may be a result of the low level of dietary lecithin (1%) being ineffective, in the early larval stages, in incorporating excess labelled FFA from triolein breakdown.

The results demonstrated the enhancing effect of dietary lecithin on the incorporation of fatty acids in seabream larval lipids, particularly in the phospholipid fraction. The data further imply that a similar marked effect on fatty acid absorption by exogenous lipases is only fully expressed when accompanied by sufficient levels of dietary phospholipid.

N-3 HUFA REQUIREMENT FOR LARVAL GILTHEAD BREAM (*Sparus aurata*).

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This study summarizes the results of several experiments on feeding and starvation of gilthead bream larvae which were conducted to investigate their essential fatty acids requirements.

In the starvation experiments 50 000 eggs were stocked in 500l tanks containing aerated seawater. Samples were daily taken to analyse their lipid and fatty acid contents. For the feeding experiments, 15 000 eggs were stocked in 100l tanks with aeration and water flow system. From the 3rd to the 18th day after hatching larvae were fed with one variety of rotifers containing different percentages of n-3 HUFA. Each treatment was tested by three replicates. At the end of the experiment, survival, growth and activity of fish were determined and samples were analysed for biochemical composition.

The results showed that both survival and growth of the gilthead bream larvae are correlated with the n-3 HUFA content of rotifers, regardless of the various egg quality of the different spawnings. The presence of a high percentage of hydrops and poor activity seems to be related with the essential fatty acid deficiency in the larvae. Methyl esters of n-3 HUFA are not suitable for the enrichment of rotifers. An excess of n-3 HUFA in rotifers may also exert ill effects on the larvae. On the contrary, triglycerides containing 40% n-3 HUFA gave the best results in growth performance and survival of the larvae in any experiment.

FEEDING STIMULANTS IN MARINE FISH LARVAE.

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Observations of larvae of cod *Gadus morhua*, dover sole S*olea solea*, turbot *Scophthalmus maximus*, halibut *Hippoglossus hippoglossus* and eel *Anguilla anguilla* with scanning electron microscopic techniques demonstrate the presence of chemosensory organs. In some of these species we have observed a well developped olfactory organ even before hatching, indicating a functional role of the olfactory organ at pre-hatching stages. The receptor cells are of two types, either with cilia or microvillae at their distal end. It seems reasonable that the behaviour patterns swimming, darting and snapping with the jaws, observed in fish larvae just after hatching, are related to feeding. Fish larvae were exposed to various chemical stimuli at different concentrations and their behaviour observed. The scores of behaviour patterns were compared to that observed when the larvae were exposed to blanks of filtrated seawater. Arginine induced feeding reactions more frequently than other L-amino acids in cod larvae. Asparagine and glycine evoked the most significant behaviour reactions in turbot larvae. In sole larvae the substances phenylalanine, lysine and asparagine were the most stimulatory.

INCREASE IN POLYUNSATURATED FATTY ACID AND Ó-TOCOPHEROL LEVEL IN *Penaeus indicus* BROODSTOCK DIET: EFFECT ON BIOCHEMICAL COMPOSITION OF ORGANS AND EGGS.

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A compound diet, suitable to sustain the egg production of *Penaeus indicus*, was formulated thanks to previous experiments. The purpose of the present experiment was to determine the effect of an increase of (n-3) PUFA and Ó-tocopherol level in diet on reproduction of P. *indicus*.

The experiment was carried out during 2 months with 3*2 batches of 8 females and 8 males of *P. indicus* each, fed experimental diet. One of the diet, NEUTE = control diet, contained cod liver oil and 300ppm of Ó-tocopherol. The second diet, PHOSE, was formulated by substitution of fish roe phospholipid for cod liver oil, which induced an increase of phospholipid level from 32 to 50% of total lipid and an increase of (n-3) PUFA level from 19 to 31% of total fatty acids. The third diet, PHO, had the same lipid composition as the second one, but Ó-tocopherol was added.

184 spawnings were collected and analysed, as were the organs of the broodstock. No differences were found in spawning performances, including spawning rate, number of eggs, hatching rate, larvae quality in batches fed NEUTE and PHOSE, but hatching rate and larvae quality were lower in batches fed PHO. The lipid level in eggs, hepatopancreas and muscle was not related to the diet. The improvement in PHO and PHO9SE diets induced only a low increase of phospholipid and (n-3) PUFA level in eggs, but a significant increase in hepatopancreas. The Ó-tocoperol level in eggs and in organs was of course very low in PHO samples, but also significantly lower in PHOSE samples than in NEUTE samples. It confirms that Ó-tocopherol is used as a biological antioxidant and this vitamin being essential for hatching as proved in previous experiments, an increase of dietary PUFA content must be accompanied by an increase of dietary Ó-tocopherol level.

PROTEIN REQUIREMENTS FOLLOWING AN OPTIMUM DIETARY ENERGY TO PROTEIN RATIO FOR *Penaeus vannamei* JUVENILES.

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After a previous experiment in which optimum gross energy/protein (E/P) ratio growth of *P. vannamei* juveniles was estimated at 1000 kcal/100 g crude protein, a second assay was conducted to determine the optimum protein level related to this assumed proper E/P ratio. Nine experimental diets were formulated using the same source of protein e.g. a 50:50 mixture of casein and crab protein concentrate and crude corn starch as a sole carbohydrate source. E/P ratio was 1050 kcal/100g crude protein and it was kept constant while protein level ranged from 18% to 34% of diet. Significant differences were found between treatments, thus indicating an effect of protein level on growth, irrespective of E/P ratio. Optimum protein level was close to 28% of diet : further investigation is desirable to confirm these findings and to assess real digestibility of crude starch by shrimp, but crude starch can already be assumed to induce a protein sparing effect in the diet.

Session 7 : Tropical Aquaculture Nutrition

Oral presentations / communications orales

PARTICULARITE DES BESOINS ALIMENTAIRES DES POISSONS TROPICAUX D'EAU DOUCE.

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Dans les revues qui leur sont consacrées, il est habituel de regrouper, sous le générique de poissons d'eaux chaudes, à la fois les espèces eurythermes élevées en eau chaude et les espèces tropicales. Même si, pour des espèces nouvellement élevées, l'adaptation du savoir en matière de besoins alimentaires, du savoir faire en matière de couverture des besoins, procure des résultats satisfaisants, il est légitime de se poser la question de l'existence de spécificité de besoins et/ou des particularités induites par les écosystèmes tropicaux d'élevage.

L'analyse des travaux effectués jusqu'à l'heure permet de dégager ainsi deux axes intéressants : l'utilisation de l'énergie d'origine non protéique, et le rôle de la flore bactérienne associée.

Si la finalité recherchée des protéines alimentaires est une fixation maximale, le rôle théoriquement dévolu à l'énergie apportée via les lipides et les glucides est : i) de couvrir les besoins énergétiques de base, ii) de fournir l'énergie nécessaire à la synthèse protéique mais non iii) d'être fixée. Les espèces tropicales, strictement d'eau chaude, présentent ainsi un plus faible taux de fixation d'énergie sous forme non protéique que les espèces d'eau froide ou les espèces eurythermes élevées en eau chaude. Cette aptitude à la gestion métabolique d'une quantité importante de nutriments énergétiques "non conventionnels" mérite d'être approfondie et valorisée.

La possibilité de synthèse des vitamines du groupe B par les bactéries intestinales et l'intervention possible des différents maillons de la chaîne trophique dans les écosystèmes d'élevage tropicaux, constituent un deuxième exemple de particularité qui mérite d'être mieux prise en compte comme axe d'intérêt cognitif, économique, et comme sujet de réflexions sur les précautions à prendre lors des recherches délocalisées pour éviter les artefacts méthodologiques.

DOES A DIGESTIVE, ACTIVE BACTERIAL FLORA EXIST IN FISH ?

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Bacterial activity performed on the digestive contents depends on the number of bacterial bodies (bb). In cold or temperate waters fish species, the number of bacteria is most often below the minimum limit of 10^7 bb/g of digestive tract.

To ensure the development of this flora, two factors seems to be essential :

- on one hand, the existence of digestive compartments;
- on the other hand, a high temperature.

The study of cellulose digestion in tropical herbivorous fish species shows that bacterial flora can reach values of 10^9-10^{10} bb/g. This function is verified by the presence of volatile fatty acids in the digestive contents.

These observations suggest that, in these conditions, the digestive flora is able to exercise other functions similar to those described in higher vertebrates.

THE PROTEIN SPARING EFFECT OF SYNTHETIC LYSINE IN PRACTICAL CARP FEEDS.

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Soybean meal is a common protein source for carp feeds. The lysine requirement of carp is among the highest of aquatic animals. The availability of lysine in soybean meal has been found lower for carp than for other monogastric animals. In addition soybean meal contains about 25% complex carbohydrates that are almost indigestible by carp.

In this study 5% total protein of a 30% protein feed were replaced by 0.5% lysine-HCl and other non-protein energy sources to balance the lysine level. Two feeding experiments in ponds were carried out for 8 weeks with carp of 240g or 395g to compare 3 feeds : a) 30% protein/1.7% lysine; b) 25% protein/1.3% lysine; c) 25% protein + 0,5% lysine-HCl/1.7% lysine.

All the fish were fed equal rations of 4% body weight, based on the 30% group.

The fish fed the lysine supplemented feed attained in both trials the same weight gains and growth rates as the 30% group, their protein retention was increased by 20% and feed costs per Kg gain were reduced by 5%. The fish fed the negative control feed lagged by 10% in weight gains, feed conversion, protein and energy retention.

The amount of excreted (non-retained) nitrogen per Kg gain was reduced by 20% with the lysine supplemented feed, compared to the 30% feed.

The reduction of nitrogen pollution has important implications on the management of high-intensive carp-farming systems.

BIOENERGETICS OF GRASS CARP, *Ctenopharyngodon idella* (Val.) : PROTEIN TURNOVER IN RELATION TO RATION AND DIET QUALITY.

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Young grass carp are omnivorous and grow well when fed a variety of diets. The relationships between food type, growth and rates of protein synthesis were investigated in fingerling grass carp which had been fed daily on either lettuce (N:C ratio of 6.3) or on a pelleted diet (N:C ratio of 7.4). Synthesis rates were measured in whole fish bodies and in the intestine, liver and white muscle. X-ray radiography allowed individual food intakes to be determined for the final meal of the pelleted diet.

The rate of synthesis in the whole bodies and in white muscle increased with increasing protein consumption and increasing growth rates and appeared to lie on the same continuum for fish fed the lettuce and the pelleted diet. The proportion of synthesised protein which was retained increased with increasing growth rate and individual fish lay on the same curve for both diets. The lower growth rates of fish fed lettuce were mainly due to the lower protein intake rather than differences in protein quality between the two diets.

Daily oxygen consumption increased as both the daily rates of food intake and growth increased. Diet type did not appear to be an important influence on the relationship between oxygen consumption and growth. An important part of oxygen consumption has been attributed to protein synthesis. The proportion of oxygen consumption associated with protein synthesis was approximately 30% of the standard oxygen consumption of a free swimming 20g fish growing at 1.5 $\%d^{-1}$ when fed the pelleted diet.

NUTRITIONAL AND FUNCTIONAL CONSTRAINTS OF UTILIZING PLANT BASED FISH FEEDS IN TROPICAL SMALL-SCALE AQUACULTURE SYSTEMS.

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Terrestrial vegetation, aquatic macrophytes, tubers and agricultural by-products have an immense potential for use in freshwater herbivorous and omnivorous fish feed of resource poor regions in tropical Asia. The nutritional value of plant-based ingredients and their potential utilization either as sole, fresh feeds or raw materials in compound feeds for the small scale tropical aquaculture are reviewed. The limiting factors of plant-based fish feeds are evaluated according to constraints to the use of certain plant materials and include nutritional imbalances, nutrient/energy density, nutrient availability, plants chemical or physical defence, functional properties of raw materials ; structural and physiological constraints imposed by fish species, dry matter intake, protein and dry matter digestibility ; and environmental constraints imposed by low assimilation efficiency. Experimental data indicated that, contrary to popular belief, the nutritional imbalances play a minor role in determining the feeding value of plant-based feeds to fish and that low dry matter intake and digestibility are far more important. The methods to overcome these limiting factors are discussed with reference to feed preparation, functional characteristics of feed materials, food processing technology and feeding stategies.

REPLACEMENT OF FISHMEAL BY GREASE MEAL IN A GROW-OUT DIET FOR *Lates calcarifer*.

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Lates calcarifer is a carnivorous species which require a fairly high level of fish meal to grow fast and exhibit a good FCR. But, due to an increasing demand, fish meal needs to be replaced by a cheaper protein source like grease meal.

The experiment relates growth performances of 10 to 50 grams Lates fed 4 months on practical diets including 3 levels of grease meal : 0, 15, 22%.

The 22% grease meal diet gave 95% of the weight gain of control diet with 0% grease meal and fish grew from 15g to 60g within 100 days in the upper weight group of fish.

The apparent digestion coefficient measured with indirect method revealed 98% for the protein and above 97% for the lipid fraction. From histological point of view, though liver cells were infiltrated with lipids, no pathological signs were observed.

It seems possible to partly substitute grease meal for fish meal without decreasing feed performances.

THE EFFECTS OF VARYING DIETARY PHYTIC ACID, CALCIUM AND MAGNESIUM LEVELS ON THE NUTRITION OF COMMON CARP (*Cyprinus carpio* L.). II. HISTOPATHOLOGY AND MINERAL BIOAVAILABILITY.

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Juvenile common carp were fed for 8 weeks on 9 purified and 2 semi-purified diets containing either 0.5 or 1.0% phytic acid. Diets contained incremental levels of calcium (0.92 to 2.22%) and magnesium (0.058 to 1.60%). Dietary treatment significantly affected plasma levels of calcium, zinc and iron but not levels of magnesium, sodium, potassium and copper. The calcium, magnesium and zinc levels in liver, kidney and final carcass were also influenced by dietary phytic acid. Dietary phytic acid influenced copper levels in kidney and liver but not in plasma and carcass. Dietary calcium and magnesium had no influence on calcium, magnesium and zinc concentrations in plasma, liver, kidney and carcass, except when the diets simultaneously contained a high level of phytic acid, calcium and magnesium.The results of this study suggest that increasing dietary calcium and magnesium levels in the presence of phytic acid significantly influenced mineral (especially calcium, magnesium, zinc, iron and copper) bioavailability and further resulted in abnormal changes in the epithelial layer of carp intestine. This reduced bioavailability may be attributable to the formation of insoluble phytate-mineral complexes.

THE EFFECT OF DIETARY L-CARNITINE ON THE GROWTH AND GROWTH EFFICIENCY IN JUVENILES OF THE AFRICAN CATFISH (*Clarias gariepinus*, Burchell 1822) IN RELATION TO DIETARY LIPID LEVELS.

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The effect of dietary L-carnitine on the growth and growth efficiency of African catfish (*Clarias gariepinus*, Burchell 1822) fingerlings was investigated. Six levels of dietary L-Carnitine (Lonza Benelux bv, The Netherlands) varying from the natural level (125 $mg.kg^{-1}$) to 3920 $mg.kg^{-1}$, were tested at two dietary fat levels (9.6% and 15.5%). The diets were iso-proteic and were fed to 36 experimental groups of 100 fishes of 5g at a feeding level of 25.2 $g.kg^{-0.8}.d^{-1}$.

The average final weights varied from 19.1 to 28.0g. At the high dietary fat level, the specific growth rate increased from 30.9 $g.kg^{-0.8}.d^{-1}$ to 35.4 $g.Kg^{-0.8}.d^{-1}$. At a dietary fat level of 9.6%, the specific growth rate increased from 30.8 to 36.5 $g.kg^{-0.8}.d^{-1}$. At lower dietary L-carnitine levels, growth increased linearly with increasing L-carnitine level, reaching a plateau at 245 $mg.kg^{-1}$ for the fat rich diet and at 490 $mg.kg^{-1}$ for the lower fat level.

Feed conversion improved significantly with increasing levels of dietary L-carnitine, reaching a plateau at 245 and 490 $mg.kg^{-1}$ for the high and low fat level respectively. Other growth efficiency parameters i.e. protein efficiency ratio, apparent net protein utilization and energy conversion efficiency improved accordingly.

THE INFLUENCE OF DIETARY ENERGY LEVELS ON THE INDUCTION OF HEPATIC MIXED FUNCTION MONOOXIGENASE BY PCB IN TILAPIA, *Oreochromis niloticus* x *O. aureus*.

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Effects of three dietary energy levels, 323, 365 and 408 kcal/100g diet, on hepatic mixed-function oxidase (MFO) system were studied in tilapia, *Oreochromis niloticus* x *0. aureus*, fed 100ppm polychlorinated biphenyl (PCB) containing diets. The experiment was carried out for 3 months in a recirculating rearing system. Growth and feed conversion ratio reduced significantly ($P<0.05$) in fish exposed to PCB when high energy diets (365 and 408 kcal/100g diet) were fed. The hepatic cytochrome P-450 and NADPH cytochrome c reductase activities were significantly ($P<0.05$) lower in PCB treated fish fed high energy diets (365 and 408 Kcal/100g diet) than in fish also treated with PCB but fed lower energy diet (323 Kcal/100g diet). The malic enzyme activity and the body lipid content in fish generally increased as the dietary energy level increased. Lower hepatic MFO enzyme activities and higher lipid synthesis enzyme activity found in the PCB treated fish fed with high energy diets may provide an indication that the NADPH supply were in a competition status between the two metabolic pathways in fish when PCB was challenged. These data suggest that the ability of metabolizing xenobiotics in tilapia reduced when high energy diets were ingested.

ADAPTABILITE DE DIFFERENTS ALIMENTS ET FERTILISANTS AUX CONDITIONS PARTICULIERES DES ELEVAGES D'*Oreochromis niloticus* EN ETANGS DANS LE MILIEU RURAL IVOIRIEN.

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Le prix de revient des intrants est aujourd'hui la principale contrainte pesant sur le développement de la pisciculture rurale en Côte d'Ivoire. Des aliments et/ou des fertilisants trop coûteux nécessitent la constitution d'un fonds de roulement le plus souvent incompatible avec l'organisation économique familiale de l'exploitant.

Cet article établit une comparaison des résultats techniques et économiques obtenus par testage en station de recherche de 6 formes différentes de nourrissage ou de fertilisation vulgarisées ou susceptibles d'être vulgarisées en milieu rural. Les traitements sont exclusivement basés sur l'utilisation de sous-produits locaux utilisés seuls (1 composant) ou associés.

Une appréciation sur ces résultats, portée en fonction de leur adaptabilité aux conditions particulières du milieu rural, met en évidence la prééminence des traitements les moins coûteux basés sur l'utilisation de son ou de farine basse de riz (un seul composant).

Pour optimiser ces traitements caractérisés par une faible valeur nutritive et un effet alimentaire direct corrélativement limité, il est nécessaire de valoriser l'effet fertilisant des parts non consommées et non digérées de l'aliment. Une voie expérimentale visant à évaluer l'importance de cet effet fertilisant et ses possibilités d'amélioration est proposée.

AQUACULTURE NUTRITION AND FEEDING IN DEVELOPING COUNTRIES : A PRACTICAL APPROACH TO RESEARCH AND DEVELOPMENT.

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The need to develop an applied aquaculture nutrition and feed development programme to suit the needs of the resident aquaculture sector within developing countries is discussed. The problems of determining dietary nutrient requirements and formulating practical rations for tropical aquaculture species within semi-intensive and intensive culture systems is examined. Particular emphasis is placed on the development of a multidisciplinary approach to supplementary and complete diet feeding, and the need for the aquaculture nutritionist to work in tandem with the commercial or rural farmer and the feed manufacturer. The success or not of a dietary feeding regime depends upon 1) the nutritional characteristics and composition of the diet formulated, 2) the manufacturing process used to produce the formulated ration and the physical characteristics of the resultant diet, 3) the handling and storage of the prepared diet prior to usage on the farm, 4) the feeding method employed to distribute the feed to the cultured fish or shrimp, 5) the water quality of the culture system, and 6) the fish/shrimp stocking density employed and natural food availability. Examples of applied feed development programmes developed by the author within Latin America, the Philippines, and Indonesia, for omnivorous fish species, penaeid shrimp and marine finfish are presented.

Session 8 : Nutrition Research and Aquaculture Development

Oral presentations / communications orales

IMPORTANCE OF NUTRITION RESEARCH ON THE DEVELOPMENT OF THE US CATFISH INDUSTRY.

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Channel catfish is the most widely cultured foodfish in the U.S. State and federal hatcheries have been providing channel catfish fingerlings to stock public and private waters for sport fisheries for well over 50 years. Commercial production of channel catfish developped in the southern U.S. during the late 1950s and early 1960s based on the pioneering work of H.S. Swingle of Auburn University in Alabama. Rapid expansion of the industry did not take place until the late 1970s and early 1980s. Current (1990) estimates indicate that 68,858 ha of water in 17 states are in production of farm-raised catfish with an annual production of 170,000 MT.

Initially catfish were raised in ponds at low stocking densities and fed low-cost incomplete feeds. This culture technique depended on the fish obtaining several essential nutrients from natural food organisms in the pond. However, as stocking densities were increased it became necessary to provide all of the essential nutrients in the form of complete feeds. Commercial complete catfish feeds were then produced based on the nutrient needs of other animals such as poultry and salmonids. Incidences of vitamin deficiencies and the fish meal crisis in the early 1970 s emphasized the urgent need to know the nutrient requirements of catfish if the industry was going to be successful. Nutritional researchers at Auburn University, the University of Georgia and Mississippi State University responded with the quantitation of most of the essential nutrient requirements. Currently, adequate nutritional information is available to produce high quality, nutritionally complete catfish feeds at reasonable costs.

REPORT ON THE NEW NRC BULLETIN ON NUTRIENT REQUIREMENTS OF FISH.

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The new National Research Council bulletin entitled Nutrient Requirements of Fish has been completed and should be released soon. This report combines the two previous publications in the "Nutrients Requirements of Domestic Animals" series dealing with fish, i.e. Nutrient Requirements of Coldwater Fishes and Nutrient Requirements of Warmwater Fishes and Shellfishes. The National Research Council subcommittee on the Nutrient Requirements of Fish felt that combining the two previous bulletins was warranted because the nutrient requirements do not vary greatly among fish species, with perhaps a few exceptions. It appears that the preferred source of certain nutrients may vary more widely than the actual requirement for specific nutrients for various fish species.

This report updates and summarizes the nutrient requirement data in a manner similar to the two previous publications. This edition for the first time includes a nutrient requirement summary table for channel catfish, salmonids, carp, tilapia and eel. The committee critically evaluated the various requirement values that have been reported in the literature and deleted certain values that appeared to be questionable. In some cases, a previously reported questionable value was replaced with only an indication that the nutrient was required. Metabolizable energy values were deleted and replaced with digestible energy values because DE values appear to be much more useful in diet formulation for fish than ME values. Crustacean nutrition was not included in this edition because of the lack of published research data on their nutrient requirements.

EFFECT OF CALCIUM AND PHOSPHORUS ON ZINC AVAILABILITY TO RAINBOW TROUT.

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Two feeding experiments were conducted to determine the effect of dietary calcium (Ca) and/or phosphorus (P) on zinc (Zn) availability to rainbow trout. In Experiment I, the effect of phosphorus on Zn availability to juvenile rainbow trout was investigated by feeding the semipurified diets (40 μg Zn/g diet) supplemented with one of varieties of phosphates ($Ca(H_2PO_4)_2$, $CaHPO_4$, $Ca_3(PO_4)_2$, NaH_2PO_4, KH_2PO_4, K_2HPO_4 and H_3PO_4) to obtain the same level of P as in the white fish meal based diet. In Experiment II, the combined effect of Ca and P was determined by supplementing diets with $CaCO_3$ and/or H_3PO_4 at levels of 0, 2.25, 4.50, 6.75 and 9.00 and/or 0, 3.5, 5.2 % in order to obtain graded levels of Ca and P (0.2-3.7 % Ca and 1-2.6 % P). In Experiment I, growth was decreased by the supplement of various kinds of phosphates except $CaHPO_4$. Supplementing $Ca(H_2PO_4)_2$ or $Ca_3(PO_4)_2$ induced short body dwarfism or eye lens cataract, respectively ; in addition to lowering of Zn content of vertebrae. In Experiment II, growth was decreased by supplementing P at level of more than 1.8 % in diet, but was improved by supplement of Ca. The best growth was obtained in fish fed the diet containing Ca and P at equal proportions. The absorption of Zn was also reduced by dietary inclusion of P, whereas it improved on Ca addition.

The results of the experiments have suggested that the content and balance of P and Ca affect the growth and availability of Zn to rainbow trout.

FRESHNESS OF FISH FOR FISH MEAL - EFFECT ON GROWTH OF SALMON.

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The effect of freshness of the fish raw material used in the production of fish meal fed to Atlantic salmon smolts has been investigated. In probably the largest trial yet undertaken with fish meal, 1500 tonnes of fresh herring (12 hours in ice after catching) having been caught from the same shoal by three trawlers, was either processed immediately (fresh - F) after 48 hours (moderately fresh - MF) or after 7 days (stale - S). Storage after landing, from 12 hours after catching for the MF and S material, was at ambient temperature of about 7°C. The fish was processed through a low temperature indirect hot air dryer.

The total volatile nitrogen content of the fish at the time of processing was 22, 62 and 143 mgN per 100g fish for F, MF and S fish respectively.

The fish meals produced were found to contain 400, 2070 and 3860 ppm of biogenic amines (cadaverine, putrescine, histamine and tyramine) respectively.

The fish meals were fed to S_1 Atlantic salmon smolts of average weight 90g, in sea water. Three 2.4m diameter tanks each containing 100 fish were allocated to each treatment.

Over a 12-week period the specific growth rate was significantly faster ($P<0.001$) with the fish meal from fresher fish (1.65, 1.52 and 1.18% respectively). Feed conversion (weight of feed/weight gain of fish) was significantly better ($P<0.001$) with fresh fish (0.89, 0.95 and 1.47 respectively).

Fish meal made from fresh fish is recommended for fast growing salmon.

GROWTH RATE OF ATLANTIC SALMON (*Salmo salar*) FED FISH MEAL WITH VARYING CONTENT OF WATER SOLUBLE PROTEIN.

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Fish meal is widely used as a protein source in fish diets. Fish meal production includes cooking followed by pressing. The press liquor (solubles) is normally returned back to the solid fraction (presscake) before the drying process. Fish meal produced with a full content of solubles is called whole fish meal. A presscake meal, is a meal without solubles.

Whole and presscake fish meal, processed under low temperature condition, were fed as the sole protein sources in dry feed for salmon of 600 g initial weights for 230 days. Salmon fed whole meal grew 7% ($P<0.15$) faster and had 7% ($P<0.05$) better efficiency of feed conversion (kg feed/kg fish produced) than those fed presscake meal.

Thus "whole" fish meal appears to be a better protein source for salmon than "presscake" fish meal.

SOYBEANS FOR ATLANTIC SALMON (*Salmo salar* L.).

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Four soybean products : full fat dehulled, whole extracted, dehulled extracted and concentrate, were evaluated as protein sources for Atlantic salmon. The products were tested at five levels of dietary inclusion corresponding to 0, 14, 28, 42 and 56% of protein, replacing high quality fish meal. A growth and a digestibility trial was carried out in sea cages with fish weighing on average 290g. A long term follow-up growth study, 10 months, with a dehulled extracted soybean meal comprising 0, 20 and 40% of protein, was carried out with 900 g fish until 2.5kg. Health and sensory quality variables were of particular interest.

In the first growth and digestibility trial significant differences in effects on growth were seen between all soybean products. The concentrate seemed as good as the fish meal, whereas the product showing the poorest growth stimulating effect appeared unsuitable for Atlantic salmon. The growth impairing effects paralleled effects on digestibility of lipids and protein for all but the full fat soybean. Ranges of protein and lipid digestibilities were 58-88% and 50-93%, respectively for the highest soybean inclusions.

In the follow-up experiment 14% growth depression was seen at the highest inclusion level. No effects were seen on health, as visually judged by a veterinary or by further organ and blood examination. Neither were any important effects found on sensory qualities.

DIGESTIBILITY OF NATIVE STARCHES OF VARIOUS BOTANICAL ORIGIN BY RAINBOW TROUT.

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Various factors affect the digestible energy brought by complex carbohydrates in fish diets. One of these factors, the botanical origin of the starch, was investigated.

7 raw starches from potato, manioc, rice, wheat, normal- waxy- and amylomaize were compared to treated ones (pregelatinized and extruded maize).

The 9 experimental diets contained 30% of starch and 70% of a common base mainly consisting of fish meal. The feeding rate was 1.5% of the live body weight (fish mean weight, 100g). The water temperature was 18±1°C during the 2-week experimental period. Feces were recovered by a continuous automatic collector.

Great differences were observed between diets concerning starch digestibility. That of cooked starch (pregelatinized or extruded) was high (95%) while that of native starch varied between 5% for potato and 60% for wheat. On the contrary, apparent digestibility of proteins remained constant (90%). Digestibility of dry matter (56% to 83%) was correlated to starch digestibility.

It is suggested that starch digestibility in trout, as in homeothermic species, is related to the physicochemical properties of starch and to its susceptibility to pancreatic amylase.

THE UTILIZATION OF DIETARY CARBOHYDRATE IN COD (*Gadus morhua*) : RESPONSE OF FEEDING AND STARVATION.

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360 cod (average weight 370 g) were captured in Masfjorden, Norway, distributed into three groups and fed diets with graded levels of extruded corn-meal. After 8 weeks of feeding, samples were collected at time intervals after the last meal : 4 h, 8 h, 12 h, 24 h, 4 days and 4 weeks. The object of this study was to elucidate the utilization of carbohydrate by measuring growth and feed efficiency after feeding, and weight loss following starvation for 4 weeks. Chemical analyses included blood glucose response, hormonal response of insulin, glucagon and glucagon-like-peptide, and deposition of glycogen and main nutrients in liver and muscle. The results from this study will by presented and discussed.

This study was supported by the norwegian Fisheries Research Council (NFFR).

RESPONSES OF ATLANTIC SALMON (*Salmo salar* L.) TO INTAKES OF RAW AND EXTRUDED WHEAT.

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In order to test the suitability of wheat as a feed ingredient for Atlantic salmon, a combined growth and digestibility study was carried out.

Experimental diets containing raw or extruded wheat at inclusions of 0%, 15%, 30% or 45% were fed to fish in net pens in sea water.

The duration of the study was three months, and only a slight reduction was found in growth performance with increasing inclusions of wheat. No negative effects were found on digestibilities of protein nor lipid, but there were great variations in starch digestibility. Plasma glucose levels and hepatosomatic indexes did not seem to be affected by high inclusions of wheat.

SOYBEAN MOLASSES IMPAIRS GROWTH AND NUTRIENT UTILIZATION IN ATLANTIC SALMON (*Salmo salar* L.).

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Effects of soybean molasses, i.e. mainly alcohol soluble soybean carbohydrates, on nutrient absorption and weight performance in Atlantic salmon were examined by a short digestibility trial in fresh water and a combined growth and digestibility trial in sea water.

In the digestibility trial, fish were fed diets containing 0, 5, 10, 15 and 20% soybean molasses.

In the digestibility/growth trial fish were fed feed either with or without 15% soybean molasses.

Soybean molasses affected only lipid absorption significantly in the digestibility trial. Longchained, unsaturated or monounsaturated fatty acids were most affected. In the sea water trial growth, absorption of dry matter, protein and lipids and fecal dry matter were negatively affected. Lipid absorption seemed to be more affected than protein.

EFFECT OF TEMPERATURE AND OF DIETARY LIPID SOURCE ON FEMALE BROODSTOCK PERFORMANCE AND FATTY ACID COMPOSITION OF THE EGGS OF RAINBOW TROUT.

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The fatty acid composition of the eggs is known to influence egg quality as measured by hatchability and larval development. The food supply and quality to the adult female have been shown to modify lipid composition of the eggs.

The aim of this study was to investigate to what extent dietary lipid source and rearing temperature can affect female broodstock performance and fatty acid composition of the eggs.

For this purpose, 4 groups of rainbow trout (average weight 100g) were fed on 2 experimental diets containing either corn oil (SM) or cod liver oil (SF). Each dietary treatment was tested at two different rearing temperatures: 8° and 18°C. The experiment lasted one year while the animals reached maturity. Fecundity, total lipid content and fatty acid composition of the eggs were determined.

At the end of the experiment, the growth was similar for the 4 groups. Gonado somatic index, weight of spawn, average weight and lipid content of the eggs were more important in 18°C reared females, irrespective of dietary treatment. Nevertheless, there were no significant differences in absolute and relative fecundity between the groups.

As regards to fatty acid pattern of total lipids in eggs, temperature had no marked effect whereas dietary treatment modified this pattern.

We observed, with the experimental diet containing corn oil compared to the cod liver oil diet, that w6 fatty acid content (especially 18=2) was higer whereas the amount of monounsaturated (16=1) and w3 fatty acid (essentially 20=5 and 22=6) were lower. Consequently, the w3/w6 ratio was clearly reduced with this diet. In fact, the fatty acid profile of the eggs reflected that of the experimental diets provided to the female broodstock.

In conclusion, this work showed that rearing temperature only influences the size of the eggs and their lipid content. On the other hand, lipid composition of broodstock diet modified the fatty acid composition of

the eggs.

DIFFERENCES IN GROWTH RATE AND FAT DEPOSITION IN THREE STRAINS OF RAINBOW TROUT.

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Most studies in fishes, particularly salmonids, have shown that growth enhancement leads to an increase in fat deposition, which is one of the main criteria for quality of cultivated fishes.

The present study investigated to what extent differences in growth rates modify tissue lipid distribution. This experiment was carried out with three strains of rainbow trout differing by their growth rates:

- COR strain : fast growth,
- GAT strain : slow growth,
- SY strain : intermediate growth.

Lipid analysis were performed on 15 month old animals, reared under similar conditions and fed with a commercial diet.

At this stage, weight gain and liver size were more important in the strain with the fastest growth rate. Hepato somatic indices did not differ significantly between the 3 strains.

Growth performance had no marked effect on circulating levels of cholesterol and triglycerides, despite great individual variations.

The total lipid content of abdominal muscle was more elevated in SY and GAT strains, with a maximal value in GAT strain which displayed the slowest growth. On the other hand, higher lipid content was found in liver and dorsal muscle in the strain with fast growth. Besides, hepatic lipid storage was more important in this strain. In all cases, differences in total lipid content reflected mainly the changes in neutral lipid fraction.

In conclusion, this study shows that growth rate affect tissu lipid distribution. In animals with fast growth, the liver and dorsal muscle were the major sites of lipid deposition, whereas in animals with slow growth lipid storage occured predominantly in abdominal muscle. Further experiments are necessary to precise this phenomenom.

EFFECTS OF DIETARY N-3 FATTY ACIDS AND VITAMIN E ON EGG QUALITY OF ATLANTIC SALMON (*Salmo salar*).

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Atlantic salmon were fed diets containing three levels of n-3 polyunsaturated fatty acids (PUFA) at two levels of vitamin E from 30g and until sexual maturation.

Egg size and chemical composition, hatching success and fry survival will be recorded.

The results will be discussed in relation to broodstock dietary regimes and chemical composition of the eggs.

SEX INFLUENCES ON GLUCOSE UTILIZATION IN THE MATURE SEA BASS (*Dicentrarchus labrax* L.).

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The utilization of glucose via glycolysis or through the pentose phosphate shunt would be expected to change from pre-spawning to spawning season of fish, considering that glucose is the primary fuel for certain tissues such as the maturing gonads. According to this, pyruvate kinase (PK) and glucose 6-phosphate dehydrogenase (G6PDH) were determined in liver and gonads of males and females sea bass at pre-spawning (November) and spawning (February) times. Fish of the same brood were obtained and maintained at the Institute of Aquaculture (C.S.I.C., Spain) in 8 m^3 tanks, under natural temperature and photoperiod conditions. Duplicate lots of animals were fed a laboratory diet with the following composition (in g/100 g dry diet) : 50% protein, 12% lipids, 10% digestible carbohydrates. Assays began in April 90 and enzyme determinations were carried out at pre-spawning (November 90) and spawning (February 91) times.

The PK activity in gonads was about twice that of the liver which remained unchanged and independent of the sex. While ovary PK activity did not change along sexual maturation the one from the testes did increase as sperm maturation proceeds. Only trace activities of G6PDH were detected in male and female gonads independently of sex or gonadal maturation. A significant decrease of liver G6PDH activity was detected at spawning, specially in males, that could be related with higher needs of NADPH production for different biosynthetic processes associated with sexual maturation.

DIETARY AND SEX INFLUENCES ON FRUCTOSE 1,6 BISPHOSPHATASE KINETICS IN SEA BASS BREEDING-SEASON.

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Very little research has been carried out on the influence of nutritive conditions on fish reproduction and there is much less information on the metabolic adaptations to the diet. Gluconeogenesis must be an important pathway to provide glucose to the developing and mature gonads, in consequence Fructose 1,6 bisphosphatase, a key gluconeogenic enzyme, was determined in response to the diet composition in spawning sea bass.

Fish belonging to the same brood were maintained at the Institute of Aquaculture of Torre de la Sal (C.S.I.C., Spain) under natural temperature and photoperiod conditions. Animals in duplicate lots were fed since April 90 with the experimental diets that contained the following macronutrients (in g/100 g dry diet) : 50P/12L/10CH (control), 50P/12L (w3 HUFA deficient)/ 10CH and 30P/12L/33CH. Fish were killed by the middle of February 91 coinciding with the spawning.

The kinetics of FBPase was determined in liver and gonads of 6 males and 6 females of each treatment. Liver enzyme activity was higher in females, while ovarian enzyme activity was important and no activity was detected in testes. On the other hand, the high carbohydrate and w3 HUFA deficient diets reduced liver FBPase activity, both in males and females. Diet composition did not alter significantly enzyme activity in the ovary.

INDIVIDUAL VARIATION IN GROWTH, FOOD CONSUMPTION AND RETENTION EFFICIENCY IN RAINBOW TROUT (*Oncorhynchus mykiss*).

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Individual fish can consume similar amounts of food and yet have markedly different growth rates. This paper correlates the variation in consumption and growth in individual rainbow trout with the variation in individual protein metabolism.

Three groups of rainbow trout (mean weight 41g) were fed three defined rations over a 73 day period. Individual consumption rates (mg dry food/g wet wt/d) were measured four times during the course of the experiment by X-ray radiography of food labelled with ballotini glass beads.

The results of the radiographs revealed variation in individual consumption on the X-ray dates. However there were highly significant correlations between estimates of consumption of individual fish between the four sampling dates and the results indicated that individual fish were feeding at a similar level over the 73 days. Individual estimates of consumption were highly correlated with growth rates for the period prior or subsequent to the X-ray and also with the mean growth rate for the 73 days. The relationship between consumption and growth was found to be curvilinear and the maintenance and optimum protein ration were defined.

As protein ration increased above the maintenance ration the protein retention efficiency (whole body protein growth divided by protein consumption) increased to a maximum (27%) at the optimum protein ration decreasing with any further increase in protein ration.

Protein synthesis rates were measured and the efficiency of retention of synthesized protein (whole-body growth rate divided by synthesis rate) increased with increasing protein retention efficiency. The results indicate that one of the factors controlling individual variation in growth rate in fish is the variation in the efficiency of deposition of synthesized protein.

EFFECT OF DIETARY PROTEIN LEVELS IN DIETS FOR TURBOT (*Scophthalmus maximus* L.) TO MARKET SIZE.

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The temperature was 15°C in all the experiments. The initial number of fry in the different experiments was about one hundred. In half of the 1988-experiments the fry came from different females, and in the rest of the 1988-experiments and all the 1989 experiments they came from one female and also one egg batch. All the fish were measured and weighed, and no size selection was done during the period. The 1988- and 1989-experiments lasted until day 730 and 407 respectively. The experimental diets were pelleted dry feed composed of low temperature fishmeal (Norse-LT 94) and special quality fishoil (Norsalmoil), and dextrinized wheat. In the 1988- experiments the protein levels were 56%, 46% and 36% respectively, and in the 1989-experiments the different diets contained 51%, 46% and 41%. Decreasing protein content was compensated by carbohydrates. Live mean weights at the end of the 1988-experiments with different protein levels of 56%, 46% and 36% were 1693 ± 633 g, 1590 ± 550 g and 1207 ± 485 g respectively. In the 1989-experiments the live mean weights at the end were 479 ± 155 g, 394 ± 135 g and 298 ± 110 g respectively for the 51%, 46% and 41% protein content in the diets. In all cases the growth rate was positively correlated with the increasing protein levels in the diets. The results show great variations in growth between the different groups, indicating that there is essential difference in the biological growth potential in offspring from different females.

A COMPARISON OF TWO VITAMIN C POLYPHOSPHATE PRODUCTS IN SALMON.

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Two commercially available vitamin C polyphosphates were evaluated in terms of growth, bio-availability and stability.

Ten replicate groups of 200 Atlantic salmon were fed diets with either no vitamin C or 100 ppm vitamin C from stay-C liquid, TROVI-C liquid or TROVI-CD dry for three months.

No significant differences in growth, feed conversion, survival were observed among diets.

Fish fed the vitamin C deficient diet had significantly lower vitamin C liver levels than the other groups. No gross deficiency signs were observed in any of the groups. All vitamin C products were equally bio-available to the fish and equally stable during extrusion and storage.

It was concluded that both commercial products in either dry or liquid form were good vitamin C sources for salmon and extruded feed.

THE EFFECT OF DIFFERENT DIETARY LEVELS OF VITAMIN C ON THE IMMUNE RESPONSE OF ATLANTIC SALMON (*Salmo salar* L.).

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Groups of Atlantic salmon, *Salmo salar*, parr were fed one of the following diets for 20 weeks : 50mg vitamin C/kg diet (Diet C1); 300mg vitamin C/kg diet (Diet C2); 3g vitamin C/kg diet (Diet C3); 7.2mg vitamin E/kg diet (Diet E1); 87mg vitamin E/kg diet (Diet E2); 800mg vitamin E/kg diet (Diet E3). Vitamin levels in the liver were taken as an indication of the vitamin status of the fish. Liver vitamin C levels in salmon fed Diet C1 were significantly lower ($P<0.01$) than those from fish fed Diets E2 or E3.

There were no significant differences in salmon plasma protein, glucose, total cholesterol or antiprotease levels in fish from any of the six diets. However, serum complement levels were affected. Fish fed diet C2 had significantly higher ($P<0.001$) or lower ($P>0.05$) activity than fish fed either diet C1 or C3 respectively. Similarly, salmon fed Diet E3 had a significantly higher serum complement activity than those fed Diet E1 ($P<0.05$).

Analysis of cellular immune parameters revealed no effect upon differential leucocyte counts from whole blood between groups C1, C2 and C3 or E1, E2 and E3. Phagocytosis and respiratory burst activity of salmon kidney leucocytes also showed no significant differences between fish fed Diets C1, C2 or C3. Specific antibody production, following immunisation, and lymphokine secretion were likewise unaffected. Fish fed Diet C1 did have a significantly higher mortality rate ($P<0.001$) compared with other vitamin C dietary groups when challenged with a pathogenic strain of *Aeromonas salmonicida*. Increased susceptibility to the bacteria was also apparent in fish fed Diet E1.

EFFECT OF STRESS ON THE SYMPTOMS OF ASCORBIC ACID DEFICIENCY IN TURBOT (*Scophthalmus maximus*).

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In turbot ascorbic acid (AA) deficiency does not induce any sign of scurvy but a hypertyrosinemia followed by deposition of tyrosin cristals into tissues and, in some individuals, death. In our experimental conditions the induction of these symptoms was very slow (128 d. before appearance of hypertyrosinemia in AA deprived lots). Since AA is considered as an antistress vitamin, lots of fish arising from 2 weight classes and previously fed on diets either AA supplemented or AA deficient for 170 d. were each subdivided into 2 groups : one normally reared and one submitted every other day to the following stress : emptying the tank during 2 mn. The experiment lasted 50 d. Stressed fish had a slower growth both in deficient and non deficient lots but the difference was significant ($p<0.05$) only in bigger animals and no interaction was observed. Deficient lots exhibited the following symptoms : slower growth, very low AA contents in liver and plasma, hypertyrosinemia in some fish and mortality. None of these symptoms was significantly aggravated in case of stress (no significant interaction). No difference in the percentage of collagen was found among the different lots. Therefore there is no evidence that stress reduces the amount of AA reserves and no evidence that AA alleviates the effects of the stress applied.

INCIDENCE CHEZ LE BAR *Dicentrarchus labrax* D'ALIMENTS CONTENANT DES LIPIDES OXYDES ET CARENCES OU NON EN VITAMINE E.

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Des bars pesant initialement 35g sont répartis en 12 bassins selon un plan expérimental factoriel (2x3). Ils reçoivent pendant 29 semaines des aliments différant par la qualité de leurs lipides (oxydés ou non) et par leur teneur en vitamine E, proche des taux de supplémentation (300, 50 ou 0 mg/kg). En fin d'expérience, des poissons sont prélevés dans chaque bassin : 1) pour analyses chimiques (eau, cendres et lipides musculaires, vitamine C hépatique, vitamine E hépatique et musculaire et taux musculaire de substances réagissant à l'acide thiobarbiturique (SRATB), 2) pour évaluation d'activités enzymatiques (ASAT, ALAT et CK plasmatiques, catalase hépatique), 3) pour observations histologiques (tissu nerveux, foie, pancréas, coeur et muscle squelettique).

La présence de lipides oxydés dans l'aliment, même en cas de carence en vitamine C n'a pas d'incidence sur la croissance, la mortalité et le comportement des poissons.

Les seules lésions significatives observées concernent le muscle squelettique. Des dégénérescences hyalines et (ou) granuleuses des fibres "blanches" apparaissent essentiellement chez les poissons recevant l'aliment oxydé et carencé ou faiblement supplémenté (50 mg/kg) en vitamine E.

La carence alimentaire en vitamine E entraîne à elle seule une forte diminution du taux de vitamine C hépatique et musculaire, mais n'a aucune incidence sur la teneur en vitamine C hépatique et l'activité de la catalase hépatique. Les taux d'humidité et des SRATB musculaires et l'activité des enzymes plasmatiques ASAT et CK augmentent modérément.

L'incorporation d'huile oxydée dans l'aliment accentue ces effets. Les teneurs en vitamine E hépatique et musculaire sont fortement diminuées, mais la teneur en vitamine C hépatique reste cependant non modifiée. Une forte augmentation du taux de SRATB et de l'activité des enzymes plasmatiques (ASAT et CK) est observée, essentiellement quand le régime est carencé en vitamine E (supplémentation 0 mg/kg), et à un degré moindre quand l'ajout de vitamine C dans l'aliment est de 50 mg/kg. Un apport de 300 mg/kg de vitamine E limite significativement la teneur en SRATB musculaire qui reste toutefois supérieure à la valeur observée chez les

poissons nourris avec l'aliment carencé en vitamine E mais ne contenant pas de lipides oxydés. La présence de lipides peroxydés dans les régimes augmente l'activité de la catalase hépatique quelle que soit la teneur en vitamine E.

TISSUE VITAMIN E CONCENTRATIONS IN FARMED ATLANTIC SALMON (*Salmo salar* L.).

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Vitamin E concentrations in the liver and plasma of farmed Atlantic salmon were measured by high-performance liquid chromatography. In healthy fish, fed commercially produced diets containing about 20mg supplementary all-rac-Ó-tocopheryl acetate 100 g^{-1}, tissue Ó-tocopherol concentrations showed a general rise. Over a 20 month period, beginning four months prior to seawater transfer, mean Ó-tocopherol concentrations ranged from 51 to 754 µg g^{-1} in liver and from 7 to 68 µg ml^{-1} in plasma. Sharp increases in the Ó-tocopherol content of these tissues coincided with a rise in the proportion of lipid as polyunsaturated fatty acid in response to transfer to seawater.

Relationships between husbandry practices, tissue Ó-tocopherol concentrations and signs of vitamin E deficiency were examined experimentally. Handling and crowding for short periods had no observable effect on plasma Ó-tocopherol concentrations, chronic crowding produced no statistically significant change in plasma and liver vitamin E, and long-term crowding had no effect on haematocrit or muscle histology in salmon fed practical diets with no supplementary source of Ó-tocopherol. Starvation caused a significant depletion of Ó-tocopherol in the tissues of post-smolt salmon in experimental tanks within 3 weeks, but had no effect on tissue vitamin E concentrations in one sea-winter salmon held in sea-cages over a four week period. These results are discussed in relation to the development of signs suggestive of vitamin E deficiency in farmed Atlantic Salmon.

DIGESTIVE ENZYME LEVELS IN FARMED ATLANTIC SALMON (*Salmo salar*) : EFFECTS ON NUTRITIONAL STATE, PANCREAS DISEASE AND ENZYME INHIBITORS.

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The digestive enzymes trypsin and chymotrypsin were assayed in pyloric caecae of farmed Atlantic salmon. The fish studied were classified histologically and treated as follows : a, healthy fed, b, healthy starved, and c, pancreas diseased. Fed healthy fish displayed a range of enzyme levels distributed normally around a mean of 0.135 μmole substrate/gramme/min. Fish which had been starved for 12 days displayed generally higher levels of trypsin and chymotrypsin. Refeeding after a fast resulted in a decline in trypsin activity in the caecal which it took 48 to recover from. Pancreas diseased fish showed a total absence of trypsin and chymotrypsin activities. Some fish were of normal histology but lacked enzyme activity and the caecal extracts of these fish displayed inhibition of other trypsin extracts.

An assay of trypsin/chymotrypsin inhibitors present in fish diets was based on a standardised enzyme extract from salmon caecae. When this was treated with extracts of diets a measure of their levels of inhibitors was obtained. A survey of commercial diets revealed a wide range of inhibitor levels.

An *in vivo* method of assessing pancreatic function based on that of Dabrowski *et al.*, 1989, was used on Atlantic salmon, feeding them a chymotrypsin-specific substrate and measuring the appearance of a breakdown product in the water. The percentage recovery of product at 24h after feeding was significantly lower in pancreas diseased fish than in healthy animals and this may prove to be a useful *in vivo* diagnostic method.

EFFECT OF FREQUENCY OF FEEDING OF DIETS WITH DIFFERENT PROTEIN CONTENT ON THE FRACTIONAL RATE OF PROTEIN SYNTHESIS AND DEGRADATION IN LIVER AND MUSCLE OF RAINBOW TROUT (*Onchorynchus mykiss*).

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The effects of feeding frequency (two or four times/day) of an amino acids based diet (ABD) on the fractional rates of protein synthesis and degradation in liver and white muscle of rainbow trout were investigated. Protein turnover is a cyclical process with synthesis of protein being opposed by its concomittant degradation. Because of this, rates of protein synthesis and degradation are considerably greater than the net flux through the protein turnover. Amino acids derived from intracellular protein degradation are reutilized for protein synthesis probably at a much greater proportion than the rate of dietary influx of amino acids. Rainbow trout, obtained from a local fish farm, with an initial body weight of 55±3 g, were maintained in 350l fiber-glass tanks, with a continuous aeration and fresh water supply (1.5 l/min and 15±0.5°C). After two weeks of adaptation to the laboratory conditions and fed with a standard commercial diet, the trouts were divided into four groups and fed with the experimental diets (diet ABD : 30% fish meal protein + 15% free amino acids; control diet : 45% fish meal protein) at a rate of twice or four times daily during 62 days before measuring the fractional rates of protein synthesis (Ks) and degradation (Kd) in liver and muscle. Our results showed that in both liver and white muscle the fractional rate of protein synthesis increased when fishes were fed four times with respect to the animals fed twice. However, when the effects of diets are compared the results are different. The Ks was greater in the liver of animals fed with the diet containing 30% protein + 15% free amino acids while the Ks of muscle was smaller.

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SIZE AND MEAL TIMING : EFFECT ON BODY COMPOSITION IN RAINBOW TROUT.

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Within the limits of a study on the improvement of rainbow trout performances, three experiments have been drawn to test the effects of size and meal timing on body composition. The 1st experiment was performed in 8 hatchery tanks (2x0.4m), in which we stocked 1,000 troutlings/tank (0.8g individual weight); fish of the first 4 tanks received the meal at 9:00 a.m., the others at 4:00 p.m. The 2nd experiment was drawn according to the same scheme, but in $2m^2$ tanks and with 70g trouts. The 3rd experiment consisted in rearing 12 lots of rainbow trouts (100g of initial weight) in larger tanks ($3m^2$). Trouts of tanks n°1-4 received their meal at 9:00 a.m., trouts of tanks 5-8 at 4:00 p.m. and the last four ones at 9:00 p.m. The samples were analyzed according to A.O.A.C. methods. The results showed that troutling responses seem to be different from the adults; in fact total lipid (percentages on wet weight) in troutlings fed at 4:00 p.m. were similar to those of troutlings fed at 9:00 a.m. (3.78±0.25 and 3.96±0.14 respectively). On the contrary the adults specimen fed at 4:00 p.m. had more lipids than those fed at 9:00 a.m. (2.04±0.79 and 0.91±0.19 respectively). As for the FA composition troutlings fed at 4:00 p.m. seem to have more PUFA than those fed at 9:00 a.m. This difference might be due mainly to C20:5n3 and C22:6n3 (4.32 and 12.7 at 4:00 p.m. and 2.22 and 5.3 at 9:00 a.m.). These differences become evident in the adult trouts at least as regard to C22:6n3 FA. In particular trouts fed at 9:00 p.m. had an amount of 22:6n3 (12.12±0.82) less than the other two lots of trouts fed at 9:00 a.m. (13.54±1.00) and at 4:00 p.m. (13.85±1.45). However differences become significant if we calculate the percentages of total lipids instead of total FA; in fact trouts fed at 9:00 a.m. had less than 1% total lipid, whereas trouts fed at 4:00 p.m. had more than 2%.

MEAL TIMING AND FEEDING LEVEL : EFFECT ON PERFORMANCES IN RAINBOW TROUT.

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The effect of different meal timings and feeding levels on productive traits in rainbow trout was evaluated in 2 trials. In the first trial 800 fish were fed with commercial diet from a 200g to about 300g liveweight for 63 days (september-november) at 9 a.m. or 4 p.m. utilizing 2 feeding levels (1.4 or 1.8% of total fish weight). Fish growth and FCR (feed conversion rate) showed better values with p.m. meals (P¾.05).

Better PER (Protein efficiency rate) and dressing percentage were related to higher feeding level, while FCR was less favourable (P¾.05). Higher content of dry matter, ash and ether extract (P¾.05) was found in the meat of fish fed at 4 p.m. while no difference appeared for crude protein. Feeding level influenced ether extract (P¾.05). In the second trial 2100 fish (3 treatments, 4 replicates) were fed with the same diet utilized in trial one from a 175g to about 250g liveweight for 84 days (may-july) at 10 a.m., 4 p.m. or 10 p.m. at 1.2% feeding level. No significant differences in performances were found in relationship to different meal timings; however slightly favourable productive traits (weight gain, PER, FCR) were found in fish fed at 4 p.m., compared to morning or night meal timings. Fish fed at 10 p.m. showed a higher ash content (P¾.05), while no significant differences could be found in dry matter, crude protein and ether extract.

THE EFFECT OF HIGH TEMPERATURE AND DIETARY PROTEIN LEVEL ON THE METABOLIC UTILIZATION OF DIETS BY RAINBOW TROUT.

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The metabolic utilization by rainbow trout of two diets with high protein (45%, diet 1) and low protein (30%, diet 2) content at two water temperatures (21.5 and 15.7°C) was compared.

Protein and energy digestibilities were not affected by diet composition, but digestibility coefficients significantly ($P<0.05$) improved at the higher temperature.

Post-prandial oxigen consumption was identical in the trout fed the two diets and was also identical at the two water temperatures. Heat increment of feeding (% EI) did not differ between the two diets but was significantly higher ($P<0.05$) at 21.5°C.

Ammonia nitrogen excretion was significantly higher in trout fed diet 1 than in those fed diet 2, both in absolute values and as a percentage of nitrogen intake, but was not affected by temperature.

Nitrogen and energy balances showed that diet utilization was more efficient at the higher temperature, essentially due to the digestibility improvement at that temperature. At both temperatures, nitrogen available for retention was higher in the trout fed diet 2 than in trout fed diet 1. Energy available for retention was also higher in trout fed diet 2 at 15.7°C, but differences in diet energy utilization were not very important at 21.5°C.

VARIATIONS QUANTITATIVES DES PROTEINES, LIPIDES ET CENDRES SOMATIQUES CHEZ LE GARDON CAPTURE, A DIFFERENTES SAISONS, DANS UNE RETENUE MESOTROPHE.

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La détermination mensuelle de la composition somatique (matière sèche, lipides, protéines brutes, cendres) a été effectuée au cours de trois années chez le gardon capturé dans une retenue (lac de Pareloup, Aveyron).

L'analyse des résultats révèle qu'il y a :

- après la ponte (avril), une forte augmentation des lipides;
- durant la période estivale, une diminution de ces composés, associée à un ralentissement de la croissance;
- en automne (novembre), une importante accrétion protéique.

La relation entre l'état physiologique du gardon et les variations des principaux facteurs abiotiques (température, oxygène, pH) et biotiques (production primaire) est discutée.

TENEUR EN ACIDES AMINES DU SOMA, A DIFFERENTES SAISONS, CHEZ DEUX ESPECES SAUVAGES : LA PERCHE (*Perca fluviatilis*) ET LE GARDON (*Rutilus rutilus*).

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Les teneurs en acides aminés du soma ont été déterminées chez la perche et le gardon capturés au printemps, en été et en automne, dans une retenue (lac de Pareloup, Aveyron). Les résultats obtenus montrent que, chez les deux espèces :

- lorsque les valeurs sont rapportées à la matière sèche, la teneur globale en acides aminés essentiels (AAE) augmente d'avril à novembre, mais la concentration d'arginine est la plus forte en été; le taux de la majorité des acides aminés non essentiels (AANE) est le plus élevé en novembre et le plus bas en août-septembre alors que les concentrations de proline et de tyrosine sont les plus importantes ces derniers mois.

- lorsque les résultats sont exprimés en g/16g d'azote, en été, la concentration globale des AAE est la plus élevée et celle des AANE la plus faible, bien que les plus fortes teneurs en proline et tyrosine soient observées à ce moment-là; cette diminution des AANE est essentiellement provoquée par la baisse du taux de glycocolle.

L'estimation des protéines brutes du soma ne démontrant pas de grandes variations, il semblerait, d'après ces premiers résultats, que la qualité des protéines soit modifiée au cours du cycle biologique.

NEUTRAL AMINO ACID TRANSPORT BY MARINE FISH INTESTINE.

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This work was devoted to the study of the structure affinity relationships in neutral amino acid transport by intestinal brush border of marine fish (*Dicentrarchus labrax or Boops salpa*). The effects of the length of the side chain on glycine, alanine, methionine and amino isobutyric acid kinetics were investigated. Neutral amino acid transport is carried out by separate mechanisms. In the presence of potassium two components were characterized. One is saturable by increased substrate concentrations, whereas the other can be described by simple diffusion mechanism. Simple diffusion is a passive, non saturable, sodium independent route and contributes largely to the transport of methionine and in a much lesser extent to alanine, glycine or aminoisobutyric acid uptakes. If a branched chain is present, as in the case of amino isobutyric acid, diffusion is low. This is a consequence of the lipophilic properties of aliphatic side chains. In marine fish, amino acids can enter brush border membrane via Na independent, saturable systems. In *Dicentrarchus*, this component has been fully characterized for methionine, but not for branched amino acids such as amino isobutyric acid.

In the presence of sodium, saturable components were shown , with low and high affinities. Two distinct sodium dependent pathways have been characterized for glycine uptake, with low and high affinities. For alanine and methionine only one sodium dependent high affinity system exists. The linear carbon side chain and the substitution of the alpha hydrogen by a methyl group (aminoisobutyric acid) affect the Kt of the high affinity system. Mutual inhibition experiments indicates that same carriers could be responsible of glycine, methionine and alanine high affinity Na dependent uptake.

The influence of sodium concentrations (100 mM to 1M) on the uptake of a low amino acid concentration was examined. Glycine, alanine, methionine and amino isobutyric acid transport can be described by an hyperbolic function, with a saturation uptake which is highly increased for methionine. On the other hand, the half saturation concentration does not seem to be strongly affected by the amino acid structure. The effect of sodium on the kinetics of alanine and methionine uptakes have been also examined. Two sodium concentrations were assayed (25 and 100mM) The results confirm the presence of saturable and no saturable transport systems for alanine, methionine and aminoisobutyric acid. The Vmax of the

saturable system clearly shows a typical relationship with sodium concentration, whereas Kt does not appreciably change. A kinetic model has been proposed to explain the effect of the length of the side chain on the uptake of amino acids transport including a possible interaction of this chain with sodium binding site.

INTERMEDIARY METABOLISM RESPONSE OF THE EUROPEAN EEL TO DIETARY PROTEIN TO LIPIDS RATIO.

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The response of liver glutamate dehydrogenase (GDH), fructose bi-phosphatase (FBPase), pyruvate kinase (PK) and glucose-6-phosphate dehydrogenase (G6PDH) to variations of the protein to lipids ratio (P%/L% : 30/12, 30/16, 30/20, 25/20) in diets for the european eel, was investigated. Results showed no change of GDH activity when measured at saturating or subsaturating substrate concentrations except when expressed as U/total tissue showing higher values for the 30/20 diet. FBPase decreased significantly for the diet with a lower protein content (25/20) when activity was expressed as U/Total liver, indicating a lower gluconeogenic activity when amino acids availability decreased. PK activity, as an index of glucose utilization, showed a decrease related with decreasing P/L ratios. The presumed relationship between pentose-phosphate-cycle and lipogenesis was indicated by the changes in G6PDH activities which were positively correlated with P/L ratios, reaching significantly lower values for the higher lipids content diets.

The variations found in the activity of the forementioned enzymes, involved in the main routes of intermediary metabolism, showed the capacity of eel liver to adapt its primary metabolism to changes in diet composition.

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EFFECTS OF LONG-TERM STARVATION ON THE NADPH PRODUCTION SYSTEMS IN SEVERAL DIFFERENT TISSUES OF RAINBOW TROUT (*Oncorhynchus mykiss*).

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The effects of a long-term starvation (8 weeks) on the kinetic behaviour of the most important NADPH production systems, glucose 6-phosphate dehydrogenase (G6PDH), 6-phosphogluconate dehydrogenase (6PGDH), malic enzyme (ME) and citosolic isocitrate dehydrogenase NADP-dependent (IDH-NADP) from several different tissues of rainbow trout (*Onchorynchus mykiss*) have been studied. It is well established that starvation significantly alters the metabolism of most organisms. However the precise nature of the length of time necessary for the changes to develop are highly species and age dependent. Rainbow trout, obtained from a local fish farm were maintained in 350l fiber-glass tanks with a continuous aeration and fresh water supply (1.5 l/min and 15±0.5°C). After two weeks of adaptation, fishes were starved during 8 weeks before measuring enzyme kinetics. Results pointed out interesting adaptive responses of the enzymes from liver and adipose tissue after starvation. In liver the maximum activity (Vmax) of G6PDH, 6PGDH, ME and IDH-NADP decreased significantly during starvation in a 60, 41, 53 and 50% respectively without significant changes in the Michaellis constant (Km). This behaviour was similar with respect to adipose tissue, in which the prolonged starvation produced a decrease in the Vmax of these enzymes (46, 32, 50 and 45% respectively) and also without apparent changes in their Km values. Finally kidney showed a less adaptive response according to its role in lipid metabolism, only the Vmax of IDH-NADP and ME were significantly smaller. The metabolic significance of the molecular changes involved in this nutritional situation could be explained by a decrease in the synthesis of these proteins during starvation.

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COMPARATIVE STUDY OF TWO LIVER ENZYMES INVOLVED IN PEROXISOMAL LIPID METABOLISM IN HALIBUT, SALMON AND TROUT.

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As part of a research project on fatty acid metabolism in fish, we have made a comparative study of two liver enzymes associated with fat catabolism and anabolism, respectively. Dihydroxyacetone phosphate acyltransferase (DHAPAT) is a key enzyme in the synthesis of ether lipids, which are important membrane components. This enzyme is relatively well characterized in mammals, but has not been extensively studied in fish. We have demonstrated activity of this enzyme in liver of salmon, trout and halibut, mainly localized to peroxisomes.

Fatty acid oxidase (FAO) is an important enzyme in the peroxisomal ß-oxidation of fatty acids. High activities were observed in liver of all three species studied.

Our preliminary results indicate species related differences in activities of both DHAPAT and FAO.

EFFECTS OF DIFFERENT DIETARY TREATMENTS, STARVATION AND EXERCISE ON FAT CONTENT IN ATLANTIC SALMON (*Salmo salar*).

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Better understanding of methods and physiological frames for altering slaughter quality is of fundamental importance in order to fulfill marked demands. The aim of this study was to determine the efficiency of different farming methods (dietary treatment, starvation and exercise), in the last period before slaughtering, in influencing the fat content of Atlantic salmon. Diets for salmon (mean initial body weight of 2kg) were changed either 5 or 3 months before slaughtering. Three diets were used; control, medium and low fat, with 22%, 18% and 13% fat respectively. The fat content of the fish was markedly influenced by the diet, leaner diets giving reduced fat in the fillet and a reduced intestinal fat index.

The effect of starvation on fat in fillet and distribution of fat between different depots was examined by prolonging the usual starvation period before slaughtering by 3-4 weeks. Results are under processing.

Salmon, with an initial weight of 1 kg, was exercised in circular tanks with a water flow rate of either 8 or 30cm per second for 5 months before slaughtering. The effects of different flow rates on fat content was in this experiment minimal.

IN VITRO AND *IN VIVO* DESATURATION AND ELONGATION OF LINOLEIC AND LINOLENIC ACID BY THE EUROPEAN EEL *Anguilla anguilla* L..

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We investigated the essential fatty acid requirements of the European eel *Anguilla anguilla L.* using *in vivo* and *in vitro* techniques to determine the desaturation and the elongation of dietary and incubated linoleic 18:2 (n-6) and linolenic 18:3 (n-3) acids.

The *in vivo* experiment was conducted during a 4 month feeding period using diets containing 0.5 or 1% of both linoleic and linolenic acid combined with 0, 1 or 2 percent resp. of the polynsaturated fatty acids 20:5 (n-3) and 22:6 (n-3). Growth rate, mortality, fat content and subsequently fatty acid composition of the muscle tissue are examined.

For the *in vitro* methodology, we verified the bioconversion of linoleic and/or linolenic acid during 8 days incubation of eel hepatocytes in maintenance culture.

Analysis of the fatty acid composition after resp. 1, 4 and 8 days of these primary cultured hepatocytes compared with the data from the *in vivo* experiment will be discussed.

FLESH COLOR ASSESSMENTS OF SALMONIDS.

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A tristimulus colorimeter (Minolta Chroma Meter) was used to measure the color appearance of fillets of Atlantic salmon (*Salmo salar*) and Rainbow trout (*Onchorhynchus mykiss*) instrumentally. The color was also determined using a color card for salmonids. The concentration of carotenoid was determined by chemical methods. The pigmentation of the fillets varied from yellowish-white to deep red.

The lightness/darkness factor (L*), the red/green chromaticity (a*), and the yellow/blue chromaticity (b*) of the Minolta measurements were correlated to the chemical measured carotenoid concentration. The quantitative hue (Hoab), the quantitative saturation (C*ab) and the color difference were calculated from the L*, a*, and b* values and correlated to the carotenoid concentration. The color card scores were also correlated to the carotenoid concentration.

No linear relationship were found between L*, a*, b*, Hoab, C*ab, color difference and the carotenoid concentration. Multiple regression analyses did show a good non-linear correlation for the a*, b* and C*ab value. The color card scores showed good correlation with carotenoid concentration.

EFFECTS OF POLYUNSATURATED FATTY ACIDS AND VITAMIN E ON FLESH PIGMENTATION IN ATLANTIC SALMON (*Salmo salar*).

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Fish were fed six diets with three different levels of polyunsaturated fatty acids and two levels of vitamin E. The two low PUFA diets were based on soybean oil, the medium diets were based on capelin oil and the high PUFA diets were based on sardin oil. All diets were supplemented with 50ppm astaxanthin.

The concentration of astaxanthin in the flesh of the fish were determined by chemical analyses. The interaction between the dietary PUFA, vitamin E and astaxanthin were studied.

ASTAXANTHIN AND CANTHAXANTHIN AS PIGMENT SOURCES FOR SALMONIDS ?

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Astaxanthin and canthaxanthin were compared as pigment sources for rainbow trout in a Latin square designed experiment where the dietary concentrations of the two carotenoids ranged from 0 mg/Kg to 40 mg/Kg. Each group contained 50 individually tagged rainbow trout of approximate 200 g.

The astaxanthin and canthaxanthin in the flesh increased linearly as response to increasing dietary concentration. The slope were 0.0928 and 0.0559 for astaxanthin and canthaxanthin respectively. This indicate a 1.7 times better deposition of astaxanthin as compared to canthaxanthin. No synergistic effects, due to combinations of astaxanthin and canthaxanthin in the diets, were observed.

TISSUE DISTRIBUTION OF ^{14}C-ASTAXANTHIN IN THE ATLANTIC SALMON (*Salmo salar*) DETERMINED BY AUTORADIOGRAPHY.

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Atlantic salmon (*Salmo salar*) were fed a diet containing ^{14}C-labelled astaxanthin for five subsequent days. Seven days after the last feeding 2 fish were sampled and submitted to whole-body autoradiography.

A high degree of radioactivity was present in the dorsal cutis, the bile, the intestinal muscosa, the caudal kidney and the developing eggs. An intermediate degree of radiolabelling was found in the muscle and the cranial kidney, while only traces of radioactivity were recorded in the blood, the spleen and the gills.

Contrary to the prevailing consensus, the level of astaxanthin and/or metabolites was higher in the myocommata than in the myotome. Furthermore, the substantial radiolabelling in the dorsal cutis strongly suggests that astaxanthin and/or its metabolites show affinity for melanin. Finally, the results give evidence for urinary and biliary excretion of astaxanthin derived metabolites and enterohepatic circulation is likely to take place.

INTERACTION BETWEEN ASTAXANTHIN AND VITAMIN A IN ATLANTIC SALMON.

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Atlantic salmon (*Salmo salar*) with a mean initial weight of 0.8 kg, were fed four diets during 8 weeks in 7°C saltwater. The diets contained 5900 or 11000 I.U. of vitamin A, with and without a supplement of 50 mg astaxanthin/kg.

The carotenoid content in flesh of salmon fed the astaxanthin supplemented diets was 2.1-2.4 mg/kg. Vitamin A supplementation to the feed did not affect dietary carotenoid concentration in the flesh. The concentration of vitamin A_1 in the liver was 18-22 mg/kg, while the concentration of vitamin A_2 was 250-280 mg/kg. Astaxanthin supplementation to the diet resulted in increased levels of vitamin A_1 in the liver, but did not affect the concentration of vitamin A_2.

ABSORPTION AND BLOOD CLEARANCE OF CAROTENOIDS IN MATURE FEMALE RAINBOW TROUT (*Oncorhynchus mykiss*).

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Using one force fed meal, eight mature female rainbow trout received 14C-astaxanthin (Ax) with 3H-canthaxanthin (Cx; n=3) or with 3H-Zeaxanthin (Zx; n=5) 200 µl of blood were collected via caudal punction every 24 hours during four days. After 96 hours, the fish were killed and pyloric caeca (P.C.) duodenal intestine (D.I.), ileal intestine (I.I.) and posterior intestine (P.I.) were removed. Ax concentration was found in the blood significantly higher ($P<0.05$) than Cx and Zx. Significantly higher ($P<0.05$) concentrations of AX than CX or ZX were found in P.C. , I.I. and P.I. No significative difference in blood rate clearance was found for all three compounds. In all gut sections, 14C-phoenicoxanthin was detected as a reduced metabolite of Ax.

TRANSPORT OF CANTHAXANTHIN IN SERUM OF RAINBOW TROUT (*Oncorhynchus mykiss* Walbaum).

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Rainbow trout serum was separated into seven lipoprotein fractions by ultracentrifugal method. Canthaxanthin was found to be associated with low density lipoprotein, LDL, (28.32%), high density lipoprotein, HDL, (61.04%) and very high density lipoprotein, VHDL, (10.60%). A small bathochrome shift (c.a; = 20nm) is noted for the absorption maximum of canthaxanthin binding by lipoproteins compared to that of extracted from lipoproteins. It can be seen also a shift of the absorption maximum of canthaxanthin binding by lipoprotein from 471.2nm to 484nm according to the density of the lipoprotein.

OPTIMUM FEEDING RATE FOR STRIPED BASS FINGERLINGS AT 20°C.

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A twelve week experiment was conducted to determine the optimum feeding rate for striped bass (*Morone saxatilis*) fingerlings. The fish were kept at 20° C and fed from 0.5 to 4.0% of their body weight per day of a dry commercial salmonid feed. Feed was dispensed continuously 24 hours per day with automatic feeders and each feeding rate was administered to triplicate groups of fish with 15 fish per group. Growth rate, feed efficiency, hepatosomatic index, liver glycogen, plasma protein, whole body moisture and lipid, and liver glucose-6-phosphate dehydrogenase (EC 1.1.1.49), 6-phospho-gluconate dehydrogenase (EC 1.1.1.44), malic enzyme (EC 1.1.1.40) and isocitrate dehydrogenase (1.1.1.42) activities were significantly ($P<0.05$) affected by the feeding rates. No significant differences were observed in the mortality rate, carcass compositions, whole body protein and ash contents, and plasma triacylglycerol, glucose, and non-esterified fatty acid levels of fish fed the different rates. Based on the maximum growth and feed efficiency, the optimum feeding rate for striped bass fingerlings with an average initial body weight of 38 g of at 20°C was between 1.0 to 1.5% BW/day.

DIURNAL FEEDING RHYTHMS IN ATLANTIC SALMON PARR.

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Atlantic salmon parr (*Salmo salar* L.) were held under both ambient and constant light conditions, and were offered a commercial salmon diet labelled with X-ray-opaque particles every 15 minutes day and night for several days. The quantity of food in the gut, was estimated by X-raying samples of fish at approximately 4h intervals. Variations in the quantity of food in the gut was considered to reflect variations in feeding activity. The experiment was conducted in July and in February, with experiments under ambient and constant light treatments conducted simultaneously on both occasions.

In July, the quantity of food in the gut exhibited a pronounced diurnal fluctuation, varying between 1.9-4.3% and 1.6-3.3% of dry body weight (% DBW) under ambient and constant light respectively. Under ambient light, the cycle of gut fullness is significantly correlated with the light cycle but not with the diurnal temperature cycle. Food consumption increases during periods of the day when light levels increase and vice versa, regardless of absolute light levels. Maximum gut fullness occurred in the early evening (1700 h BST) while minimum gut contents were observed at 0500h. Under conditions of constant light, the cycle of gut fullness becomes significantly correlated with the temperature cycle with maximum and minimum gut contents occurring at 2100h and 0900h BST respectively. In winter, the body burden of food is much less than in summer and little diurnal variation in gut contents was observed. under ambient and constant light conditions respectively, gut contents fluctuated between 0.3-0.9% DBW, and this appears to be independent of diurnal fluctuations in either light or temperature.

SELF-SELECTION OF A DIET COVERING ZINC NEEDS IN THE TROUT.

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The capacity of discrimination between diets with normal and deficient levels of zinc was investigated in rainbow trouts with a previous different zinc status. An automatic self-feeding system controlled by computer and designed by the authors was employed. Temperature and light controls were also mediated by computer being the experimental conditions : 15±0.5°C and 12h/12h day/night photoperiod. Trouts of about 65g body weight were individually placed in 50l tanks with a water supply of 1 l/min. Diets were only different in the zinc content : 41.0 and 5.5 ppm of Zn^{++}. After 35 days under the dietary regimes animals were weighed and two trigers were placed on the tank water surface for diet preference studies. Deficient animals, fed on Zn^{++} deficient diet, and with a significant body weight loss, took option for the control diet ($+Zn^{++}$) in less than 8 days. The same behaviour was showed by the animals previously fed on zinc sufficient ($+Zn^{++}$) diet. Furthermore, when triger position was crossed a sudden option change occurred which indicated a net and clear preference for diet covering zinc needs showing the presence in trout of a specific appetite for this element.

EFFECTS OF FEEDING STRATEGIES ON THE UTILIZATION OF DIFFERENT CARBOHYDRATES BY RAINBOW TROUT FINGERLINGS.

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A 16 week growth experiment was conducted to study the effects of continuous and four meals per day feeding on the utilization of glucose, maltose, dextrin, and raw corn starch by rainbow trout (*Oncorhynchus mykiss*) fingerlings with an average initial body weight of 5.5g. The carbohydrates were included at 32% in the diets and the fish were fed 2.0% of their body weight per day. Significantly ($P<0.05$) higher growth, feed efficiency, protein deposited (PD), body moisture and lipid, plasma glucose and protein, hepato-somatic index (HSI), and liver glycogen and enzyme activities of glucose-6-phosphate dehydrogenase (G6PDH), 6-phosphogluconate dehydrogenase (6PGDH), malic enzyme, and isocitrate dehydrogenase (ICDH) were observed in continuously fed than meal fed fish. Growth, PD, body moisture and lipid contents, viscerosomatic index, plasma glucose, HSI, and liver glycogen, G6PDH, 6PGDH, and ICDH were also significantly affected by the carbohydrate sources. Interactions between feeding strategies and carbohydrate sources were significant in growth, PD, and plasma glucose. Ability of rainbow trout fingerlings to utilize the four carbohydrates, based on growth, was maltose > glucose > dextrin = starch in continuous feeding and maltose = glucose = dextrin > starch in meal feeding.

EFFECT OF FEEDING STIMULANTS ON FEED CHOICE OF RAINBOW TROUT.

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The feed choice of rainbow trout was studied with commercial-type extruded dry pellets, using eight different combinations of betaine, amino acids, hydrolyzed protein of shrimp or fish origin and lecithine as feeding stimulants. The choice of each of the stimulant feeds was compared to that of the control feed in circular tanks with two feeders supplying at excess rate equal amounts of the control and stimulant feed. The pellets were floating, enabling a complete collection of the remaining feed after feeding at water outlet. The stimulant feeds contained a small content of lead glass microballs, and the proportions of the control and stimulant feed could be identified by X-raying the remaining feeds. Further, the uptake of both feeds and the relative choice between them were calculated. Each trial consisted of 2-4 weeks acclimatization period and two weeks measuring period.

In addition to the choice of the different feeds, tank effect, feeder effect, effect of the time of the day and effect of acclimatization to feeds on feed choice were evaluated. The tank effect was mostly insignificant, whereas the feeder effect was apparent in several trials. Thus the feeds in the feeders were changed in the middle of the trial. Feed uptake was highest in the morning and so was also the differnce in the choice of the preferred and despised feed.

Acclimatization generally pronounced the preference of feed. Due to the large number of measuremments (four per day) and moderate variation in feed choice, relatively small preferences (ca 5%) in feed choice resulted to significant differences.

From the studied stimulants, betaine in combination with amino acids of plant origin or in combination with lecithine plus hydrolyzed fish or shrimp meal was significantly preferred, whereas non-hydrolyzed shrimp meal or hydrolyzed fish meal with lecithine did not produce any preference. The results indicate the importance of small-molecule, highly soluble compounds like betaine and amino acids, for the attractivity of feed pellets. However, the total feed uptake was not increased in the groups with high preference to stimulant feed. This may be related to the experimental system,

which limited the availability of highly preferred feeds.

INCORPORATION DE QUELQUES PROBIOTIQUES DANS L'ALIMENTATION DU JUVENILE DE BAR (*Dicentrarchus labrax*).

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Afin d'apprécier l'intérêt éventuel d'une incorporation de probiotiques dans l'alimentation du juvénile de bar, trois aliments contenant respectivement :

- du Proligerm : bactéries lactiques vivantes sélectionnées, sur support nutritif -méthode Acosil - DELPORTE.
- du Paciflor : spores revivifiables de Bacillus IP5832 - PRODETA.
- du Fermacton : bactéries lactiques sur support Fermacto 500 - BIO BRETAGNE.

aux doses recommandées par les fabricants, sont distribués, à la demande, pendant 8 semaines à des lots homogènes de bars de 30 g et comparés à des témoins sans probiotiques (3 replicats par aliment). Tous les aliments contiennent 50% de protéine et 12% de lipide (% matière brute).

La prise de nourriture est équivalente pour tous les lots. Les croissances observées (T.C.S.) bien qu'apparemment supérieures (5%) pour les lots contenant du Proligerm ou du Fermacton, ne sont pas significativement différentes ($p>0,05$) des lots témoins. Les taux de conversion alimentaires (T.C) sont très voisins. Les régimes n'induisent pas de modification de la composition corporelle finale. L'utilisation des protéines des aliments (C.U.P.) renfermant des probiotiques n'est pas significativement différente de celle du témoin.

Le fait de n'avoir pas pu démontrer de façon significative, au seuil considéré, une action bénéfique de ces substances sur la croissance du bar, ne permet pas d'écarter définitivement l'intérêt potentiel qu'elles représentent dans les élevages de poisson pour lesquels les données sont extrêmement rares. Un effort de recherche est nécessaire ; il devra cependant être abordé en priorité sur les tout jeunes stades, en particulier lors du sevrage car c'est là que les potentialités des probiotiques pourront réellement se révéler.

EFFET DE LA VIRGINIAMYCINE ET DE SES CONSTITUANTS SUR LA CROISSANCE, LA COMPOSITION CORPORELLE ET LES TAUX D'HORMONE DE CROISSANCE PLASMATIQUE CHEZ LA TRUITE ARC-EN-CIEL.

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La virginiamycine (VM) est un antibiotique polypeptidique actif sur les bactéries gram+ du tube digestif. Elle est composée de deux facteurs principaux (M et S) qui agissent en synergie et de façon optimale lorsqu'ils sont mélangés dans les proportions 4:1 (M:S). Il a été démontré que l'utilisation de VM en tant qu'additif alimentaire provoquait une augmentation de croissance chez le poulet, le dindon, le veau et le porc. Ahmad et Matty (1989) et Viola *et al.* (1990) ont observé des effets similaires chez la carpe.

Le but de ce travail a été d'étudier l'effet sur la croissance de la VM et de ses deux constituants, le facteur M et le facteur S, chez la truite arc-en-ciel. Sept lots d'une centaine de poissons d'un poids moyen initial de 50g ont reçu les régimes suivants : témoin, VM 10 ppm, VM 40 ppm, M 10 ppm, M 40 ppm, S 10 ppm et S 40 ppm.

Les résultats montrent qu'après 11 semaines d'expérimentation, le gain pondéral (% PMI) est plus élevé (11-13%) chez tous les lots traités par rapport au lot témoin, alors que l'indice de consommation est plus faible chez les poissons ayant reçu un régime additivé. La composition corporelle a peu varié suivant les lots et il n'a pas été observé de variations significatives du taux d'hormone de croissance plasmatique.

APPLICATION OF A SETTLING COLUMN SYSTEM TO STUDIES OF DIGESTIBILITY IN THE EEL.

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Digestibility data of feedstuffs are of prime importance in fish feed formulation as well as for the understanding of the results obtained when feeding fishes on a given diet.

The main problem in digestibility studies with fish is to use a suitable method for collecting feces. Several possibilities have been tested with variable results; one of the most useful is based on settling the tank water before its drainage or recirculation. Thus, the efficiency of a settling method has been tested in order to obtain eel feces and, in the order hand, to study the effects of several protein/carbohydrate ratios in diet on the digestive utilization of protein and whole organic matter by comparing results with those obtained in trout fed with the same diets.

The feces collection apparatus was a slight modification of the "Guelph System" (CYAQ-2) developed by C.Y. CHO.

Four isoenergetic experimental diets (19.5 KJ/g) with different content in fish meal protein and corn starch and 0.5% Cr_2O_3 added as inert indicator, were provided to triplicate lots of eels and rainbow trout during three months. After this period, feces were collected and analyzed.

The method has revealed to be effective in order to obtain representative eels feces. The different ADC obtained show a progressive decrease in the digestive utilization of protein, energy and organic matter, as protein/carbohydrate ratio increases, for both species; although slight differences are observed between them, in the sense of a better digestive diet utilization by the trout except for the highest carbohydrate diet.

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FECAL COLLECTION METHODS FOR DETERMINING PHOSPHORUS DIGESTIBILITY IN RAINBOW TROUT.

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Phosphorus (P) has been recognized as one of the first-limiting nutrients in freshwaters, but it is also an essential macromineral in fish diets. Many diets contain supplemental P to meet the dietary requirement because absorption of P directly from the environment is minimal. Estimates of P digestibility or absorption would allow more precise dietary formulation and potentially reduce total dietary P; thus maximizing digestibility and decreasing effluent P. Reduced effluent P will aid new aquaculturists in many areas where regulatory concerns have been expressed regarding effluents and their affects on aquatic habitats. We have initiated a series of studies designed to quantify P digestibility in rainbow trout. As a first step in this line of research, we compared the Guelph fecal collection system to dissection as a means of collecting adequate fecal samples for analysis of P and chromium. This initial study was conducted as a repeated Latin Square experiment using fish meal, soybean meal and soybean meal plus phytase as sole P sources in otherwise nutritionally-complete diets. Results are being calculated presently and will be presented as an initial step in delineating appropriate methods for determining P digestibility in rainbow trout.

INFLUENCE OF DIFFERENT BINDERS ON DIETARY AVAILABILITY OF NUTRIENTS IN THE TROUT (*Oncorhynchus mykiss*).

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The use of binder agent in fish feeds is a common practice since it provides a higher consistence and improves the stability of the pellet in the water, therefore reducing nutrient losses and water pollution.

There are numerous substances used as binders, even in experimental diets utilized in nutritional research. Nevertheless, the effect of such substances on nutrient utilization by the fish is not well known. Several studies have shown that alginates and guar gum at different rates of incorporation in the diet, tend to alter nutrient digestibility, fish growth and bone Ca/P ratio.

The aim of this work is to know the effect of three binders : sodium alginate, carboxymethil cellulose and carbapol (C-941), added at 2% in diet, on digestibility of different diet components. For this purpose, triplicate lots of rainbow trout (30g of average body weight) were adapted for a week to experimental diets (containing Cr_2O_3 as inert indicator) and tanks; after that, feces were daily collected by a settling method based on "Guelph System" (CYAQ-2) developed by C.Y. CHO.

The ADC protein, fat, energy, organic matter and different essential minerals were calculated, indicating that carboxymethil cellulose is the binder which provides the best results.

This work was supported by Grant MAR89-0412 from CAICYT.

STUDIES ON THE USE OF DIETARY ENERGY BY GILTHEAD SEABREAM (*Sparus aurata* L.) JUVENILES.

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Dietary energy source and type and their effects on feed digestion and utilization in *S. aurata* juveniles were assessed. Non-faecal nitrogen losses were also estimated using comparative carcass analysis.

Increasing dietary fibre levels resulted in decreased digestibility. Carbohydrate digestibility was less than 77% regardless of source. Food conversion, dry matter and protein, was poorest at lower dietary lipid levels (10.8%) and improved with addition of up to 16.3% lipid. Lipid conversion (retention) was not greatly affected by dietary lipid level.

Non-faecal energy losses did not vary with diet. Recovered energy (RE), protein conversion and energy retention efficiency (ERE) all improved with increasing levels of dietary lipid. The studies reported suggest that *S.aurata* juveniles require 35.7 kJ digestible energy per gram of digestible crude protein intake with a diet containing 48% digestible crude protein and 15.8% digestible lipid.

EFFECT OF DIETARY PROTEIN TO LIPID RATIO ON GROWTH AND CHEMICAL COMPOSITION OF CHINOOK SALMON (*Oncorhynchus tshawytscha*) IN SEA WATER.

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This study was conducted on chinook salmon in sea water to (1) determine the optimum amount of dietary protein in relation to non-protein energy for maximizing growth and feed efficiency and, (2) assess the influence of dietary protein to lipid (P/L) ratio on the whole body and edible muscle proximate and lipid composition.

Six extruded dry pelleted diets varying in protein (38 or 46%) and lipid (15, 20 or 25%) content on a moisture-free basis were prepared. All diets had similar essential amino acid profiles and, the estimated amounts of metabolizable energy and digestible carbohydrate varied between 3705-4535 kcal/kg and 6.3-18%, respectively. Duplicate groups of 78 chinook salmon (initial mean weight, 106-113g) were each fed by hand twice daily to satiation one of the six diets for 140 days (March-July) using a randomized complete block design. Each group was held in an outdoor 4000-L fibreglass tank supplied with running, aerated, ambient temperature (7.5-15°C) sea water (salinity, 26-28%).

All groups exhibited slow growth between March and early May. Thereafter, the growth rates (GR) of all groups increased in correspondence with the rise in water temperature and daylength. Diets containing 46% protein supported higher GR and feed efficiencies (FE) than those with 38% protein during the study. FE, protein efficiency ratios (PER), and whole body and muscle lipid percentage were noted to be inversely related to dietary P/L ratio. Whole body and muscle protein percentages, however, showed the opposite relationship. The influence of dietary P/L ratio on the muscle lipid composition is still under investigation.

Under our test conditions, it is concluded that chinook salmon require = 46% protein, and 15-20% lipid in their diet for maximum GR and FE. Dietary lipid above 20% (i.e. 25%) slightly improved PER but led to more carcass and muscle lipid deposition at the expense of protein.

FRESHWATER FISH AS A SOURCE OF W3 POLYUNSATURATED FATTY ACIDS AND THEIR APPLICATION TO HUMAN NUTRITION.

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Since several years two fish species new for ichthyofauna are produced in inland waters of Central Europe. These are silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Aristichthys nobilis*) which are endemic in the big Chinese river systems. They were introduced in various European countries from Soviet Union, where the annual yield comes to more than 100 000 metric tons.

Both species are seston feeders, main food of silver carp is phytoplankton, while bighead carp consumes partly phytoplankton, otherwise detritus and zooplankton. Big specimen of silver carp and bighead carp generally have a high lipid content. Especially rich in fat are the intestines (up to 50% of wet matter) and the ventral muscles (up to 20% of wet matter). Owing to their food the lipid composition is characterized by high levels of w3 polyunsaturated fatty acids (PUFA) like eicosapentaenoic (EPA) and docosahexaenoic acid (DHA). The levels of SPA and DUA in various parts of silver carp and bighead carp amount to 7-12% and 5-12% respectively of the total lipid content.

From several investigations it is known that the rate of eating fish rich in w3 PUFA is inversely proportional to the incidence of coronary heart diseases. Experiments with spontaneous hypertonic rats and a clinical test proved the beneficial effect of silver carp oil with regard to blood pressure drop and decrease of the blood triglyceride level. Therefore these fish species can be recommended as dietetic food for prophylaxis and therapy of cardiovascular diseases.

INFLUENCE OF DIFFERENT CARBOHYDRATES ON DIGESTIBILITY, GROWTH AND CARCASS COMPOSITION OF CARP (*Cyprinus carpio* L.).

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In experiment 1 carp kept in tanks were fed corn (I) or wheat (III) starch, hydratable corn (II) or wheat (IV) starch, potato starch (V), each at 47% of a basal diet, or manioc meal (VI) at 41%. Rations I-IV showed a mean energy digestibility of 9O%, while rations V and VI had only a digestibility of 85 or 87%, resp.. The different types of starch did not distinctly influence growth rate (period of a live weight (LW) from 146g to 519g and feed expenditure. However, the carcasses of carp fed rations I, II or III had significantly higher dry matter and fat contents.

In exp.2 hydratable corn starch (C) or sucrose (S) were fed to carp (period of a LW from 31g to 220g) in increasing amounts from 10 to 50% (steps of 5% each) supplying a basal diet. The feeding quantity of the basal diet was 1.5% of LW, while the diets with carbohydrates increased to 2.25% of LW. Raising additions of C or S to about 30% relative similarly increased growth rate, fat and energy content of the carcasses, and therefore, the daily energy retention was increased from 5.9 to 8.8 kJ per carp, too. Higher amounts of S did not improve the energy retention, while the additions of C from 35 to 45% averagely raised the daily energy retention up to 9.4 kJ per carp.

GROWTH AND BODY COMPOSITION OF TURBOT IN RELATION TO DIFFERENT PROTEIN/FAT RATIOS IN THE DIET.

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Trials were carried out with 5 different feed types where protein/fat ratios ranged from 0.23 to 0.77 on dry weight basis, all feed types were allocated to the fish at two ration levels regarding to the amount of protein.

Growth, feed conversion, as well as biochemical body composition (in fillet, fin borders, viscera, and the rest) were determined.

The results show that higher levels of fat in the diet cause accumulation of fat, especially in the fin borders. Protein energy is more important for growth than fat energy. Protein sparing effect could be obtained only by concurrent accumulation of fat. Farmed turbots have remarkably higher levels of fat than wild fish.

EFFECTS OF DIETARY PROTEIN AND FAT LEVELS IN DRY FEED FOR JUVENILE HALIBUT (*Hippoglossus hippoglossus* L.).

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Halibut fry with a start weight of 35 g were fed experimental diets composed from low temperature fish meal (Norse LT-94(R)), special quality of fish oil (Norsalmoil(R)), dextrinized wheat and vitamins and minerals. Diets no. 1 to 4 contained 38%, 48%, 52% and 58% protein respectively, the protein being replaced by carbohydrates with constant levels of fat (24%). Diets no. 5 and 6 contained 52% and 48% protein and 28% and 32% fat respectively, with 1,5% of carbohydrates.

Live weights after 120 and 294 days of feeding were for diets 1 and 6 respectively 93.0±13.8, 85.0±22.8, 107.0±3.6, 109.0±12.6, 99.0±5.6 and 106.3±4.9 g, and 273.7±22.0, 260.0±49.0, 270.7±20.3, 314.3±10.6, 253.5±13.4 and 260.5±6.3 g. After 294 days of feeding the live weight on the highest protein level (58%) was thus about 15% higher than that on the lowest (38%) protein level.

Differences in fat levels did not affect growth rate.

HIGH ENERGY DIETS : EXCELLENT GROWTH, BUT WHAT ABOUT FISH QUALITY ?

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Atlantic salmon of initial mean weight 873g held in small net pens (5mx5mx5m) in sea water were fed *ad libitum* diets varying in both energy density and energy distribution for 8,5 months. Each diet was distributed in duplicate net pens containing 200 fish each.

Dietary effects on growth, body composition and early maturation were studied.

Total growth in the experiment was not significant due to dietary treatments, but there was a tendency of higher growth rate on the highest dietary energy level. Very fast growth on the highest energy level was observed during springtime March to May.

Frequency of early matured fish was markedly higher on the highest energy level, and can be related to the very fast growth during the springtime.

Significantly lower slaughter percentage, and a tendency towards higher fat content in fish cutlets was shown on diets with high energy content and low protein/energy ratio.

The results indicate that both protein/energy ratio and energy density are important factors for explaining differences in fat deposition.

ALIMENTS EXTRUDES EN ELEVAGE INTENSIF : EFFET DU RAPPORT PROTEINE/ENERGIE SUR LES PERFORMANCES D'ELEVAGE, LA QUALITE DE LA CHAIR ET SUR LES REJETS PISCICOLES.

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Trois aliments commerciaux extrudés A_1, A_2, E de densité énergétique de 22,8; 23,8; 24,8 kJ/g de MS d'aliment, de rapport protéines brutes/énergie brute 21,6; 20,2; 18,2 mg/kJ et de rapport protéines digestibles/énergie digestible de 22,1; 20,4; 19,0 mg/kJ, ont été testés en conditions de pisciculture avec des truites arc-en-ciel. L'essai a débuté à un poids moyen initial de 300g et s'est terminé à un poids moyen final de 8OOg.

Le taux moyen journalier de croissance est très proche de 0,88; 0,84 et 0,87%/jour pour les lots A_1, A_2 et E respectivement.

En prenant pour référence l'aliment A_1, les résultats obtenus avec les aliments A_2 et E sont : diminution régulière de l'indice de consommation; augmentation de la rétention protéique; diminution des pertes énergétiques d'origine protéique; l'utilisation plus importante des lipides à des fins énergétiques.

L'analyse de la composition corporelle met en évidence une réduction des rejets azotés. Quant au phosphore, l'aliment E présente une teneur faible et une meilleure biodisponibilité, assurant ainsi une réduction de moitié du rejet par rapport à l'aliment A1.

La consommation d'oxygène des poissons liée à l'alimentation (SDA), relevée sur quelques jours en conditions de pisciculture n'a pas révélé de différences significatives entre les lots.

Ces résultats confirment l'intérêt des nouveaux aliments aquacoles et montrent l'importance du choix des procédés de fabrication, des matières premières et du respect des équilibres entre les nutriments pour l'amélioration des performances et pour le respect de l'environnement.

PRELIMINARY DATA ON SEMI-SYNTHETIC DIETS FOR CRUCIAN CARP LARVAE.

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Crucian carp larvae were reared for 3 weeks at 24°C. Larvae were fed with one compound diet or six semi-synthetic ones. Survival and growth of larvae fed the compound diet was higher than others. Among the groups fed semi-synthetic diets the best was a diet based on casein and casein hydrolysate and containing phosphatidylcholine. Analogical diet containing strong supplementation of vitamin mixture was not so efficient. Larvae fed diet containing casein as a basic ingredient and those fed diet containing casein and casein hydrolysate supplemented in RNA manifested strong mortality.

THE USE OF PROTIBEL AS A SUBSTITUTE FOR CASEIN IN ARTIFICIAL DIETS FOR LARVAE AND JUVENILES OF THE AFRICAN CATFISH, *Clarias gariepinus*.

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Artificial diets were tested as reference diets directed towards the determination of nutritional requirements. The protein sources used in the different diets were : 1) casein, 2) casein + protibel and 3) protibel. Protibel is a yeast mixture of two *Kluyveromyces* species. Two experiments were performed in order to determine the effect of the replacement of casein by protibel in artificial diets for African catfish larvae and juveniles. From the larval experiment there were indications that partial or complete substitution of casein by protibel had a positive effect on growth and survival of the larvae. Significantly higher mean weights and survival percentage were also obtained with juveniles fed diets where casein was replaced by protibel. Especially in the experiment with the juveniles, the differences were so extreme that it could be assumed that the basic nutritional requirements of African catfish larvae and juveniles were not fulfilled when casein was used as the only protein source in the diet. It was also concluded that protibel could be useful as a food component in experimental diets directed towards the determination of nutritional requirements.

AGE COURSE OF ENERGY ASSIMILATION AND CONVERSION FOR GROWTH IN CARP LARVAE FED DIFFERENT FOOD.

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Carp larvae were fed at 26°C on formulated diets; a zooplankton-fed group served as a control. Food consumption (C), production of larval body (P) and respiratory metabolism (R) were measured and all expressed in energy units (J indiv.$^{-1}$ d^{-1}), P+R being assimilated energy = metabolizable energy (A). Both, assimilation efficiency, K_A=A (C and efficiency of utilization of consumed energy for growth, K_1=P) C, were initially very low : 1.7-3.7% and 0.9-2.2%, respectively, in the diet-consuming larvae on the 2nd day of feeding (4th d posthatch). Both efficiencies increased with age. Formulated diets were less effectively assimilated (lower K_A) and converted into body tissue (lower K_1) than live food. At the age of 22 days the K_A and K_1 values in the zooplankton-fed group approached the high level (59% and 37%, respectively), typical of juvenile well-fed fish.

EFFECT OF VARIOUS LIPID ENRICHMENT IN ROTIFERS ON DEVELOPMENT OF FIRST FEEDING TURBOT.

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The effect of lipid level and (n-3) HUFA level in live feed were tested on growth and development of first feeding turbot (*Scophthalmus maximus*) larvae. The turbot larvae were offered cultivated rotifers (*Brachionus plicatilis*). The qualitative composition of fatty acids was obtained by long term cultivation with either soybean oil (SO) or Super-Selco, an oil rich in long chain (n-3) fatty acids (SS). A high lipid content was obtained by short-term enrichment of SS-rotifers with Super-Selco (ESS). Total lipid content was ±13% in the SO- and SS-rotifers, and ±27% in ESS-rotifers. Content of (n-3) HUFA was ±50% of the fatty acids in SS and ESS, and <5% in SO.

The turbot larvae were kept at 18°C and no water exchange was applied until 6 days posthatching. Two days after hatching, rotifers were added to a concentration of 5000 ind/l. This concentration was kept throughout the experimental period (two weeks after hatching). Growth rates were correlated to the initial lipid content of the rotifers, if no algae were added to the larval tanks. The relatively poor growth in these groups (5-10 %/day) were probably due to an energy shortage during the period of stagnant water, as the nutritional value of the rotifers decreased. With algae (*Tetraselmis* sp.) present in the tanks, larval growth rates ranged between 10-20 %/day, but no significant differences were found between the groups.

Histomorphological studies by electron microscopy revealed a substantial lipid absorption in the gut epithelial cells of ESS larvae. Small lipid-like particles were observed between the cells and in the blood vessels, which implies an intracellular digestion and a further distribution of lipids via the blood. However, the continuous supply of very high doses of lipids seemed to overload the digestive capacity of the larvae. The very lipid absorption in the gut of ESS larvae also seemed to affect the protein absorption in the hindgut. In larvae fed rotifers cultivated on soybean oil, a similar large lipid absorption was obvious in the gut epithelium. However, no lipid particles were observed between gut epithelial cells or in the blood vessels surrounding the gut, thus indicating that no (or very little) intracellular digestion took place in the larval gut for these lipids.

The conclusion is that both lipid level and lipid composition of the live feed is crucial for the first feeding period of turbot larvae.

COMPARISON OF THREE KINDS OF ROTIFER ENRICHMENTS FOR TURBOT LARVAL CULTURE.

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Three kinds of enrichments for the rotifer *Brachionus plicatilis* (microcapsules, microparticles, lipid emulsion) are compared in turbot (*Scophthalmus maximus* L.) larval culture. The emulsion induces in rotifers a content in n-3 polyunsaturated fatty acids twice as high as other enrichments. However the growth and survival rates obtained with these rotifers seem to be lower than with the other ones, the differences being non significant but observed in two experiments.

The fatty acid profiles of turbot larvae show few differences between treatments and are similar to that of newly hatched larvae. The requirement of turbot larvae in n-3 fatty acids appear to be covered with the different rotifer enrichment techniques. The microcapsules and microparticles providing nutrients other than lipids seem to be more efficient.

NUTRITIONAL VALUE OF ROTIFERS FED DIFFERENT ENRICHMENT DIETS.

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At present many experiments are being conducted on the effectiveness of different enrichment methods for *B. plicatilis*. In this study we compared the effect of four diets on the nutritional value of rotifer for larval gilthead bream.

Rotifers were enriched for 22h. with the following treatments : A) a lipid emulsion (EPA 28, NIPPAI, CO. LTD.), B) a microencapsulated feed (Booster, FRIPPAK FEED LTD.), C) the microalgae *Nannochloropsis sp.* and D) the microalgae *N. gaditana*. A water system with no exchange was used to rear the 3 day old larvae and the water temperature ranged between 17.5-20.0°C. Larvae were fed with enriched rotifers for 14 days, three replicates for each treatment. Growth of 10 and 17 day-old larvae was determined by measuring the total length of 30 live fish. Survival rate was also determined at the end of the experiment. Samples of diets, rotifers and larvae were analysed for lipid, protein and moisture contents as well as for fatty acid composition.

The best larval growth was obtained with the treatment of *Nannochloropsis sp.*, followed by that of microencapsulated feed, lipid emulsion and finally *N. gaditana*. Growth rate was significantly different between microencapsulated feed and lipid emulsion treatments.

The highest survival rate (32.93%) was supported by the enrichment with *Nannochloropsis sp.* and the lowest (7.16%) by *N. gaditana*, both being significantly different from the rest of the groups.

ESSAIS DE SEVRAGE DU LOUP (*Dicentrarchus labrax*) AVEC DIFFERENTS ALIMENTS EQUILIBRES.

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L'objectif de cette recherche est de comparer quatre différents types d'aliments donnés pendant 20 jours à des bars (*Dicentrarchus labrax*) en période de sevrage. Trois de ces aliments sont actuellement disponibles sur le marché, alors que le quatrième a été formulé *ad hoc* pour une commercialisation ultérieure. Initialement ont été faites des analyses de contrôle sur les contenus protéiques (acides aminés), lipidiques (acides gras) et vitaminiques. Pour le déroulement des essais ont été utilisés 8 lots de 50 000 larves âgées de 55-60 jours. Chaque type d'aliment a été distribué en deux lots, pour un total de huit lots. Au début et à intervalles réguliers de 5 jours ont été relevés poids et longueurs sur des échantillons provenant de chacun des lots. Simultanément ont été relevés quotidiennement le numéro et le poids des sujets morts indépendamment de problèmes liés à des phénomènes de pathologie. Chaque jour ont été relevés en entrée et en sortie des bassins, les principaux paramètres physico-chimiques de l'eau. A la fin des essais il a été possible de sélectionner l'aliment le plus adapté en fonction du profil de la croissance pondérale, de la longueur des poissons, des taux de survie et de la production des métabolites toxiques.

FEEDING PRACTICES IN SEA BASS (*Dicentrarchus labrax*) DURING WEANING AND ONGROWING ONTO SEVBAR.

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Sevbar is an expanded pellet developed at IFREMER for marine fish weaning and ongrowing and currently commercialized by Sanofi Aquaculture. The limits and possibilities of use of the last commercially available formulation are presented for sea bass feeding during the hatchery phase.

In a first set of experiments, Sevbar efficiency is tested in our standard condition of weaning (with a direct switch from Artemia) in D.33-D.36 juveniles (30-32mg wet weight). The experiment is of 20 D. duration and is performed both in 50 L. (I, 4 replicates) and 150 L. tanks (II, 2 replicates). The results obtained show high efficiency of Sevbar in terms of survival (90 and 83%), growth rate (SGR of 6.9-7.0) and food conversion (1.1).

In similar experimental conditions (I, 3 replicates and II, 2 replicates), Sevbar appears to be also an efficient food for sea bass ongrowing from D.60 to D.90 p. hatching : 97-99% survival, 1.2-1.3mg final wet weight, food conversion rate of 0.9. A growth model and a reference survival curve are given for sea bass rearing with practical data for daily food rations and fish size dispersion when Sevbar feeding starts at D.30-35.

It is shown that Sevbar efficiency during weaning is related to the initial fish "quality" (weight; state of development). An important growth retardation is observed with fish of less than 10mg wet weight.

Latest data, using "standard" experimental conditions as described above, and with a more recent Sevbar formulation/presentation, show promising results at even earlier weaning.

MISE AU POINT D'UNE TECHNIQUE DE MESURE DE L'INGERE CHEZ LE JEUNE ALEVIN DE BAR (*Dicentrarchus labrax*) A L'AIDE D'IODURE D'ARGENT MARQUE.

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L'ingéré individuel, qui n'est pas directement mesurable chez le jeune alevin de bar de 1 à 2g a été estimé par une méthode indirecte faisant appel à un marqueur non absorbable, l'iodure d'argent marqué (^{125}I), dérivant de celle de STOREBAKKEN *et al.* (1981). Le comptage de la radioactivité gamma est effectué sur le poisson entier après une distribution d'aliment marqué pendant une période bien définie. Si le marqueur est réparti de façon homogène dans l'aliment, il permet une estimation de l'ingéré moyennant des corrections faites à l'aide d'équations de régression préalablement établies. Cette méthode a permis, avec deux aliments différents, de mesurer l'ingéré après un jeûne défini, de suivre l'évolution de la consommation au cours du temps et d'estimer le temps de retour de l'appétit après un repas. Elle est fiable et extrêmement rapide, elle permet le calcul de paramètres caractérisant l'appétence de l'animal pour un aliment donné sur des lots de plusieurs dizaines de poissons et peut servir également d'outil pour l'étude du transit gastrique et intestinal, plus difficilement appréciable par les méthodes faisant appel aux marqueurs classiques.

THE EFFECT OF ALGAL ADDITION ON LIPIDS AND FATTY ACID CONTENT OF TURBOT LARVAE.

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The aim of this study was to examine the transfer of fatty acids from micro algae to rotifers and turbot larvae during first feeding. The rearing tanks were supplemented with rotifers and *Isochrysis galbana* (I-tanks); quantitatively high in lipids and w3 HUFA, or rotifers and *Tetraselmis* sp. (T-tanks); quantitatively low in lipids and w3 HUFA. Control tanks (C-tanks) were reared with rotifers without addition of algae to the water.

The lipid level of the rotifers in the fish tanks decreased with time in C-tanks, remained fairly constant in T-tanks, and increased in I-tanks. The w3 HUFA level of the rotifers decreased somewhat in all treatments, but was higher in I-tanks than in C- and T-tanks. The fatty acid distribution (%) of the rotifers in the rearing tanks added micro algae approached that of the algae added.

Both the lipid and the w3 HUFA content of 11 d turbot larvae were >20% higher in I-tanks than in C- and T-tanks, whereas the content of 22:6 w3 was >35% higher. The fatty acid distribution of the larvae also approached that of the algae supplied, but the differences in relative fatty acid distribution were moderate compared to the quantitative values.

Algal fatty acids were probably mainly mediated to the larvae indirectly through the rotifers. The results suggested that the turbot larvae had ingested at least some micro algae directly from the water.

RIBOFLAVIN REQUIREMENT OF FINGERLING RED HYBRID TILAPIA GROWN IN SEAWATER.

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Red hybrid tilapia fingerlings were fed diets containing 0, 2.5, 5.0, 10.0, 20.0 and 40.0 mg/kg, and 0, 2.5, 5.0, 7.5, 10.0 and 20.0 mg/kg of riboflavin in separate 8 and 12 week feeding studies, respectively. The dietary riboflavin level required to provide maximum growth and survival, and prevent deficiency symptoms in red hybrid tilapia fingerlings was found to be approximately 5 mg/kg of diet. In both trials, fish fed diets devoid of supplemental riboflavin has anorexia, reduced growth, light coloration and nervous symptoms after 4 to 6 weeks. Mortality started to occur after the 6th week. None of these abnormalities were observed during the first 6 weeks in fish fed the riboflavin supplemented diets. However, by the 7th week, fish fed diet supplemented with 2.5 mg/kg of riboflavin showed reduced appetite and growth rate. In experiment 1, short dwarfism and eye cataract were observed at 8 weeks in the group of fish fed the unsupplemented diet. Histological study of liver, kidney, spleen, striated muscle, gill, heart, nervous system and gastro-intestinal tract is being conducted.

EVALUATION OF SUITABILITY OF MIXED FEEDING SCHEDULES IN TWO INDIAN MAJOR CARPS, CATLA (*Catla catla*) AND ROHU (*Labeo rohita*).

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It is generally recommended that carps should be fed on 30% protein diet to achieve the best growth. Recent studies with tilapia (*Oreochromis niloticus*) and common carp (*Cyprinus carpio*) have shown the existence of daily variation in digestibility of protein and it was observed that feeding these fish with varied protein levels did not alter the growth significantly, thereby reducing the feed input cost.

Laboratory studies indicated the existence of such a rhythmcity in digestibility of protein in the two Indian major carps, namely, catla (*Catla catla*) and rohu (*Labeo rohita*). Based on this observed variation in the digestibility of protein, two diets with high protein (31.84% diet H) and low protein (15.86% diet L) were employed to test the suitability of five randomnly determined mixed feeding schedules *viz.*, 1L/1H, 1L/2H, 1L/3H, 2L/2H and 2L/2H (numericals indicate the number of days low or high protein diet fed continuously) were evaluated for their suitability in these species.

Results of the two trials conducted with catla and rohu over a period of 70 and 98 days respectively, revealed the suitability of mixed feeding schedules as compared to either providing only low protein diet or high protein diet. Excepting for the significantly lower weight of fish fed with low protein diet, there was no difference in the final weights of high protein fed fish and those grown on mixed feeding schedules. Based on the score system for various indicators like SGR, FCR, PER, percent protein retention, biomass production and flesh calorific content, 1L/3H and 2L/3H treatments in catla and 1L/1H, 2L/2H and 1L/3H in rohu were found to be the best feeding schedules. This difference in the performance of two species could be attributed to the magnitude of daily variation in protein digestibility. It was possible to save considerable protein and/or feed input costs without affecting the fish yield through the adoption of mixed feeding schedules. The results are discussed considering their utility for adoption at farmers level in tropical aquaculture.

EFFECT OF ENVIRONMENTAL TEMPERATURE AND FEEDING RATE ON THE GROWTH, FOOD UTILIZATION AND BODY COMPOSITION OF COMMON CARP (*Cyprinus carpio* L.) FRY.

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Two 25-day growth trials were conducted to examine the effects of temperature and feeding rate on growth, food conversion, protein utilization and body composition of common carp (*Cyprinus carpio L.*) fry (live weight 46-73mg). The experiment was carried out in a laboratory recirculatory system at temperatures ranging from 24°C to 35°C in relation to feeding rates of 10%, 15%, 20%, 25%, 30% and 35% body weight per day (BW/day). Specific growth rates of carp fry were plotted to illustrate the overall relationship between growth, feeding rate and temperature. The relationship between growth and feeding rate shows that at any rearing temperature, the specific growth rate (SGR) increased with feeding rate up to a level above which it either decreased or remained constant. From the growth curve at 24°C, it is postulated that the scope for maximum growth did not occur above 25% BW/day, but lay between 20% and 25% BW/day. At 28°C the maximum growth rate appeared to occur at feeding rates between 25% and 30% BW/day. Both at 32°C and 35°C, maximum growth was found at the feeding rate of 30% BW/day. The results of this study also demonstrate that the optimum temperature for the growth of carp fry shifted upwards with increase in feeding rate. At feeding rates between 10% and 15% BW/day, 28°C appeared to be the most suitable temperature for maximum growth, whereas at feeding rates between 20% and 35% BW/day, 32°C was found to be the optimum. Increasing the feeding rate resulted in an increase in food conversion ratio (FCR) at all rearing temperatures. However, with exception of 24°C, increase in feeding rates from 15% to 30% BW/day at each rearing temperature did not greatly affect the efficiency of food utilization. On the contrary, with the increase in temperature except at 35°C, FCR decreased considerably at all feeding levels. Temperature and feeding level influenced the body composition of carp fry. In general, at each rearing temperature, increase in the feeding rate resulted in a decrease in carcass moisture and an increase in carcass lipid content. An increase in the rearing temperatures resulted in a decrease in carcass lipid content. It is concluded on the basis of growth and food conversion efficiency that 32°C may be considered as the optimum rearing temperature for common carp fry at feeding rates between 20% and 30% BW/day.

GROWTH RESPONSE OF *Tor Khudree* TO SILKWORM PUPA INCORPORATED DIETS.

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Deoiled silkworm pupa (DSP) was evaluated as partial or total replacement for fish meal through pelleted diets employed to Deccan mahseer, *Tor khudree*, incorporating at 20, 30, 40, and 50% levels, the last diet being fish meal-free. All the test diets had an overall protein content of 40%. The growth trial was conducted in triplicate over a period of 126 days in 25 m^2 cement cisterns without any soil base. Stocking was done at the rate of 20 fingerlings/cistern. Growth obtained was compared with that of fish fed on fish meal based control diet. 50% DSP diet resulted in the best fish growth. Specific growth rate reflected pattern of weight gain. Test diets showed better nutrient digestibility. Survival and fish quality were unaffected by dietary administration of silkworm pupa.

EVALUATION OF SILKWORM PUPAE MEAL AS DIETARY PROTEIN SOURCE FOR CATFISH (*Heteropneustes fossilis*).

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A laboratory trial was conducted over a period of 60 days to evaluate the silkworm pupae meal as fish meal substitutes in the diet of fingerling catfish (*Heteropneustes fossilis*). The silkworm pupae was included in the diet at various inclusion levels (25, 50, 75 and 100% of dietary protein) and the response of fish fed these diets was compared to fish fed a fish meal based control diet. Five isonitrogenous diets (32% protein) were prepared and fed to fish initially weighing 2.11 ± 0.02 g with three replication for each treatment. On the basis of observed growth rate, food conversion ratio, protein efficiency ratio and apparent net protein utilization diets 3 and 4 containing 50 and 75% silkworm pupae protein respectively, produced significantly ($p<0.05$) the best growth performance while the control diet produced the lowest. Apparent protein digestibilities (APDs) for all the diets were fairly high, ranging from 78.80 to 86.72% with control diet producing the lowest. In general, APD values increased with the increasing silkworm pupae in the diets. Compared to the control, fish fed diets containing higher levels of silkworm pupae had lower levels of carcass moisture and higher levels of carcass protein and lipid. This study suggests that the silkworm pupae meal can be used as a substitute for fish meal in fish feed.

A PRELIMINARY STUDY ON USE OF POULTRY OFFAL MEAL AS DIETARY PROTEIN SOURCE FOR THE FINGERLING OF INDIAN MAJOR CARP *Labeo rohita* (Hamilton).

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A thirteen-week growth trial was conducted to evaluate the suitability of poultry offal meal (POM) as a substitute for dietary fish meal protein for Indian major carp, *Labeo rohita* (Hamilton), fingerling (mean weight 3.94g; SD ± 0.12). Four experimental diets were formulated to contained 25%, 50%, 75% and 100% of the total dietary protein as test protein using protein from poultry offal meal. The control diet was prepared with fish meal as the sole source of protein. All diets were formulated to contain about 30% protein. The experiment was conducted under laboratory condition with two replications for each treatment. The performances of the diets were evaluated on the basis of growth, food conversion, protein utilization, body composition and histopathological changes. There was no significant ($P>0.05$) variation in the observed growth responses and food conversion ratios among diets containing 50%, 75% and 100% POM, but all these diets showed significantly ($P<0.05$) better performances than both control and 25% POM diet. Protein efficiency ratio values for control and POM diets ranged between 1.21 and 1.36 and were not significantly ($P>0.05$) different from each other. Apparent net protein utilization values ranged between 14.64% and 23.43%, the highest value being recorded at 50% POM diet. However, in terms of cost of feed and economic return, diet containing 100% inclusion of POM was found to be cheapest of all diets. In general, increase in the level of POM in the diet resulted in an increase in carcass moisture and lipid and a decrease in carcass protein content. The histopathological changes observed in the liver at different POM diets were congestion, fatty change and pyknotic nuclei, but the changes were comparatively more marked at higher levels of inclusion. The results are discussed on the possibility of using POM as an alternative protein source for this major carp fingerling.

ENERGY SUBSTRATES UTILIZATION BY A TROPICAL AIR-BREATHING CATFISH, *Hoplosternum littorale*.

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How fish can use other energy substrates than protein to cover their energy needs is a dramatical point for the improvement of fish feed. Compared to temperate fish, tropical species seem to make a better use of non protein energy substrates, especially carbohydrates. Our intention was to quantify which kind of energy substrates are really burned by a tropical fish, *Hoplosternum littorale* (an air breather siluriform from South-America).

Both endogenous and exogenous substrates have been considered. First of them were evaluated following the reduction of each body substrates during a long term fast (50 days), and by indirect calorimetry using the amount of oxygen uptake, carbon dioxide and nitrogen excretion by fasted fish. As the exchanges take place in air and water for *H. littorale*, a special metabolic chamber was designed in this attempt.

This method was also used for the determination of exogenous substrate utilization coming from food.

Higher during the first ten days of fast, energy losses are reduced to quarter for the last 40 days. As other fish species, *H. littorale* use protein to cover their energy needs. And if their fat content remains relatively constant over the whole 50 days fast period, fat utilization is limited to the first 10 days. Indirect calorimetry method on fish fasted for 10 days give reliable results, taking into account that protein consumption evaluation using the quantity of nitrogen excreted as protein catabolism endproducts (quite exclusively ammonia for these species) could not be strictly compared to the net protein losses as other way of nitrogen losses can occur as mucus secretion or dermal erosion.

Following a food intake, protein are actively catabolised as energy consumption increased. During this rise, *H. littorale* is able to use available carbohydrates, and respiratory quotient indicate that some fat synthesis occurs during the twenty hours just after the meal. Twenty hours more later, the pattern of energy substrate utilization joins those obtained for fasted fish.

DIETARY REQUIREMENTS OF MILKFISH (*Chanos chanos* Forsskal) FOR ESSENTIAL AMINO ACIDS.

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Experiments were conducted to determine the dietary requirements of milkfish juveniles for essential amino acids. The fish (8.0g or less) were reared in fiberglass tanks provided with flowthrough seawater at temperature and salinity of 28°C and 32ppt, respectively, for 12 weeks. In each experiment, a series of amino acid test diets was formulated containing a combination of whole protein sources (casein/gelatin, fishmeal/gelatin or fishmeal/zein), and crystalline amino acids (40-45% dietary protein) to simulate the levels found in milkfish tissue proteins except for the test amino acid. Each set of isonitrogenous diets contained graded levels of the amino acid to be tested. At the end of the feeding experiment, growth, survival and feed efficiency were determined. The requirement level for each essential amino acid was estimated from breakpoint analysis of the growth curve. The dietary essential amino acid requirements (as percent of dietary protein) of milkfish juveniles are : arginine-5.25; histidine-1.95; isoleucine-4.00; leucine-5.11; lysine-4.00; phenylalanine-4.22 (tyrosine-1.00), 2.80 (tyrosine-2.67); threonine-4.88; tryptophan-0.60; and valine-3.55. The methionine requirement was previously estimated to be 2.7 (cystine-0.78) or 1.51 (cystine-4.11) (Sastrillo, 1990). This information is valuable in developing cost-effective practical or commercial feeds for milkfish juveniles.

ESSENTIAL FATTY ACID REQUIREMENT OF JUVENILE SEABASS.

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Two experiments were conducted to determine the 3 highly unsaturated fatty acid (3 HUFA) requirement of seabass. In experiment I, the purpose of which was to broadly define 3 HUFA requirement levels and deficiency signs, four fish meal and casein diets with different levels of 3 HUFA at 0.46, 0.88, 1.72 and 2.70% were fed to seabass for 12 weeks in seawater. Some of the fish fed on the diet 0.46% 3 HUFA began to show reddening of the fins from the second week, and later they manifested chronic essential fatty acid (EFA) deficiency signs. Their growth rate and feed efficiency were significantly lower than other treatments. The fish fed on the diet containing 0.88% 3 HUFA also showed slight EFA deficiency sign. Fish fed the diet containing 1.72% 3 HUFA or 13% of total dietary lipids provided the best growth rate and feed efficiency. The fatty acids in the phospholipid of experimental seabass accorded with their dietary fatty acids. In experiment II, the purpose of which was to more precisely define 3 HUFA requirement, fish meal and casein diets containing smaller increment level of 3 HUFA 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0% were fed to seabass for 10 weeks. The results show that there was no significant difference in weight gain, feed efficiency and survival among these treatments. It is concluded that 3 HUFA has an essential role in seabass nutrition and the quantitative requirement is 1.0-2.0% in diet for good growth, high feed efficiency and freedom from EFA deficiency signs.

EFFECT OF THIAMINE, RIBOFLAVIN, PANTOTHENIC ACID AND INOSITOL ON GROWTH, FEED EFFICIENCY AND MORTALITY OF JUVENILE SEABASS.

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The experiment was conducted to determine the effect of dietary thiamine, riboflavin, pantothenic acid and inositol on growth, feed efficiency and mortality of juvenile seabass in seawater. Deficiency signs were also recorded. Five experimental semipurified diets, including : 1) control diet with a complete vitamin profile, 2) thiamine deficient, 3) riboflavin deficient, 4) pantothenic acid deficient and 5) inositol deficient, were fed to juvenile seabass, average initial wet weight 1.29 g/fish for a period of 16 weeks.

At the end of week 4 compared to control diet 1, fish fed pantothenic acid deficient diet showed significantly lower feed intake, feed efficiency, weight gain and survival. They showed the following deficiency symptoms : dark colourations, anorexia, abnormal swimming behaviour, haemorrhagic operculum, chin isthmus pelvic fin, erroded pelvic fin and clubbed gills. After supplementation with pantothenic acid in the test diet, recovery was quick, feeding rate increased, growth and feed efficiency improved and mortality ceased in two weeks.

The following deficiency symptoms were recorded after 10 weeks of feeding the thiamine deficient diet : dark colouration, anorexia, poor growth, posthandling shock and mortality, after 12 weeks of feeding the riboflavin deficient diet deficiency symptoms included : dark colouration, sluggishness, photophobia, cataracts, stunted body, reduced feeding rate, low feed efficiency, poor growth and high mortality.

After 16 weeks, compared to control diet 1, fish fed thiamine and riboflavin-deficient diets should significantly lower total weight, feed efficiency, feed consumption, and higher mortality.

Results indicate a requirement for thiamine, riboflavin, and pantothenic acid by juvenile seabass for normal growth and survival in seawater.

Posters / Affiches Session 8

QUANTITATIVE LYSINE REQUIREMENT FOR ATLANTIC SALMON (*Salmo salar*) FINGERLINGS.

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An experiment was conducted to determine the quantitative lysine requirement of Atlantic salmon (*Salmo salar*). Triplicate groups of Atlantic salmon (4.7 ± 0.2 g) were fed ad libitum diets containing 1.15, 1.40, 1.65, 1.90; 2.15, 2.40 and 2.65% lysine for a period of 70 days. Broken-line regression of growth versus dietary lysine level showed the dietary requirement of lysine to be 1.99 % of the dry diet or 3.98% of the protein at 50% of protein in the diet. A lysine requirement of 1.84% was obtained from broken-line regression of expired $^{14}CO_2$ (following an intraperitoneal injection of L (U-^{14}C)lysine) versus dietary lysine concentration. Except for a loss of appetite resulting in low food intake and depressed growth, no nutritional deficiency signs were observed in fish fed a lysine deficient diet for 14O days.

ZINC REQUIREMENT IN ATLANTIC SALMON (*Salmo salar*) FRY.

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Atlantic salmon (*Salmo salar*) fry from the breed of the Matre Aquaculture Station were start fed a diet based on cod muscle meal as a protein source for 12 weeks. The diet was added 0, 10, 20, 40, 80, 1000 mg Zn/kg as $ZnSO_4*7H_2O$. The basal diet contained 17 mg Zn/kg.

There were significant lower growth in the fish fed the two diets lowest in zinc. Fish from these groups also showed elevated whole body iron levels and increased condition factor.

The mean whole body zinc concentration from pooled samples of fry further changed from 24 mg Zn/kg wet weight in the fish prior to the start feeding to a mean of 14.5, 17.9, 21.5, 28.4, 40.8 and 71.2 mg Zn/kg after 12 weeks.

Interestingly, the largest fish from the four feeding regimes lowest in zinc showed lower whole body zinc concentration than the mean.

Based on the these data an addition of 40-80 mg Zn/kg (total of 57-97 mg Zn/kg) diet seemed to be needed to keep the whole body zinc concentration on a normal level in the fastest growing fish.

THE EFFECTS OF VARYING DIETARY PHYTIC ACID, CALCIUM AND MAGNESIUM LEVELS ON THE NUTRITION OF COMMON CARP (*Cyprinus carpio* L). I. GROWTH AND FOOD UTILIZATION.

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Juvenile common carp were fed for 8 weeks on 9 purified and 2 semi-purified diets containing either 0.5 or 1.0% phytic acid. Diets contained incremental levels of calcium (0.92 to 2.22%) and magnesium (0.058 to 1.60%). Dietary phytic acid depressed growth rate, food conversion and protein utilization in carp. Reduced growth of fish fed phytic acid containing diets was significantly influenced by the presence of high dietary calcium and magnesium levels. Diets containing phytic acid had lower apparent protein digestibilities. Both synthetic and naturally occurring phytic acids were equally effective in reducing growth rate and food utilization in carp. This reduced growth rate may be attributable to the formation of insoluble protein-phytate complexes or effects on mineral bioavailability.

EFFECT OF GRADED LEVELS OF DIETARY ASCORBIC ACID ON MINERALIZATION OF CALCIUM AND PHOSPHOROUS IN RAINBOW TROUT, *Salmo gairdneri*.

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A feeding trial was conducted to evaluate the effect of dietary ascorbic acid (ASA) on the mineralization of calcium and phosphorus in rainbow trout, *Salmo gairdneri* (mean weight 64.6 g + S.D 9.0). An egg-albumin basal diet was supplemented with graded levels (0, 10, 20, and 200 mg/100 g diet) of ASA and the fish were fed *ad libitum* twice a day for 20 weeks. Duplicate groups each containing 20 fish were used in 50l aquarium having flow through system. Muscle was analysed for ash and vertebra was analysed for ash, calcium and phosphorus. Blood serum was analysed for calcium and phosphorus. Analyses were done after 9 and 20 weeks of feeding. There was no significant ($P>0.05$) differences in muscle and vertebra ash contents due to variation in dietary ASA. However, muscle ash contents were found to be significantly ($P>0.01$) higher after 20 week feeding than that of after 9 week feeding in each group. There were no significant ($P>0.05$) differences in vertebral calcium and phosphorus contents among the fish fed different levels of ASA nor did the calcium and phosphorus contents vary after feeding for 9 and 20 weeks within each group. Vertebral calcium and phosphorus contents ranged between 10.62% & 12.10% and 8.36% & 9.26% respectively. Serum calcium contents in each group determined after feeding for 9 and 20 weeks did not vary significantly. There was no significant differences among the values of serum calcium and phosphorus due to variation in dietary ASA. But in each group, serum phosphorus content was found to be significantly higher ($P<0.01$) in fish fed for 20 weeks than the fish fed for 9 weeks. Values of serum calcium ranged from 30.35 to 36.82 mg/100 ml and that of phosphorus from 27.00 to 48.17 mg/100 ml. The results of the present study indicate that the dietary ASA may not be essential for the mineralization of calcium and phosphorus in juvenile rainbow trout.

EFFECTS OF DIETARY CALCIUM SOAPS ON GROWTH AND BODY COMPOSITION OF JUVENILE SEA-BASS (*Dicentrarchus labrax* L).

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An experiment was made to evaluate the effects of the replacement of dietary fish lipids (FL) (herring meal and oil) by fatty acid calcium soaps (FAS) (obtained by a blend of vegetable oils) on growth and body composition of juveniles sea-bass (*Dicentrarchus labrax* L.). Triplicate groups of 60 fish (12.6±1.1 g) were fed four isoproteic and isolipidic diets (52.57, % Nx6.25 and 13.39, % E.E., on d.m. basis) with different ratios FL/FAS : diet A, 100/0; B, 75/25; C, 50/50; D, 25/75. EPA+DEA and saturated fatty acid (C12+C14+C16+C24) contents in the diets were respectively 19.0 and 28.8% (A); 10.0 and 34.6% (B); 6.4 and 38.2% (C); 4.3 and 39.8% (D) of the total lipids. Fish were kept in twelve 400l tanks supplied with 5.0 l/min of brackish water (20.0 ± 1.1.°C; 14.2 ± 1.9% NaCl). After 146 days the fish fed diet D had the lower weight gain (38.81 gA; 35.92 gB; 35.25 gC; 31.73 gD; ($P<0.01$) and the worst feed/gain ratio (A 1.81; B 1.78; C 1.95; and D 1.98) ($P<0.05$). Proximate composition of fish was unaffected by dietary lipid sources. Decreasing the dietary levels of FL caused a progressive decrease of total PUFA and particularly of EPA+DHA content (17.2 A; 13.8 B; 11.9 C; 8.3 % D) ($P<0.01$). Saturated fatty acid content in fish body did not vary among treatments (28.3 A; 28.8 B; 27.7 C; 28.5 D). Taking into account the growth performance, body fatty acid composition and the percentage of spinal deformity observed in fish fed diets C and D (1.67-2.77% respectively vs 0.55 B, 0.0% A) it can be concluded that fatty acid calcium soaps from vegetable oil may replace 25% fish lipids.

EFFECT OF THE REPLACEMENT OF THE INORGANIC ZINC OF THE DIET BY ZINC/METHIONINE ON VEGETABLE AND ANIMAL PROTEINS UTILIZATION BY RAINBOW TROUT.

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Four experimental diets were tested during 21 weeks in triplicate. Two diets have animal proteins (fish meal and meat meal) as the only protein sources and the other two only vegetable proteins (maize gluten, full-fat soybean and lupin seed meal). All the diets were formulated with the same protein and energy levels. The diets ZN1 and ZN2 (animal proteins) have the same ingredients except for zinc source. In diet ZN2 the zinc of the mineral premix was replaced by zinc/methionine. The content of methionine was corrected in diet ZN1. The same method was utilized for the formulation of diets with vegetable proteins (ZN3 and ZN4). Triplicated groups of rainbow trout (29,1±0,3 g) were fed the experimental diets during 21 weeks. Weight gain and plasma, body and viscera levels of zinc, calcium and magnesium were measured.

During the experimental period no significant differences for zinc in plasma, body and viscera were observed, and also for calcium in plasma and body. Higher values of calcium in viscera were observed for diets ZN1 and ZN2. A tendence for high levels of magnesium in viscera were observed for treatments with zinc/methionine (ZN2 and ZN4).

Final weight gain and specific growth rate were higher in diets ZN1 and ZN2. No significant differences were observed for feed gain ratio and protein efficiency ratio. A significant difference was observed during the 21 weeks of the experiment for voluntary intake, that was higher for diets ZN1 and ZN2.

In conclusion the diet formulation with vegetable or animal proteins, based on raw materials utilized in this work, which represents the major constituents of the commercial fish diets, was not enough to induce deficiencies on micronutrients like zinc. In the same way no evidence for a negative effect of the dietary calcium interaction with zinc or magnesium availability for rainbow trout was also demonstrated. However, fish performances were negatively affected with diets containing only vegetable proteins because of a significant decrease on voluntary feed intake.

EFFET DE L'INCORPORATION D'UNE DOSE ELEVEE DE SEL DANS L'ALIMENT SUR LE TRANSFERT EN MER DE LA TRUITE FARIO (*Salmo trutta*).

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Des truitelles réparties en 4 classes de poids (22, 29, 36 et 46g), subdivisées chacune en deux lots reçoivent un mois avant le transfert en mer une alimentation supplémentée ou non en chlorure de sodium (10%). Chacun des 8 lots comprend 2 répétitions. La croissance, la survie et différents paramètres physiologiques sont étudiés pendant le mois qui précède et celui qui suit le transfert en mer (salinité 35 °/00).

La croissance est légèrement ralentie en eau douce pour les animaux recevant l'alimentation salée, mais sur l'ensemble des deux périodes aucune différence significative n'apparaît entre les traitements. Pour l'ensemble des lots, les survies sont toujours supérieures à 92% même chez les petits animaux. Bien que les différences de survie entre animaux traités ou non soient faibles, un effet favorable du sel ($p<0,05$) est à noter pour toutes les tailles de poisson. L'activité ATPasique branchiale augmente fortement pendant l'élevage en eau douce quel que soit le régime ("pseudo smoltification" ?). Toutefois cet accroissement est plus marqué ($p<0,05$) au moment du transfert chez les poissons ayant consommé l'aliment salé. Aucun déséquilibre notable de la pression osmotique n'apparaît après transfert en mer. De même, en première analyse, aucune différence claire au niveau du nombre de cellules à chlorure n'est observée entre les lots traités ou non traités.

Ce travail, corroborant des résultats antérieurs, confirme l'intérêt des aliments salés pour la préadaptation de la truite fario au milieu marin et apporte les premiers éléments d'interprétation physiologique.

THE CONTRIBUTION OF SUPPLEMENTARY SEA WATER ON THE MINERAL BALANCE IN ATLANTIC SALMON ALEVINS.

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The concentrations of Ca, K, Mn, Mg, Na, P, and Zn were monitored in eggs and larva of Atlantic salmon (*Salmo salar*) incubated in buffered freshwater and buffered freshwater to which 2% seawater was added. Ca concentrations were significantly higher in the larva reared in the seawater supplemented water, but did not differ in the incubating eggs. The levels of the other elements did not differ in the eggs or larva. Mortalities in the larva reared in freshwater increased after hatching but remained low in the seawater added group. The results suggest that the low Ca concentration present in the acid waters of western Norway may be responsible for increased mortality and retarded development in Atlantic salmon fry.

NORSEAMINK(R) AND NORSE LT-94(R) - SPECIAL PRODUCT FISH MEALS IN DRY FEED FOR ATLANTIC SALMON (*Salmo salar*).

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The purpose of these experiments has been to show the significance of low temperature dried fish meal (Norse LT-94(R)) compared to steam dried fish meal (Norseamink(R)) in growth trials with Atlantic salmon.

A total of four growth trials with small salmon (90g-170g) and two growth trials with large salmon (approx. 2.0 kg) have been conducted. The experiments with small salmon have mainly been run at low seawater temperatures. The growth effect of replacing Norseamink(R) as the only protein source in the diet with Norse LT-94(R) has been an average improvement of 15% for small salmon and 22% for large salmon.

The results further show that the protein content in the diet for small salmon may be reduced from approx. 46% to 32% without giving any negative effects on growth. This indicates that the protein content in the diet for small salmon may be significantly reduced if the fish meal is of top quality (Norse LT-94(R). The better growth found by use of Norse LT-94(R) is preliminary due to a more gentle heat treatment of the fish meal in the production process. In one of the experiments the protein digestibility of the fish feed was tested on both salmon and mink.

The protein digestibility of the diet based o Norse LT-94(R) quality fish meal was approximately 5% higher than that of the Norseamink(R) diet.

THE GROWTH RESPONSE OF TURBOT (*Scophthalmus maximus*) AND WOLF FISH (*Anarchichas lupus*) ON TWO DIFFERENT QUALITIES OF FISH MEAL.

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A feeding trial with the objective of testing different protein and fat levels in diets for turbot revealed some interesting differences between fish meals.

2 qualities of commercially available aquaculture fish meals gave significantly different growth responses in both turbot and wolf fish.

2 groups of turbot (40g, initial weight) were fed to satiation 3 times a day for a period of 170 days. The diets were identical except from the quality of the fish meal.

The mean daily growth rate was 0,98 and 1.14 and the mean final weight was 209g and 279g for the poorest and the best quality fish meal, respectively.

The same effect was shown in another experiment with wolf fish. Individuals of 107g were fed diets similar to those in the turbot trial for 7 1/2 months. The growth was markedly higher in the group fed the top quality protein. The final weights were 231g and 317g and significantly different.

NUTRITIONAL VALUE OF SHARK MEAT INCORPORATED IN RATIONS FOR TURBOT (*Scophthalmus maximus*).

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Turbot, with mean initial live weight of 44 g, were kept in closed circuit, during 72 days, being allocated to two different treatments (with three replicates each), each treatment corresponding to one experimental ration. Control ration (T), in the wet form, was made, essentially, of turbot meat (60%) and turbot meal (30%). In diet S, containing only shark meat, the same proportion, as above, of fresh fish and fish meal was maintained.

Experimental fish were fed at the maximum rate of 2% of their live weight. For treatment S the following results were obtained : relative growth - 78% (treatment T, + 26%) ; feed consumption (g/day) - 5,4 (T, + 24%); live weight gain/dry matter consumption -1/1,7 (T, + 42%); protein efficiency ratio (live weight gain/crude protein consumption) - 1,4 (T, + 33%) ; total protein blood level (mg/100 ml) - 4,4 (T, + 39%). The comparison with turbot meat, as a standard protein source, seems to show both a lower palatability and a poorer protein quality of shark meat. Nonetheless the differences observed were not significantly different in statistical terms.

PARTIAL SUBSTITUTION OF FISHMEAL WITH DIFFERENT MEAT MEAL PRODUCTS IN DIETS FOR SEABREAM (*Sparus aurata*).

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Seabream (*Sparus aurata*) fingerlings having an initial mean weight of 5 grms were fed for 72 days experimental diets containing various inclusions of differently processed meat and bone meals, and a high fat meat and poultry meal blend. Three types of meat and bone by products were used to substitute 20% and 40% of the fish meal protein in a control diet. A commercial product, lipromel $_R$ was tested at a level of 15% of the diet formulation because of its high fat content. The diets were designed to be isonitrogenous and isocalorific in gross protein and energy, with a 50% crude protein and 10% crude fat content.

Statistically all the diets performed as well as the control fishmeal based diet. However one type of meat and bone meal produced better results at a 40% inclusion level. Feed conversion ratios (FCR) ranged from 1.52 to 1.60. Specific growth rates (SGR), protein efficiency ratios (PER) and net protein utilization (NPU) values were found to be similar for all diets. It was therefore concluded that meat and bone meal can effectively replace up to 40% of the fishmeal component in practical diets for Seabream.

EVALUATION OF FOUR SEMI-PURIFIED PROTEIN SOURCES FOR USE IN JUVENILE ATLANTIC SALMON (*Salmo salar*) TEST DIETS.

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Four semi-purified protein sources, vitamin-free casein, blood fibrin, egg white, and isolated fish meal protein, were evaluated in feeding trials as basal protein source in test diets for juvenile Atlantic salmon. A commercial diet was fed as a standard. The diets were fed to duplicate groups of fish for 8 weeks. The egg white and blood fibrin diets had low palatability. The percent weight gain, PER, PPV (%), and feed efficiency (weight gain/feed fed) of the casein diet were : 262, 2.63, 40.7, and 1.50. These parameters did not differ from those of the isolated fish meal protein or the commercial diets indicating that casein can be used as the main protein source in semi-purified diets for juvenile Atlantic salmon.

NUTRITIVE UTILIZATION OF EARTHWORM PROTEIN BY FINGERLING RAINBOW TROUT (*Oncorhynchus mykiss*).

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The great increase of vermiculture in the last years has provided the possibility of using a new protein source in fish feed formulation. *Eisenia foetida*, one of the most cultivate species, has a high protein content on a dry basis and a very good amino acid composition which makes it a suitable protein source for fish. However, several studies have shown that *Eisenia foetida* meal is unpalatable for trout, probably due to its coelomic fluid composition.

The aim of this work is the evaluation of *Eisenia foetida* meal as protein source in trout diets. For this purpose, 50% of fish meal protein was replaced by earthworm meal protein in diets for rainbow trout fingerlings (2.5 g of average body weight).

Diets were supplied *ad libitum* to duplicate lots of trouts, during four weeks.

In order to improve the palatability of diets incorporating *Eisenia* meal, worms coelomic fluid was removed and/or flavouring was added to diets.

Both treatments improved diet acceptance, but control diet intake was higher. Anyway, this is not the check point in the utilization of this feedstuff because diet with earthworm meal showed the worst indexes of nutritive utilization of protein. Further more, a lower proteolytic activity can be observed in the digestive tract as *Eisenia* meal intake increases, suggesting an inhibitory action of *Eisenia* meal on protein digestion.

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EVALUATION OF SOYABEAN AND LUPINSEED MEALS AS PROTEIN SOURCES FOR JUVENILE GILTHEAD BREAM (*Sparus aurata*).

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The use of vegetable protein sources in diets for marine fish has not been so much studied as in freshwater fish, in spite of the real need of partial substitutes to fish meal protein in such diets.

In order to test the nutritive value of two vegetable protein sources, 21 groups of 12 gilthead breams (*Sparus aurata*) of an average initial weight of 39 g were stocked in 100 l fiberglass tanks provided with a continuous flow of filtered seawater (19.0±1.5°C). Fish were fed on isonitrogenous (45% Nx6.25) and isocaloric diets. Dietary protein, supplied only by fish meal in the control diets, was partially substituted by soybean meal (SBM) or lupin seed meal (LSM) proteins, at 10, 20 and 30%. Each diet was fed ad libitum to triplicate groups of fish during 8 weeks.

All diets were well accepted, even those including highest levels of SBM or LSM proteins. Mean food intake was not influenced by the level of protein substitution parameter. Mean weight increase ranged from 50 to 70% on initial weight basis, obtaining the best results when including 10% of SBM or LSM proteins. Fish fed on this level also presented the best conversion index, 1.6, whereas fish fed on diets including higher proportions of vegetable proteins showed values around 2.

These preliminary results suggest the possibility of using a 10 or even 20% of SBM or 10% of LSM proteins in diets for juvenile gilthead bream.

NUTRITIVE EVALUATION OF SUNFLOWER MEAL AS A PROTEIN SOURCE FOR RAINBOW TROUT.

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The search for alternative protein sources is of great strategical interest because some countries depend on fish (FM) and soybean (SBM) meals for fish feeds manufacture. Among proteins from vegetable origin, sunflower meal (SFM) is an abundant by-product after oil extraction in many countries.

According to this, a comparative study was designed to evaluate the nutritive utilization of SFM protein against that of FM and SBM proteins.

Rainbow trouts of an average initial body weight of 40g were placed in triplicate fiberglass tanks of 65l capacity with a settling feces collector attached similar to the "Guelph system". Water was supplied at a rate of 2.3 l/min and at a temperature of 15±0.5°C.

Diets were made isocaloric (18.5 MJ/Kg) and isonitrogenous (45%). Respecting to controls, SBM and SFM proteins were at a 40% of total dietary protein.

SFM protein showed the best digestive utilization (93) followed by SBM protein (91.5) and FM protein (85.3). Nevertheless, organic matter digestibility coefficient was lower for SFM diet probably as a consequence of its higher fiber content. The best protein utilization indexes (PER and PPV) were obtained for FM protein (2.39 and 42.1) followed by diets including SBM (2.27 and 40.3) and SFM (2.16 and 37.4).

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EFFECT OF COOKING/EXTRUSION OF THREE LEGUME SEEDS ON GROWTH AND FOOD UTILIZATION BY RAINBOW TROUT.

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A 12 week feeding trial was conducted with rainbow trout (*Oncorhynchus mykiss*) to evaluate the nutritive value of three legume seeds, lupin seed meal (*Lupinus albus*), pea seed meal (*Pisum sativum*) and faba bean meal (*Vicia faba*) as a dietary replacement for a brown fish meal. These vegetable raw materials were incorporated at 20% of dietary protein with or without cooking/expansion (145°C, 25 Kg/cm^2) in six experimental diets formulated to contain 40% crude protein and 12% lipid. Experimental diets were tested in duplicate and compared to a control diet with fish meal as the only dietary protein source. Fish were fed twice a day *ad libitum* and fish bimass was determined at fortnightly intervals. Apparent digestibility coefficients of experimental diets were determined.

At the end of the trial fish fed the diets containing vegetable proteins performed better in terms of growth performance than those fed the control diet although only the fish fed the two diets containing lupin seed meal and cooked pea seed meal performed significantly better than those fed the fish meal control diet.

Thus, according with these results the feed/gain ratio and the specific growth rate of fish fed the control diet were the worst (2.19 and 1.73, respectively) than those fed all the other treatment. However, these results are not in agreement with the protein efficiency ratio (PER) of fish fed the control diet which is among the best, 1.45 compared with the best PER of 1.46 obtained with fish fed the diet containing lupin seed meal.

A COMPARATIVE STUDY OF THE NUTRITIVE UTILIZATION OF DIETARY CARBOHYDRATES BY EEL AND TROUT.

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Previous studies of others and our own group have stated a good aptitude of the eels for using with profit diets including high carbohydrates levels in a situation clearly different from that of other cultured fish. In this line we scheduled an experiment to perform a comparative study aimed to the evaluation of the adequacy of several dietary carbohydrates/protein (CH/P) mixtures in promoting production in rainbow trout and european eel.

Four isoenergetic (19 KJ/g) diets were formulated with different CH/P ratios (20/45, 30/37, 40/29 and 50/21 in % d.m.). Three replicate lots of each species were fed on each experimental diet. Trouts and eels, purchased from the respective fish farms, having an individual initial weight of 40-45g and were fed *ad libitum*, twice a day, during an experimental period 13 weeks long, on the respective diets in a pelleted form.

Although a reduction in food intake was observed for both, trout and eels, as CH/P ratio increased, this fact was more pronunced for trouts than for eels. Growth rate and Conversion Index follow a similar trend but even more pronunced. In fact, indices of protein utilization dropped drastically for 50%-CH diet in trouts whereas they were practically unchanged in eels. On the other hand, the high body fat content of eels revealed as not affected by dietary composition, even for the poorly ingested 50%-CH. All these facts seem to confirm a comparatively greater ability of eels to handle with high CH diets. Studies at both digestive and metabolical levels, now in progress, must corroborate this assertion.

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UTILISATION DE LEVURES DANS L'ALIMENTATION DU JUVENILE DE BAR (*Dicentrarchus labrax*).

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Trois types de levures inactivées (lactique, boulangerie, bière) sont incorporés à doses croissantes (10, 20, 30% des protéines) dans un régime à base de farine de poisson de Norvège. Les différents aliments (45% de protéine, 12% de lipide) sont comparés à un régime témoin sans levure, au cours d'un test de croissance de 56 jours, sur de jeunes bars de 5 g de poids moyen initial (3 répétitions par aliment). La ration journalière (distribution continue) est fixe et identique pour tous les lots.

La croissance semble légèrement améliorée, bien que de façon non significative ($p > 0.05$), pour les aliments renfermant 10% de levure lactique ou de boulangerie. Elle est par contre sérieusement déprimée ($p < 0.05$) pour 20 et 30% d'incorporation de levure de bière. Les différents régimes n'induisent pas de modification nette de la composition corporelle finale. Les taux de conversion alimentaire reflètent les résultats de la croissance. Les coefficients d'utilisation protéique sont presque toujours améliorés par utilisation des levures. La digestibilité protéique des différentes matières premières a été calculée : farine de poisson de Norvège, 91,2%; levure lactique, 87,0%; levure de boulangerie, 75,4%; levure de bière, 52,9%.

L'amélioration des coefficients d'utilisation protéique et, pour une moindre part, de la croissance pour les régimes contenant des levures ne peut donc vraisemblablement s'expliquer que par une augmentation de la valeur biologique des protéines du mélange farine de poisson - levure, ce qui reste à confirmer.

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