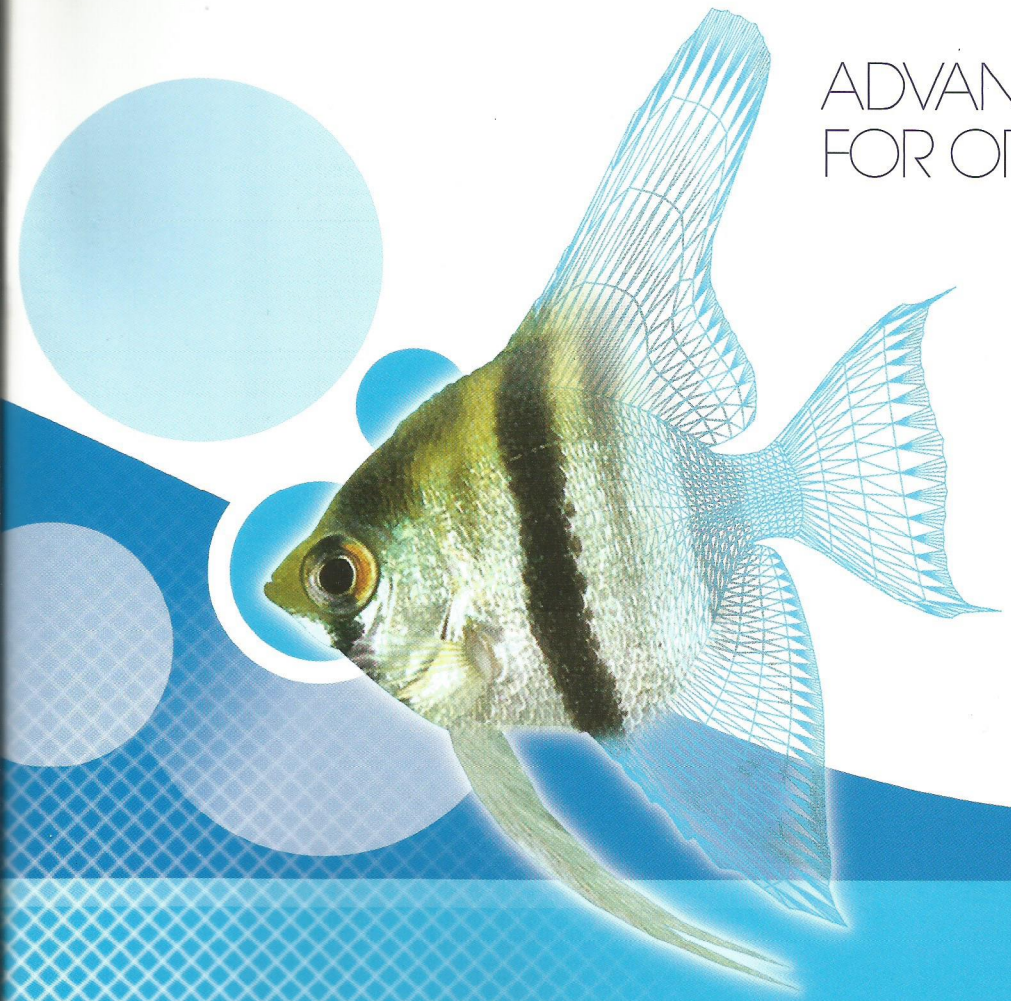
ADVANCED NUTRITION FOR ORNAMENTAL FISH



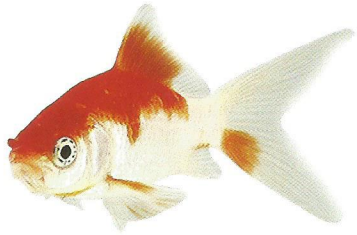
AQUARIAN®

GOOD FOOD FOR GOOD HEALTH

Good nutrition is paramount to the health and well-being of ornamental fish. The nutritional quality of the diet will have a profound influence on all aspects of the fish's lives: growth, reproduction, longevity, colouration, behaviour, activity, and resistance to disease and environmental stressors.

The combination of a high quality diet and optimal environmental conditions is the key to successful fish-keeping.

Fish food manufacturers have a responsibility to deliver the best nutrition for ornamental fish. Mars FishCare, the owners of AQUARIAN® foods, takes this responsibility very seriously.



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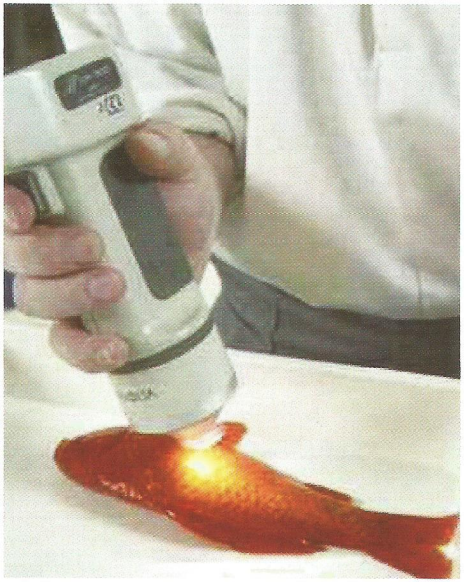
EXPERTS IN ADVANCED NUTRITION OF ORNAMENTAL FISH

AQUARIAN® has accrued over 30 years know-how in ornamental fish nutrition, health and husbandry. Part of the global Mars Fishcare business, AQUARIAN® has dedicated aquarium facilities that house tropical, freshwater, marine, and temperate fishes of ornamental interest. It is staffed by university-qualified scientists, fish nutritionists, chemists, aquarists and aquatics technicians.

RECENT AQUARIAN® RESEARCH PROGRAMMES

Research field	Details
Antioxidant properties of phytonutrients	Evaluating the benefits of dietary carotenoids in combating the side-effects of oxidative stress in ornamental fish.
Haematology and blood plasma chemistry	Investigating haematological parameters of ornamental fish species. This data helps assess nutritional status, health and immune function.
Optimised protein utilization and water quality	Studies on protein metabolism and amino acid profiling to achieve high-performance low-polluting diets.
Dietary pigments and skin colour	Studying effects of dietary colour enhancers on social signalling in the dwarf gourami *(Colisa lalia)*.
Environmental enrichment	Advancing nutritional and environmental enrichment techniques to stimulate natural feeding and activity behaviours in aquarium fish.



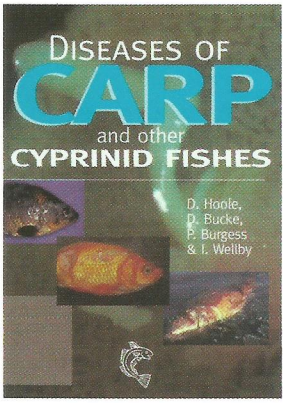
'AQUARIAN® staff regularly present their findings at international scientific conferences and in peer-reviewed scientific journals and books'

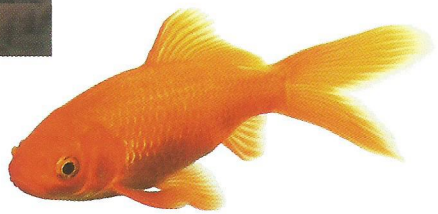
AQUARIAN® staff regularly present their findings at international scientific conferences and in peer-reviewed scientific journals and books. Over 100 articles have been published in the aquarium hobby and aquatics trade press.

AQUARIAN® actively collaborates with leading universities that are engaged in improving fish nutrition and fish heath — including the University of Plymouth, Cardiff University, and the University of Swansea.

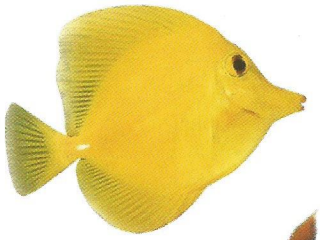
AQUARIAN® supports and funds a university lectureship in Aquarium Sciences and Conservation at the University of Plymouth.

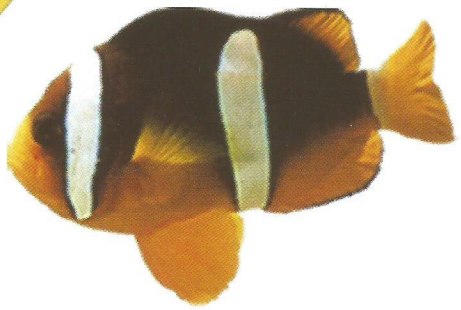
AQUARIAN® staff lecture on ornamental fish nutrition and health to aquatics training colleges (such as Sparsholt College and Reaseheath College).





COMPLETE NUTRITION

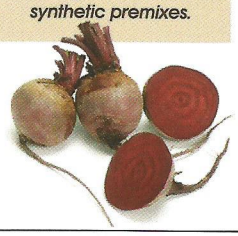




A complete diet delivers all the essential nutrients that fish need for healthy development and normal function. The importance of a complete diet is especially relevant to captive fish (particularly those held in aquariums) which have to rely mostly on foods provided by the fishkeeper.

MAJOR COMPONENTS OF A COMPLETE DIET

COMPONENT **Protein**	COMPONENT **Fats & Lipids**	COMPONENT **Carbohydrates**	COMPONENT **Vitamins**	COMPONENT **Minerals**
FUNCTIONS *Essential for tissue growth and repair, and for metabolic regulation processes. Also used as an energy source.*	FUNCTIONS *A rich source of energy; fats have twice the calorific (energy) value of proteins and carbohydrates. Also a key component of cell membranes and for the synthesis of prostaglandins and other eicosanoids.*	FUNCTIONS *Used for energy.*	FUNCTIONS *Diverse roles associated with physiological and metabolic activities. Some vitamins play an important role in immunity and the resistance to stress.*	FUNCTIONS *Major structural elements of bones and teeth. Also play a role in blood formation and function. Present in cell fluids and other tissues.*
MAJOR SOURCES IN AQUARIAN® FISH FOODS *Eggs Fish meal*	MAJOR SOURCES IN AQUARIAN® FISH FOODS *Cod liver oil*	MAJOR SOURCES IN AQUARIAN® FISH FOODS *Wheat Starch*	MAJOR SOURCES IN AQUARIAN® FISH FOODS *Vegetables. Vitamin levels are boosted using natural and synthetic premixes.*	MAJOR SOURCES IN AQUARIAN® FISH FOODS *Various raw components. Levels boosted using a premix.*

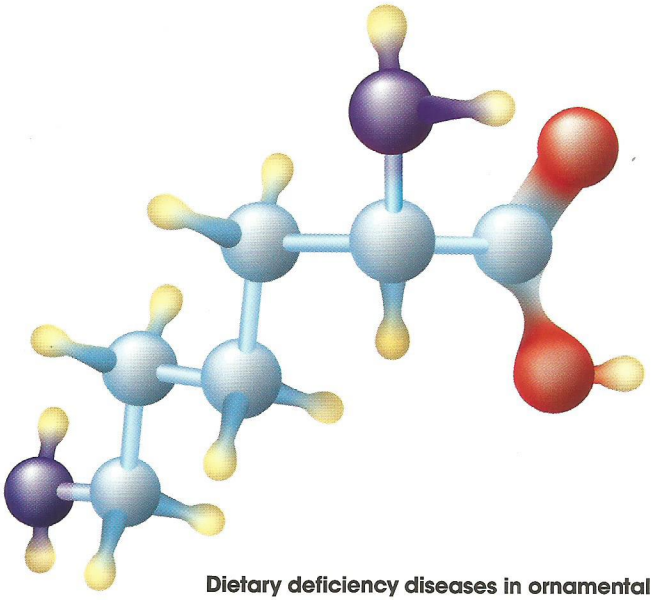


Protein chemistry: essential amino acids

Proteins are large molecules that consist of chains of many hundreds or thousands of sub-units known as amino acids. About 20 different amino acids are used in the construction of proteins. Some of these amino acids can be synthesised by the fish. However, there are ten amino acids that fish cannot manufacture themselves and these must be obtained via the diet — these are known as essential amino acids (EAA).

All AQUARIAN® foods supply the ten essential amino acids that fish require in order to manufacture proteins. They are: Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan, and Valine.

MOLECULAR MODEL OF LYSINE
– an essential amino acid for fish



Dietary deficiency diseases in ornamental fish

Nutritional deficiency problems in fish are mostly caused by a lack of certain key micronutrients. Even if just a single essential ingredient is missing from the diet, this will result in development abnormalities, disease, or even death.
For example, a dietary lack of thiamine (vitamin B1) or riboflavin (vitamin B2) has been linked to poor growth, haemorrhaging of the fins or skin, and disorders of the nervous system.

'...there are ten amino acids that fish cannot manufacture themselves and they must be supplied by the diet — these are known as essential amino acids (EAA)'

Micronutrient	Deficiency symptoms in fish
Pantothenic acid	Anaemia. Exophthalmia (pop-eye). Clubbing of the gill lamellae.
Niacin	Dropsy-effect (oedema in stomach). Swollen gills. Skin haemorrhages.
Folic acid	Anaemia (lowered red blood cell count). Pale gills.
Vitamin E	Anaemia. Pale gills.
Vitamin C	Haemorrhaging of fins and skin. Deformed backbone (scoliosis and lordosis). Poor wound healing.
Vitamin A	Exophthalmia (pop-eye). Fading of skin colours. Haemorrhaging of fins and skin.

AQUARIAN® ADVANCED NUTRITION — MADE WITH NATURAL INGREDIENTS

Why natural?

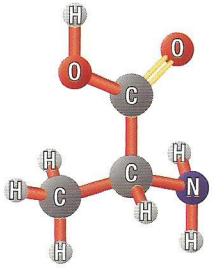
The inclusion of natural ingredients in AQUARIAN® diets helps reflect the various food items that fish consume in the wild — such as single-celled microorganisms, algae, higher plants, aquatic invertebrates, and fish.

The use of natural ingredients ensures the best formulation to deliver maximum nutritional value. For example, amino acids and sugars can each exist in two structural forms, known as L and D isomers. These two isomers are mirror images of each other — just like our left and right hands.

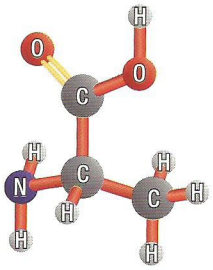
Fish and other animals utilise L isomer amino acids whereas the D amino acid isomers are of less nutritional value. In the case of sugars, it is the D isomers that are nutritionally important.

The incorporation of natural ingredients in AQUARIAN® foods ensures that fish receive the correct isomeric forms of these key nutrients.

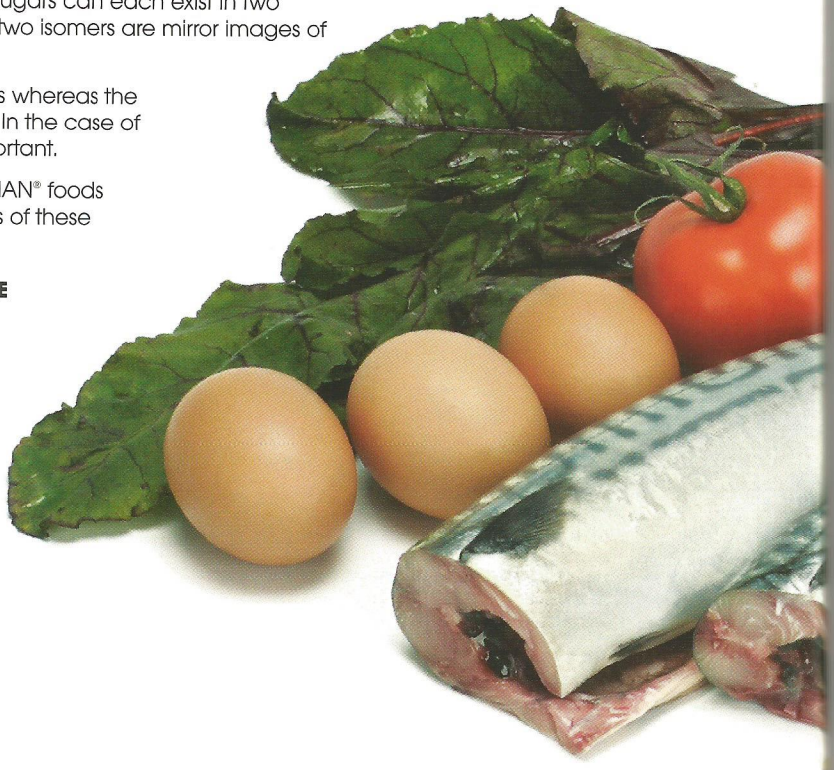
L- AND D- ISOMERS OF THE AMINO ACID, ALANINE



L-Alanine



D-Alanine

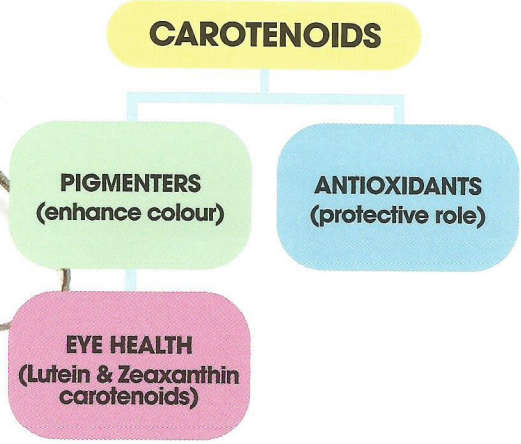


'Fish cannot manufacture carotenoids themselves, hence these important substances must be obtained via the diet'

Natural phytonutrients

The term phytonutrients describes certain organic components that are present within plants (e.g. vegetables). They comprise a range of chemical families including the carotenoids that have proven benefits to ornamental fish. Fish cannot manufacture carotenoids themselves, hence these important substances must be obtained via the diet.

- Carotenoids function as pigmenters, helping to bring out the full natural colours of fish.
- Carotenoids help protect fish against oxidative stress, and boost the immune system to help fight disease.
- The carotenoids lutein and zeaxanthin are important for eye health.



ENHANCING THE NATURAL COLOURS OF FISH

Skin colouration in fish serves a number of beneficial purposes, such as camouflage, recognition, and behavioural signalling. Much of the natural colouration within the fish's skin is derived from dietary pigments.

AQUARIAN® research into fish colours

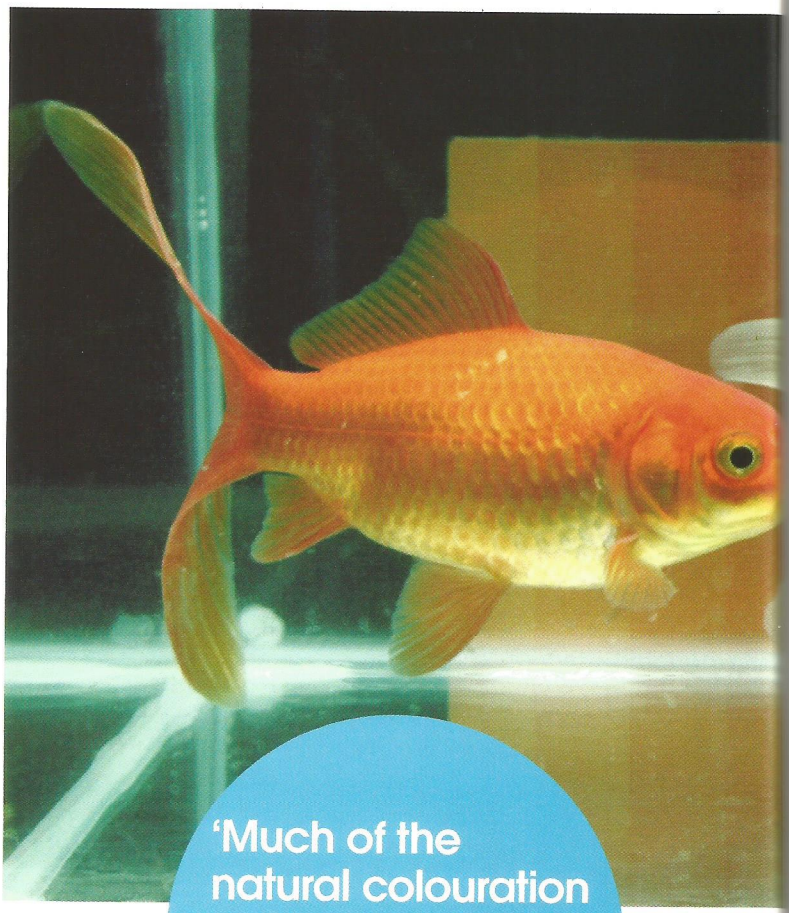
Over the years, AQUARIAN® has undertaken extensive studies on dietary pigmenters and their beneficial effects on ornamental fish (see, for example, Obra *et al.* 1999).

AQUARIAN® has developed a non-invasive technique for quantifying skin colour in fish, which involves using a Minolta colorimeter (AQUARIAN® research publication: Mela *et al.* 2002).

Using this methodology a study was conducted comparing the influence of a number of natural pigmenters on goldfish colouration. The most effective pigmenter was found to be the carotenoid lutein, found naturally in marigold meal. Significant colour enhancement was detected within three weeks of receiving the lutein-rich diet.

Lutein is commonly found in the xanthophores (yellow pigment cells) of several fish species, including goldfish. Lutein is one of several natural colour enhancers used in AQUARIAN® foods.

The betalains are another group of natural pigmenters found in fish. Studies by AQUARIAN® have shown that dietary betalains protect the colours of ornamental fish when stressed (AQUARIAN® research publication: Baron *et al.* 2008). Betalains also have antioxidant properties — see Antioxidants, page 12.



'Much of the natural colouration within the fish's skin is derived from dietary pigments'

The goldfish on the left was fed a diet containing lutein. The goldfish on the right was fed the same diet but without lutein.

How fish get their colours

The colour of the fish's skin is due mostly to pigments that are packaged within special cells known as chromatophores. The chromatophores are located mainly in the dermal layer of the skin. The fish's internal organs may also possess 'free' colours that are not associated with chromatophores.

Colour cells in fish

The colours produced by cells are either due to pigments (known as biochromes) or are the result of light refracting or reflecting from the fish's body surface (these are known as 'structural' colours or schematochromes).

Dietary pigments and reproduction in ornamental fish

Studies by AQUARIAN® in conjunction with the University of Plymouth (UK) have revealed a link between dietary pigments and mate choice in dwarf gouramis (*Colisa lalia*). Female dwarf gouramis were found to be more attracted to males whose skin colour had been enhanced through the dietary intake of certain pigments. (AQUARIAN® research publication: Baron *et al.* 2008). These studies show the potential benefits of dietary pigmenters for the captive breeding of gouramis and other ornamental fishes.

All AQUARIAN® food granules contain lutein. AQUARIAN® colour flakes contain higher quantities.

ANTIOXIDANTS PLAY A KEY ROLE IN HEALTH AND LONGEVITY

Antioxidants are important dietary constituents that have many health benefits for fish. They play a role in dampening the side-effects of oxidative stress.

Free radicals and oxidative stress in fish

Fish (and other animals) produce chemicals known as "free radicals" during normal metabolism (e.g. mitochondrial respiration) and as part of their response to disease, ageing, pollution, and certain forms of stress. If allowed to persist in the body, the highly reactive free radicals can damage the cells and tissues causing oxidative stress.

Within the fish's body, free radicals are mopped up (neutralised) by other chemicals known as antioxidants. Fish obtain these beneficial antioxidants via their diet. Important dietary micronutrients that possess antioxidant qualities are the carotenoids and vitamins E and C.

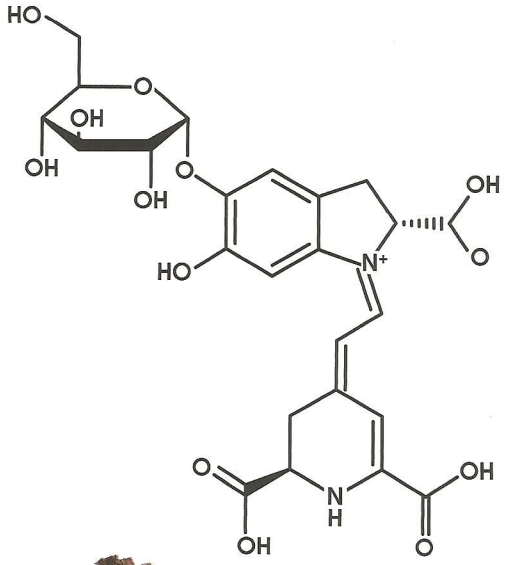
Lycopene, lutein and betalain carotenoids — natural dietary antioxidants

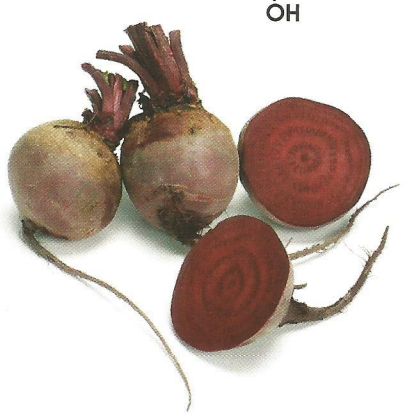
Among the natural antioxidants studied by AQUARIAN® is the betalain group of carotenoids. (The term "betalain" is derived from beetroot which is a rich source of these phytonutrients).

The betalains are themselves divided into two sub-groups — the betacyanins and the betaxanthins. A major betacyanin is betanin.

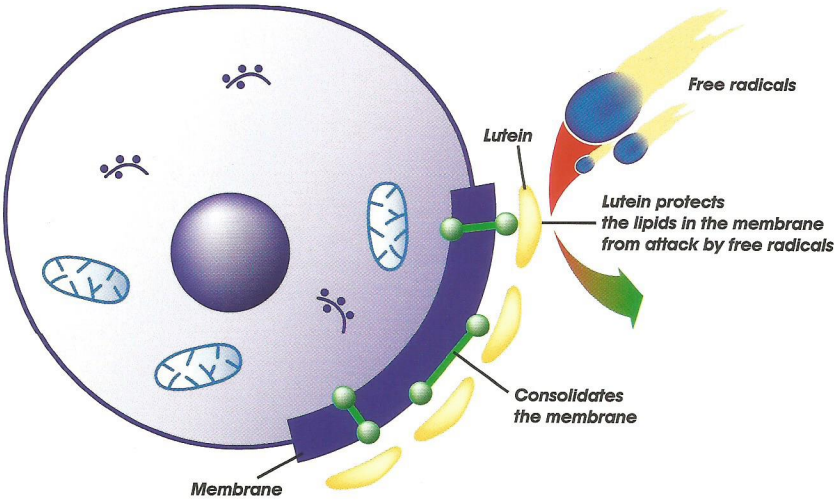
Other carotenoids with antioxidant properties include lycopene (from tomatoes) and lutein, both extensively studied by AQUARIAN®.

BETANIN- 2D MOLECULAR STRUCTURE





PROTECTIVE MECHANISM OF ANTIOXIDANTS



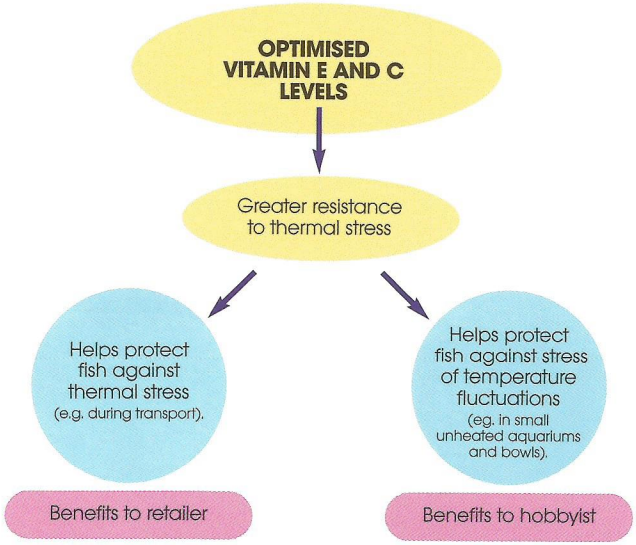
'..free radicals are mopped up (neutralised) by other chemicals known as antioxidants'

AQUARIAN®'s antioxidants combat thermal stress

AQUARIAN® studies on goldfish have shown that when fish are exposed to higher water temperatures they produce more free radicals (due to the fish's increased metabolism). This thermally-induced elevation in free radical levels can cause oxidative stress to the fish.

Studies on AQUARIAN® foods show that their scientifically optimised blend of vitamin antioxidants (vitamins E and C) helps protect fish against the stress of temperature fluctuations. These findings support the use of higher levels of vitamins E and C in AQUARIAN® diets. (AQUARIAN® research publication: Snellgrove *et al.* 2007).

Further studies have shown that the antioxidants used in AQUARIAN® diets are taken up into the fish's blood and tissues where they help the immune system.



CREATING THE PERFECT BALANCED FOOD

A correctly balanced diet contains all the necessary ingredients in the right proportions to deliver optimal nutrition. This is one of the hallmarks of an advanced food formulation.

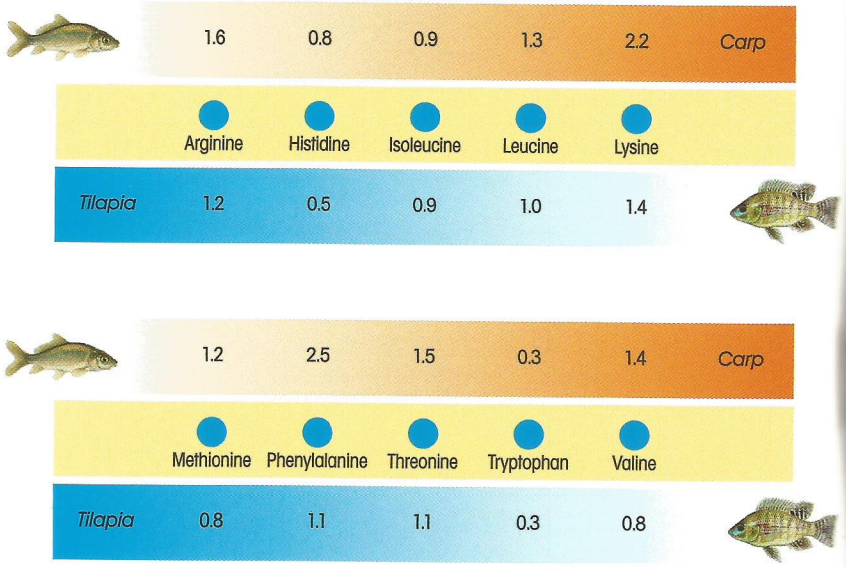
Considerations when formulating a balanced diet

- Provision of appropriate lipids and carbohydrates as energy sources.
- Provision of quality proteins (containing all the essential amino acids) for tissue growth and repair.
- Understanding of possible synergistic antagonistic and sparing interactions between macro — and micro-nutrients.
- Provision of non-limiting levels of minerals, vitamins, and other micro-nutrients.
- Provision of the essential fatty acids - Omega 3 and 6 series.

Amino acid profiling

AQUARIAN® uses amino acid profiling techniques to ensure that its diets contain the essential amino acids in the correct proportions for protein synthesis. This is important as some essential amino acids are required in greater proportions than others. For example, the fish's dietary requirements for the amino acid lysine are generally far higher than for histidine or tryptophan (based on percentage of dry diet).

ESSENTIAL AMINO ACIDS PROFILE



Indispensable amino acid requirement of juvenile common carp and juvenile Nile tilapia. Values as percentage of dry diet. Carp and tilapia diets comprise 38.5% and 28% total dietary protein respectively (Data from Nose, 1979; Santiago and Lovell, 1988).

'Optimised dietary amino acids profile in AQUARIAN® – benefits for water quality and fish health'

Optimised amino acid composition

Individual amino acids (colours represent different amino acid types)

High proportion of amino acids used for protein synthesis (tissue growth)

Sythesized protein from amino acid building blocks

Minimal levels of excess amino acids

Minimal production of toxic ammonia

Cleaner, safer aquarium water

Healthy fish

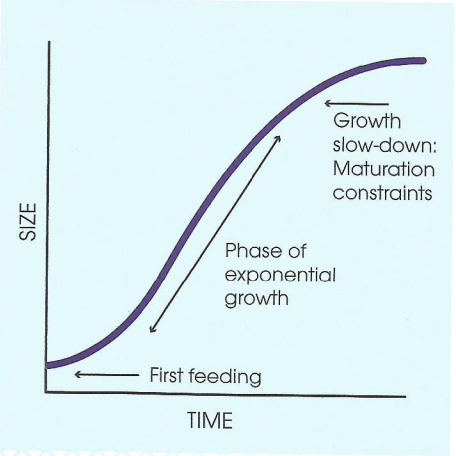
HEALTHY GROWTH AND NUTRITION

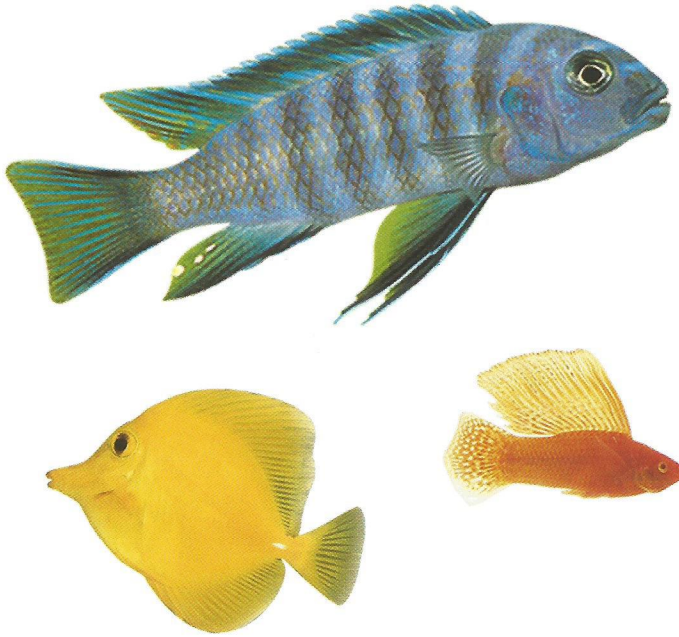
Many fish that are purchased for the aquarium or pond will be immature specimens that have not reached adult size. Proper growth of these young fish is essential for their long-term health, for any growth abnormalities are generally irreversible and incurable.

Paramount to healthy growth is good nutrition.

Poor nutrition is a significant cause of growth abnormalities in fish. For example, a dietary lack of phosphorus can lead to stunted growth and bone defects such as demineralisation ("fragile bones") and spinal curvature.

SIGMOID GROWTH CURVE OF A TROPICAL FISH





Fish do not grow at a steady rate. During early development, their rate of growth (relative to body weight) can be extremely high. For example, the fry of some species are capable of increasing in weight by up to 40% per day. With the onset of sexual maturity, the growth rate slows down and a significant proportion of the diet is channelled into gonadal development: ovaries and testes. When fully adult, growth virtually ceases.

'Paramount to healthy growth is good nutrition'

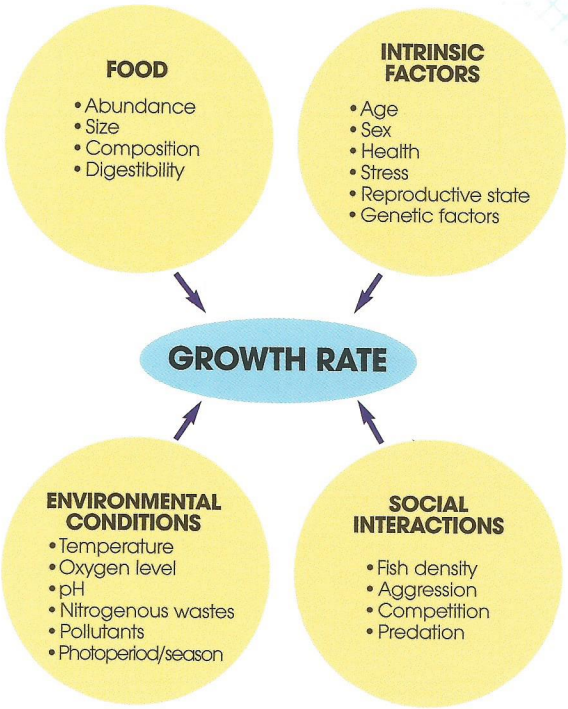
AQUARIAN® ensures that all its diets produce normal growth in fish. As part of AQUARIAN®'s scientific feeding trials a number of growth indices are monitored at regular intervals over the course of the study. The resultant morphometric and weight-gain data is critically evaluated to confirm that fish fed on AQUARIAN® diets grow into normal healthy adults.

Growth and dietary performance indices monitored during AQUARIAN® feeding trials:

Specific growth rate (SGR) = 100 x (ln w2–ln w1)/ trial days) where w1 and w2 is the weight of the fish on day 0 and end day, respectively.
> Measures gain in body weight over time.

Food conversion ratio
(FCR) = Bodyweight gain (g) / weight of food fed (g).
> Indicates proportion of food converted into tissues.

FACTORS THAT CAN INFLUENCE GROWTH IN AQUARIUM FISH



AQUARIAN® FOODS TECHNICAL DATA

AQUARIAN® FLAKE DIETS

Tropical flake

- Advanced formulation fully meets the nutritional requirements of tropical community fish.
- Rich in natural protein sources including fish meal.
- With natural pigmenters and antioxidants to improve colour and health.

Goldfish flake

- Delivers superior nutrition for goldfish and other coldwater cyprinids.
- Contains optimal protein levels required by goldfish, as shown by AQUARIAN®'s in-house nutrition studies.
- For all types of common and fancy goldfish. Also ideal for small koi and other coldwater fish.

Colour enhancing food

- Enriched with high-performance natural pigmenters selected from AQUARIAN® trials.
- Scientifically proven to enhance the natural colours of tropical and coldwater fish.

Vegetable flake

- Contains unique blend of plant and algae-derived ingredients.
- Specially formulated for freshwater and marine fish that require high levels of dietary vegetable matter.
- Ideal for barbs, livebearers and other herbivorous species. Provides vegetable enrichment for all community fish.

Marine flake

- Delivers all the nutritional needs of marine fish.
- Includes fish and shellfish derivatives, algae and molluscs — reflecting natural food organisms found on the coral reef.
- Readily accepted by wild and captive-bred marines, as proven by AQUARIAN®'s scientific palatability studies.

Baby fish food

- Complete protein-enriched diet to ensure healthy growth and development in young fish.
- Optimal levels of essential amino acids, minerals and vitamins for normal formation of soft tissues and bones.
- Ideal for livebearer fry and for weaning egg-layer fry onto dry foods.

OTHER AQUARIAN® DIETS

Algae wafer

- Unique formula contains three types of algae (*Spirulina, Chlorella,* and *kelp*).
- Slow-dissolve formulation ideal for plecs and other slow-grazing fishes.
- Perfect for bottom-dwelling fish that enjoy algae as part of their diet — e.g. plecs (including L numbers), otocinclus, botias, labeos, and borneo suckerfishes (balitorids). Also enjoyed by mollies, barbs, and algae-eating cichlids.

Sinking pellets

- Delivers complete nutrition for all tropical aquarium fish.
- Rich in natural protein sources including fish meal (herring and menhaden).
- Ideal for medium-large tropical community fish, including cichlids (e.g. angels and discus), barbs, large tetras, and gouramis.

Cichlid pellet food

- Suitable for small, medium and large cichlid species
- Scientifically formulated to meet the nutritional needs of South American cichlids (e.g. Discus, Angels, Acaras) and African cichlids (e.g. Lake Malawi and Tanganyika cichlids, and Kribensis).
- With Spriulina algae for cichlids that require vegetable matter

Goldfish pellets

- A complete diet comprising floating and sinking pellets to allow goldfish to feed at all levels.
- Perfect nutrition for all types of goldfish including common, shubunkins, moors, lionheads, fantails and orandas. Also ideal for small koi and other coldwater fish.

FLAKE INGREDIENTS

Up to five different types of flake are used in the AQUARIAN® flake food range: brown, red, yellow, orange and black. Each colour flake delivers complete nutrition but has its inherent benefits and unique nutritional profile. AQUARIAN®'s flake mix provides fish with nutritional variety and feeding enrichment.

BROWN — With natural kelp for herbivorous fish

RED — Rich in fish protein and amino acids

YELLOW — Egg protein to deliver essential amino acids

ORANGE — Contains high-performance antioxidants and carotenoids for health and colour

BLACK — High in protein for healthy growth and development

FEEDING STRATEGIES

AQUARIAN® has developed a concise yet comprehensive range of superior diets that enable simple feeding programmes. They offer complete nutrition and feeding enrichment without the need to use a bewildering range of fish food products.

AQUARIAN® diets fall into two categories:

Staple diets. Nutritionally complete diets which can be fed every day, 7 days per week.

Speciality diets and treats. These foods are also nutritionally complete. However, they are generally given occasionally – e.g. 4 to 5 times per week instead of the staple diet. These foods provide feeding enrichment and satisfy the special dietary needs of certain fish, such as algae-eaters.

Simplified feeding programmes

GOLDFISH AQUARIUMS
Staple diet (every-day food)

- For small-medium goldfish feed AQUARIAN® Goldfish Flakes.
- For medium-large goldfish (and small koi), feed AQUARIAN® Goldfish Pellets.

Speciality diets and treats (occasional foods)

- To enhance the natural colours of goldfish (e.g. if fish go off colour) give occasional feeds of AQUARIAN® Colour-enhancing food.

FRESHWATER TROPICAL AQUARIUMS
Staple diet (every-day food)

- For small-medium tropical fish feed AQUARIAN® Tropical Flake.
- For large tropical fish (e.g adult angels, discus, large barbs), feed AQUARIAN® Sinking Pellets.

Speciality diets and treats (occasional foods)

- For aquariums that house cichlids (e.g. Lake Malawi and Tanganyika cichlids, Discus, Angels, etc), feed AQUARIAN® cichlid pellets.
- To enhance the natural colours of tropical fish (e.g. if fish go off-colour) give occasional feeds of AQUARIAN® Colour-enhancing food.
- For aquariums that house barbs, livebearers and other fish that enjoy extra vegetable matter, give occasional feeds of AQUARIAN® Vegetable Flake.
- For aquariums that house benthic fish (bottom-dwellers), such as plecostomus species, botias and labeos ("sharks"), give occasional feeds of AQUARIAN® Algae wafer.

MARINE AQUARIUMS
Staple diet (every-day food)

- For most community marine fish, feed AQUARIAN® Marine Flake.

Speciality diets and treats (occasional foods)

- For marine aquariums that house yellow tangs and other fish that enjoy extra vegetable matter, give occasional feeds of AQUARIAN® Vegetable Flakes.

FRY REARING AQUARIUMS

- Good nutritional is vitally important for the healthy development of fry. AQUARIAN® Baby Food is specially formulated to ensure healthy growth in young fish.

This high protein diet is ideal for baby livebearers (e.g. guppies, mollies) and for weaning baby egg-layers onto dry foods.

FEEDING DYNAMICS – HOW MUCH, HOW OFTEN?

In addition to researching the nutritional composition of its diets, AQUARIAN® has undertaken extensive studies on the practicalities of feeding ornamental fish.

Feeding quantity

The energy requirements of fish are much lower than those of mammals or birds. For example, the maintenance energy requirements of a goldfish (at 20°C) is around 40 kJ / kg bodyweight / day whereas those of a dog or budgerigar are considerably higher, at around 460 and 1670 kJ / kg bodyweight / day, respectively. AQUARIAN® have studied the energy requirements of a range of ornamental fish in order to produce diets that deliver the correct energy levels (AQUARIAN® research publication: Pannevis & Earle, 1994).

For aquarium fish, gauging how much to feed is complicated by the widely differing energy needs of the various species and sizes of fish within a community aquarium. For example, a 0.18g neon tetra requires sufficient food to deliver 68 Joules of energy per day, whereas a 1.9g moonlight gourami requires around 500 Joules per day (AQUARIAN® research publication: Pannevis & Earle, 1994).

One simple feeding strategy is to give only as much food as the fish will completely consume within a few minutes. Remove any food left after this time, to prevent pollution. Some species, however, require longer foraging times, such as algae-grazing loricariid catfishes: AQUARIAN® has catered for such needs by producing a "slow-dissolve" formulation Algae wafer food that can be safely left in the aquarium until fully consumed.

Feeding frequency

The majority of ornamental fish are small species that tend to feed frequently in the wild. Studies by AQUARIAN® have shown that such fish utilise food more efficiently if the daily food ration is split into two or more separate feeds. Most ornamental fish will therefore benefit from being fed two or three times per day. Young fish need more frequent feeds.

Target feeding

It is vital to ensure that all the fish within the aquarium receive sufficient food. A strategy known as target feeding can be useful in some situations to achieve this goal.

For example, fast-sinking foods, such as AQUARIAN® Algae wafer, are ideal for target feeding benthic (bottom-dwelling) fishes, such as catfishes and loaches, that may otherwise lose out at feeding times. Nocturnally active benthic feeders (e.g. some catfishes), can be target fed by offering a fast-sinking food an hour or so after the aquarium lights have been switched off.

Species	Initial Weight (g)	Energy Requirements JDE/fish/day	Feeding Requirements mg/fish/day	% body wt./day	flakes/fish/day
Goldfish *(Carassius auratus)*	3.6	239	14.4	0.4	2.4
Neon Tetra *(Paracheirodon innesi)*	0.18	68	3.8	1.9	0.6
Zebra Danio *(Danio rerio)*	0.3	<128	<7.2	<2.4	<1.2
Kribensis *(Pelvicachromis pulcher)*	1	<182	<10.2	<1.0	<1.7
Moonlight Gourami *(Trichogaster microlepis)*	1.9	<508	<28.5	<1.5	<4.9

Energy requirements of five species of ornamental fish (Pannevis & Earle, 1994). Feeding requirements are based on AQUARIAN® flake diets of 1665 kJ / 100g and 1783 kJ / 100g, digestible energy for goldfish and tropical species respectively. Goldfish were maintained at 20°C, tropical species at 26°C (JDE = Joules of Digestible Energy).

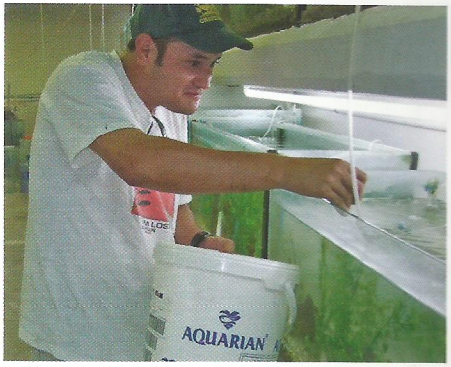
AQUARIAN®– A KEY PLAYER IN FISH CONSERVATION PROJECTS

Conservation projects supported by Aquarian®.

AQUARIAN® diets are widely used by professional aquarists and by 9 out of 10 major UK public aquariums.

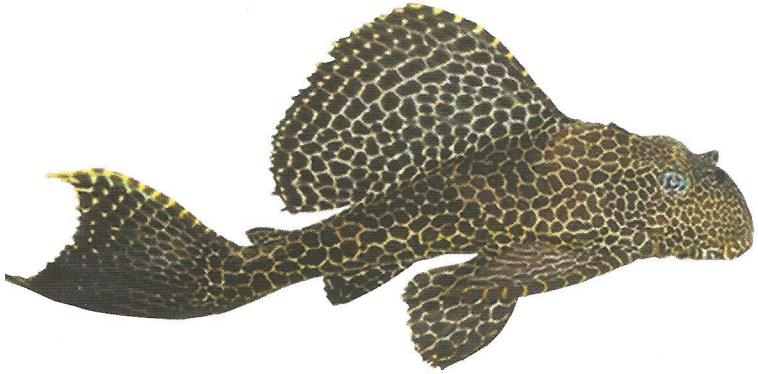
Supporting ex-situ conservation programs

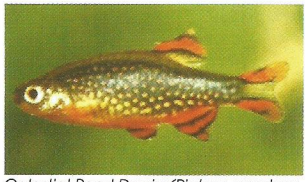
AQUARIAN® foods are used by a number of academic institutions involved in the captive breeding of highly endangered fishes. These include the Fish Ark project at Morelia University in Mexico which is involved in conserving and breeding highly endangered Mexican fishes (including livebearing goodeids such as *Ameca splendens, Allotoca goslinei,* and *Zoogoneticus tequila*).



Dr Omar Dominguez-Dominguez feeding AQUARIAN® to rare Mexican fish (Morelia University).

AQUARIAN® has funded a working visit by London Zoo aquarium staff to Project Piaba in the Brazilian Amazon. Project Piaba is involved in the sustainable ornamental fishery for cardinal tetras and other Amazonian species of aquarium interest.





Celestial Pearl Danio (Picture courtesy of Bolton Museum Aquarium).

'AQUARIAN® diets are widely used by professional aquarists and by 9 out of 10 major UK public aquariums'

Saving the Celestial Pearl Danio

Discovered in 2006, this beautiful fish is already under threat in its native Myanmar. An ex-situ breeding programme was needed to help save this species from extinction. World-class aquarists Pete Liptrot and Paul Dixon of Bolton Museum's Aquarium rose to the challenge and became the first to successfully breed this fish in captivity.

Superior nutrition was crucial. "We needed a diet that contains plenty of appetite stimulants and meets all their nutritional requirements" said Pete. "AQUARIAN® was ideal and was accepted instantly by our wild-caught adults."

PUBLISHED RESEARCH BY AQUARIAN®

A selection of scientific papers and conference presentations by AQUARIAN® staff (names highlighted) and academic partners.

Baron, M., Davies, S., **Alexander, L., Snellgrove, D.** and Sloman, K. A. (2008). The effect of dietary pigments on the colouration and behaviour of flame-red dwarf gourami, *Colisa lalia*. *Animal Behaviour* **75**: 1041-1051.

Hoole, D., Bucke, D., **Burgess, P.** and Wellby, I. (2001). *Diseases of carp and other cyprinid fishes*. Blackwell Science. 264pp.

Lupatsch, I., Floyd, R.J., Sheilds, R.J., and **Snellgrove, D.L.** (2008). Assessment of feed requirement for maintenance and growth of the anemone clown fish *Amphiprion percula*. Presented at Aquaculture America, Florida, USA (2008).

Mela, M., Smullen, R. and **Obra, R.** (2002). Non-invasive methods for measuring the accumulation of carotenoids in common goldfish (*Carassius auratus*) fed by astaxanthin, canthaxanthin and lutein supplemented diets. *Proceedings of the 10th International Symposium on Nutrition and Feeding in Fish*, 225.

Obra, R., McCartney, A.I., Boaz, M., and **Priestley, S.M.** (1999). Carotenoid metabolism in ornamental fish. *Proceedings of the 1st International Meeting on Zoo Animal Nutrition*, Rotterdam, Netherlands.

Pannevis, M.C and **Earle, K.E.** (1994). Maintenance energy requirements of five popular species of ornamental fish. *Journal of Nutrition* **124**: S2616-2618.

Priestley, S.M., Stevenson, A. E., and **Alexander, L.G.** (2006). The influence of feeding frequency on growth and body condition of the common goldfish (*Carassius auratus*). *The Journal of Nutrition*, **136** (7S): 1976S.

Priestley, S.M., Stevenson, A.E., Hawthorne, A.J. and **Alexander, L.G.** (2006). Methods for predicting food allowances from body length in tropical and temperate ornamental fish species. *The Journal of Nutrition*, **136** (7S): 2078S.

Snellgrove, D.L., Priestley, S.M. and **Alexander, L.G.** (2007). The effect of water temperature on plasma antioxidant and MDA levels in the common goldfish *Carassius auratus*. Presented at *Aquaculture, Texas*, USA.

Snellgrove, D. L., Priestley, S.M. and **Alexander, L. G.** (2008). Effect of dietary protein level on growth parameters, blood haematology and apparent protein digestibility in adult goldfish *Carassius auratus*. Presented at Aquaculture America, Florida, USA (2008).

Snellgrove, D.L., Priestley, S.M., Brown, S.C., Mann, S.J., Tregaskes, C.A., and **Alexander, L.G.** (2008). Haematology and plasma chemistry of the red top ice blue mbuna cichlid *Metriaclima greshakei*. Presented at XIII ISFNF, Brasil (2008).

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