

## MAN-MADE FISH: DOMESTICATED FISHES AND THEIR PLACE IN THE AQUATIC TRADE AND HOBBY

Svein A. Fosså, President, Ornamental Fish International

---

The following text was presented as the Keynote Address at Aquarama 2003, held in Singapore between 30 October and 2 November, 2003.

---

In this presentation, I will discuss the place of domesticated fishes in the aquatic trade and hobby. For this, we first need to establish what exactly I mean by a domesticated fish. For example, is everything we keep in aquaria domesticated in a sense, or can we narrow it down in any way?

### The Domesticated Animal

Although the word 'domesticated' has the same origin as 'domestic', the domestication of animals is a process involving much more than merely keeping the animals in our homes, or on our farms. For the term 'domestication' to have any practical meaning, we must define it as changing animals so that they differ in some significant way from their wild ancestors, whether those predecessors are still extant or are now extinct. We can define 'domesticated animals' as "animals that have been genetically altered as a direct result of their involvement with us"<sup>1</sup>. We are talking about animals where man has had control over breeding over a long period of time, so much so that the animals are significantly changed in behaviour and/or appearance<sup>2</sup>.



Domesticated goldfishes were the very first fishes to be commonly kept as pet fish in Europe. Detail from vintage postcard (ca. 1910), in Svein A. Fosså's possession.

Domestication is qualitatively different from the term 'taming'. A 'tamed animal' would be one that is technically still a member of a wild species, but where it, possibly along with more individuals, have been behaviourally adapted to tolerate the proximity of man. That is probably how the domestication of most animals started, when the first dogs, goats, sheep and reindeer were



kept by man, many thousands years ago. At that time, man did not set out for strange places in pursuit of exotic species, like we have done over the last several centuries. It was the animals surrounding them, where they lived, that were gradually adapted to tolerate man's presence, and man's use of them. In Asia, the elephant is a good example of a local animal that was tamed very early – but probably never really domesticated, in the sense I am using the term here.

Going back to the common domesticated farm animals that we now see all over the world, it is not easy to establish exactly when man's presence first induced so much effect on the genetic qualities of the first tamed species, that they could be called 'domesticated', since there are no direct historical records. Furthermore, the remains of early domesticated animals that occur in archaeological finds are, more often than not, indistinguishable from the remains of wild animals from the same era. Still, the dates of actual domestication are being constantly pushed back by discoveries both in the past world of archaeology and in the inner world of DNA<sup>2</sup>. Today it is generally believed that domestication of several species began more than 10,000 years ago; for some, like the dog and goat, it had probably already begun 15,000 years ago<sup>1</sup>.

### Man's Aesthetical Desires

While most of the first processes of domestication probably focused on food and nutritional needs, as well as improving the use of animals for other products and services that man needed, like beasts of burden and watchdogs, man had also other interests in animals. Taming of animals for keeping as pets is known even from old and primitive cultures, and many changes in domesticated animals were soon carried out for improving the looks of these animals.

The desire to improve on nature for aesthetical reasons has long traditions. Consider, for instance, the desire to build parks and gardens, something that has been, and is, practised in nearly all advanced human cultures. Changing the qualities of animals is no exception in this respect. Already from ancient Egypt, we find many examples of manipulation of animals' looks. For instance, the Egyptians developed cats with 'godly' looks for use in their temples, and they created cattle breeds with extremely long and impressive horns. Chinese culture, too, has played an immense role in creating mainly decorative plants and animals, not only goldfish, which may be the most relevant species to us, but also, for instance, dog breeds with lion-like appearances.

European culture has shown the same trends. Through hundreds of years, European breeders have focused on creating new, more beautiful, more impressive or stranger varieties of roses, tulips, carnations and many other flowers, as well as of dogs, cats, rabbits, pigeons, chicken, budgerigars and canaries.

All in all, man has induced so many intentional changes in domesticated animals and plants, that – when Charles Darwin needed arguments to explain his theory of evolution – he used the variation of animals and plants under domestication<sup>3</sup> for this.

## Technologies

Before we continue on to the specifics of fish domestication, it might be worthwhile to summarise some of the technology that has been and is being used to alter the genetical qualities of animals and plants (see Table 1).

Notwithstanding the fact that, for thousands of years, classical breeding has been used to alter animals and plants, there is no doubt that the rediscovery and recognition of Mendel's laws of inheritance in 1900, and their application, gradually made breeding a science-based technology. In agriculture, particularly in crop improvement research, modern technology rapidly gained a foothold. It certainly took much longer before ornamental fish breeders started to use more advance methods, but only by looking at the agenda for the 2003 Aquarama Conference, there is no question that technology now has become an important aspect of the aquarium industry as well.

**Table 1: Technologies**

- Classical breeding (selective breeding, inbreeding)
- Induced mutation
- Interspecific hybridisation
- Chromosome engineering
- DNA marker technology
- Genome sequencing (genomics)
- GM techniques



## Early Keeping of Fishes

Although reliable ancient sources indicate that the very first fish keepers, who kept fishes in ponds, lived in the Middle Eastern cultures of Assyria, Summeria and Mesopotamia already more than 4,000 years ago<sup>4/5</sup>, it is not clear whether these people had much interest in the fishes beyond their practical use for human consumption.

Egyptians and Romans, on the other hand, showed obvious interest in the decorative value of the fishes they kept. Wall paintings from ancient Egypt, dating back to about 1,400 B.C., shows the use of cichlids in decorative garden ponds<sup>6</sup>, and several literary sources tell of fishes being kept as precious pets by the Romans as long as 2,000 years ago.

The orator Quintus Hortensius and the triumvir Marcus Licinius Crassus were said to have kept moray eels as pets and to have wept when they died<sup>7</sup>. Morays were also adorned with jewellery, earrings and neckbands, and were trained to come at the call of their names! Still, none of the sources relating to these very early examples of fishkeeping give any indication of selective breeding or true domestication being attempted. That, of course, does not necessarily mean that it did not take place. After all, we know that other animals were actively domesticated at the same time and places.

## The First Domesticated Fish

The honour for having created the first truly domesticated fishes, according to the definition of domestication that we have established, is something we can, with near absolute certainty, attribute to the Chinese. The earliest Chinese literature that mentions goldfish (or at least, we believe they were goldfish) dates from the first half of the first millennium and notes reports of specimens of wild fish with red scales in the Tsin (or Jin) dynasty period (AD 265-420).

Most probably, religious aspects played an important role in elevating these red-scaled fish from a merely interesting natural phenomenon, up to a first case of domestication of fish. Buddhism came to China from India in the first century of the first millennium, and one of its more important tenets is respect for all forms of life. One way of showing such respect was by rescuing some potential food animals from their fate. This was often done by setting captive animals free, something which is still a popular tradition for many Buddhists, although the practice is increasingly being criticised because of its potential environmental impact<sup>8</sup>. Another way of rescuing animals was to establish sanctuaries. With their conspicuous colour, the early goldfishes were very likely candidates for keeping in fish ponds within Buddhist temples and monasteries where the monks acted as guardians<sup>10</sup>.

Under the dynasties that followed, the Chinese goldfish breeding was gradually perfected, but it is particularly from the latter part of the Ming dynasty (1368-1644)

that we can find evidence that goldfish breeding became very important. Ming is the single Chinese Imperial dynasty that is best known in the West, something that obviously relates to it being the Golden Age of Chinese ceramics and pottery production. As earthenware vessels became readily available, goldfish were not any longer reserved for the wealthy or temples and monasteries; they gradually became pets for the masses. Control of breeding also became easier when breeding stock could be confined by more practical means.

Chinese sources from the 16<sup>th</sup> century tell of single-coloured goldfish, as well as multi-coloured and variegated fishes. Even more interestingly, sources which are more than 400 years old describe exclusive fishes with double and triple tails, fishes with enlarged eyes and fishes



The oranda is among the goldfish varieties that are suspected to suffer from too extensively developed hoods, impairing swimming and reducing eyesight.

Photo: SVEINA. FOSSÅ



with shortened bodies<sup>9</sup>. Goldfishes without dorsal fins, and telescope-eyed varieties were already well known in China in the early 18<sup>th</sup> century<sup>10</sup>. As early as the 16<sup>th</sup> century, goldfish were already well established in Japan<sup>11</sup>, and about a hundred years later, the first imports to Europe took place. It is generally acknowledged that the fishes that the famous Londoner, Samuel Pepys, noted in his Diary of 28 May, 1665, to have seen at the home of "Lady Pen" (the mother of William Pen, founder of Pennsylvania, USA) were, indeed, goldfish: "Thence home and to see my Lady Pen, where my wife and I were shown a fine rarity: of fishes kept in a glass of water, that will live so for ever; and finely marked they are, being foreign."<sup>12</sup>

Already in 1742, the English poet, Thomas Gray, wrote his famous *Ode on the Death of a Favourite Cat, Drowned in a Tub of Goldfishes*, which was magnificently illustrated by William Blake around 1798. Some time between 1775 and 1784, it became a very common practice in England to keep goldfish, which were commonly termed "Gold and Silver Fish", in glass bowls<sup>13/14</sup>. This was seventy or eighty years before the appearance of the world's first aquarium book (Gosse's *The Aquarium: An Unveiling of the Wonders of the Deep Sea*<sup>15</sup>), commonly accepted to be the starting point of modern aquarium keeping. In other words, it would be fair to say that Chinese domesticated goldfish were the first fishes to be commonly kept as pet fish in Europe.

### More Domesticated Ornamental Fishes Appear

Time does not permit me to go into more detail on the development of the aquarium hobby, but we know that the first massive aquarium interest in Europe in the Victorian era focused exclusively on keeping native species, fresh- and saltwater. However, the public's vast interest in exotic animals, as one could see in many other groups of pet animals like monkeys and parrots<sup>16/17</sup>, gradually led to imports into Europe and North America of an increasing number of exotic, foreign fish species as well. The difficulties involved in keeping fishes alive on long journeys meant that it took some time, though.

At the turn of the 19<sup>th</sup> to 20<sup>th</sup> century, the Paradise Fish (*Macropodus opercularis*) had become the staple tropical fish of the hobby. In fact, it was the only foreign fish, beside the goldfish and the common carp, that was included in the American hobby's landmark book *Goldfish Breeds and Other Aquarium Fishes*<sup>18</sup>, by Herman T. Wolf in 1908, but a few others, including the Chanchito (*Cichlasoma facetum*), had also clearly been imported by that time.

By 1910, a very large number of foreign fishes, primarily from South America and Asia, had been imported into Europe<sup>19</sup>, and - via Germany - many of them also rapidly entered the USA<sup>14</sup>. Among these were the Siamese Fighting Fish (*Betta splendens*), and the Guppy (*Poecilia reticulata*), which were soon to become new targets for extensive domestication aimed at the aquarium market. Exactly when domestication started in these fishes, is hard to establish with certainty, but knowing their great ability to be shaped by selective breeding, it would be fair to guess that it started immediately when breeding was undertaken, as was the case for many other species. Man has this inherent desire to 'improve' on nature, and fish are no exception.

**Table 2: More Domesticated Ornamental Fishes Appear**

Species	Varieties and hybrids of tropical fish, described by Innes, 1935 <sup>21</sup>
<i>Rivulus urophthalmus</i>	Golden Rivulus (oldest known reference from 1927) <sup>20</sup>
<i>Macropodus opercularis</i>	Albino Paradise Fish (introduced from Germany in 1933)
<i>Betta splendens</i>	Veiltail Betta, in several colour morphs (imported from Thailand in 1927)
<i>Poecilia sphenops</i>	Black Molly, and various other colour morphs
<i>Poecilia latipinna</i>	Black Sailfin Molly
<i>Poecilia reticulata</i>	Guppy, several tail and colour varieties
<i>Xiphophorus maculatus</i>	Blue Platy, Red Platy, Black Platy, Golden Platy, Variegated Platy, Berlin Platy
<i>Xiphophorus helleri</i>	Red Swordtail, Calico Swordtail, Black Spangled Swordtail (all hybrids of <i>helleri</i> X <i>maculatus</i> )
In addition, Innes mentions hybrids of several other species (including <i>Brachydanio</i> and <i>Colisa</i> ), but generally he describes these as either sterile or uninteresting or both.	
Species	Varieties and hybrids of tropical fish, described by Axelrod & Schultz, 1955 <sup>22</sup>
<i>Rivulus urophthalmus</i>	Golden Rivulus (Illustration after Innes)
<i>Macropodus opercularis</i>	Albino Paradise Fish (described as quite popular)
<i>Betta splendens</i>	Veiltail Betta, in several colour morphs, including the "Tutwiler Butterfly Betta"
<i>Poecilia sphenops</i>	Black Molly, and some other colour morphs
<i>Poecilia latipinna</i>	Black Sailfin Molly
<i>Poecilia reticulata</i>	Guppy; Golden, Golden lacetail, Blue, Red, Roundtail, Swordtail, Lyretail, Pintail, Speartail
<i>Xiphophorus maculatus</i>	Platy; Red, Red Moon, Red Tuxedo, Red Wagtail, Green Tuxedo, Black Wagtail, Golden, Gold Crescent (Moon), Golden Wagtail, Blue Moon, Salt-and-Pepper
<i>Xiphophorus variatus</i>	Variatus Platy; Redtail, Yellowtail, Sunset, Rainbow
<i>Xiphophorus helleri</i>	Swordtail; Green, Green Wagtail, Green Tuxedo, Red, Red Wagtail, Red Tuxedo, Albino
<i>Pterophyllum scalare</i>	Black Angelfish, Blue Angelfish (?)



By 1935, the American author, William Thornton Innes, described no fewer than 243 exotic freshwater aquarium fish species<sup>21</sup>. Among these were also a number of domesticated, man-made breeds produced through selective breeding, mutations and/or hybridisation (see Table 2).

Innes describes most of the man-made varieties as popular, beautiful and valuable additions to the aquarium hobby. In his description of the many platy varieties, he states: "Beyond doubt, the general awakening of public interest in exotic aquarium fishes is due in large measure to the outstanding characteristics of a few species. ... The Platy, in addition to being one of the most attractive and generally satisfactory fishes in its own right, has contributed to the aquarium a most interesting assortment of hybrids". The Veiltail Betta, originally imported from Thailand in 1927, is described as having "launched the hobby in a big way in America". He goes on to say that "its extraordinary, spectacular beauty made instantaneous conquests among those who would never have looked twice at any other fish, but are now dyed-in-the-wool fanciers and doing all in their power to interest others in the hobby".

By 1955, Axelrod and Schultz describe approximately 410 exotic aquarium fish species<sup>22</sup>. Although the number of species of which domesticated varieties occur has gone up only by two (to ten), the actual number of recognised varieties has about doubled in the twenty years since Innes (see Table 2). The general attitude towards the domesticated varieties continues to be positive and indicative of man-made fish being regarded as an asset to the aquarium hobby.

As should be common knowledge, the number of domesticated varieties continued to grow, nearly explosively up till today, when it is not uncommon to find export price lists with well over 300 different domesticated varieties belonging to 50 or more species.

The generally positive attitude to new breeds is something that continues for a long time. Even in the 60's and 70's one rarely find much critical remarks on the production of new varieties of fishes in any literature. Books, journals and aquarium society pamphlets alike, seem to carry the same message of domesticated fish varieties being an asset to the hobby. And, as we all know, customers in most markets have been similarly favourable towards new varieties as they appear.

## Early Negative Views

Obviously, it is difficult to please everybody. So just as some people would regard many new domesticated varieties as interesting additions to the assortment of ornamental fishes, others might consider them to be without interest or even a downright negative addition. Even Charles Darwin was not entirely in favour of all he saw in the world of goldfish breeding. In his extensive work on the variation of animals and plants under domestication<sup>3</sup>, first published in 1868, he wrote:

"Many of the varieties [of goldfish] ... such as triple tail-fins, &c., ought to be called monstrosities"; but he went on to state, quite wisely, "but it is difficult to draw any distinct line between a variation and a monstrosity".

The famous British aquarium book writer and director of the London Zoo Aquarium at the beginning of the 20<sup>th</sup> century, Edward George Boulenger, was equally negative to some goldfish varieties in *The Aquarium Book*<sup>23</sup>, published in 1925 (quote):

"As with many of our domesticated animals, its powers of adaptability have been abused. By interbreeding and selection, varieties have been produced some of which are really captivating, but others, at least in my opinion, are mere repulsive."

In more modern time, I first saw massive scepticism towards domesticated fishes published in the Scandinavian aquarium hobbyist magazine *Akvariet* during 1979.

It all started with an article by one of Sweden's most well known and widely published aquarium writers and speakers at the time, Sune Holm, in which he asked the question of whether we wanted "New Aquarium Fishes at Any Cost"<sup>24</sup>. Holm raised concern over some of the newer varieties of ornamental fish, where he claimed to see a trend in the direction of increasing abnormality and monstrosities in the fishes. Specifically, he pointed towards 'balloon mollies' and the more extreme veiltail varieties of species like angelfishes, mollies and guppies – where the swimming abilities were, in some cases, severely affected, or, for the live bearers, the gonopodium was disfigured in a way that would make reproduction impossible.

Although Holm, strictly interpreted, criticised only what he saw as animal welfare problems, his article could also easily be interpreted as an attack on the production of domesticated fish varieties in general. He had counted the number of fish species, wild types and domesticated forms, in three (apparently randomly selected) Singapore export price lists and raised concern of the large percentage of man-made varieties in these lists (Table 3).

**Table 3: Wild/Domesticated Fishes in Singapore Pricelists**

<b>Company no.</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>2003 average</b>
Total no. of all species & varieties:	231	253	343	608
No. of wild types:	126	121	165	253
No. of domesticated varieties:	105	132	178	355
No. of varieties of Angelfish:	22	22	24	30
No. of varieties of Guppy:	9	24	39	39
No. of varieties of Swordtail:	17	21	36	39
No. of varieties of Platy:	20	21	28	47

It is a fact that the number of domesticated varieties on the Singaporean market has increased quite a bit since this. When I counted the species and varieties offered by randomly selected Singapore exporters in 2003, I found an average of 355 domesticated varieties. The



numbers of varieties of each of the four species that Holm selected has also gone up, so there are good reasons why these recent figures could provoke even more criticism than the 24-year-old ones. Interestingly enough, however, I also found an average of 253 wild type species on offer – so that, as well, had gone up since 1979, hopefully putting, once and for all, an end to the myth that an increased selection of domesticated varieties necessarily entails a reduced selection of wild type fishes.

Reverting to the 1979-debate; "It is difficult to understand", Holm said, "how the many pitiful varieties can be sold with such success", and he immediately got a great deal of support from other writers. The discussion went on in the *Akvaret* magazine for well over a year, and although most of the debaters took a clear stand against what they called "extreme forms" (without ever defining the term properly), there were about as many defending the tradition of domesticating fishes as there were people criticising it. Still, this discussion marked, in many ways, the beginning of negative focusing on all domesticated fishes, as something inferior to wild type fishes. "Why keep a red swordtail", someone might say, "when the natural green, wild form is so much more beautiful?"

### Shifting Hobby Interests?

Critical remarks towards domesticated fishes, like the ones I have just mentioned from Scandinavia, are bound have occurred also in other parts of the world at the same time or even earlier, but I have not been able to find literature references to such. But it has been a fact that, over the last two or three decades, the advanced aquarists in the west have become increasingly interested in wild type fishes. This is a development that is clearly documented by the type of articles one finds in aquarium magazines and the focus area of the majority of books.

I am sure that many people in the trade will object and say that this isn't true, that man-made fishes in increasingly new variations are the real best sellers. I do not object to that. The problem isn't that there is no market for domesticated fish, the problem is that the opinion makers, book authors, magazine article writers and other aquarists in the spot-light, tend to describe culture forms of fishes as something negative, or rather, do not mention them at all.



Fishkeepers may love a new variety of fish, like this magnificent Flower Horn photographed at Aquarama 2003, when they first see it in the shop, but the very instant someone tells them the fish doesn't occur in nature, it can mysteriously become a symbol of evil!

Photo: SVEINA. FOSSA



When Internet became part of everyone's every-day-life, dispersal of opinions became much more easy for everybody. Over the last 4-5 years, the Internet has literally exploded with attacks on nearly all forms of domesticated fishes. A search through the most popular aquarium discussion boards on the Internet, particularly in Europe, but to some extent also in North America, reveals heaps of attacks on domesticated fishes. It is, particularly, varieties where the body form has been altered – as in veiltail goldfishes, balloon mollies and parrot cichlids – that form the main target, so that a novice aquarium keeper asking for help with his/her Red Platy might, as well, often be recommended to buy a wild type fish instead.

The Internet also carries lots of articles and websites dedicated to criticism of fish varieties and hybrids, with titles like *"Who needs another hybrid?"*<sup>25</sup>, *"The museum of horrors"*<sup>26</sup>, and *"Cruel breeds and tastelessness"*<sup>27</sup>. These are mere samples; I invite you to search the Internet yourselves for loads more stuff.

*"What relevance does this have"*, you might ask. After all, the Internet is full of strange messages, misguided beliefs and urban myths. I wouldn't have bothered too much myself, if it hadn't been so obvious that this is a spreading trend. Increasingly, we are seeing the same attitude in more traditional media, like magazines, newspapers, broadcasting, and even in government documents.

### Government Interference

"The Committee has further been informed by the Federation of Aquarium Societies, of circumstances concerning the trade in aquarium fishes, where artificially-produced aquarium fishes occur. These are produced by selective breeding, genetical manipulation, or injection of colour or cutting of fins."<sup>28</sup>

This quote is possibly the very first example that general negative attitudes towards cultured fish forms have reached Parliament levels in any country. The quote has been translated from a recent document by the Standing Committee on Business and Industry of the Norwegian Parliament, and was the direct result of lobbying from the Norwegian Federation of Aquarium Societies. So far, no laws or provisions have been enforced regulating the breeding or sale of domesticated fishes in Norway, but, for many years now, we have had regulations that can probably be used to stop some of the more extreme varieties, where it can be suspected that the animal might suffer under normal aquarium conditions.

Worse than any possible restriction on sale of certain varieties, is, however, the general negative publicity the trade receives by the suggestion that "artificially-produced fishes" are a problem. What about all the other animals we keep, also in Norway, that are artificially-produced to exactly the same extent?

No other country has gone as far in trying to prevent animal welfare problems connected to domesticated varieties of animals as Germany. As part of their Animal Welfare Laws, the German Government produced, in 1999, provisions aimed at banning any animal breeding that could lead to "pain, suffering or damage" to the animal<sup>29</sup>. Such varieties are referred to as "Qualzüchtungen" in German, freely translated we might call it "cruel breeds" "suffering breeds".

The current German provisions give detailed information on what isn't permitted in animals like dogs, cats, rabbits and many birds, but has not yet been formally applied to ornamental fishes, although German aquarium literature is filled with examples of what the individual authors regard as "Qualzüchtungen" of aquarium fishes. It must be expected that some of this will gradually be implemented in laws.

In most cases it is not a question of banning a specific breed, but, rather, to ban continued breeding with parents that carry certain unwanted traits. Let me give you some selected examples of breed traits that are considered unacceptable and, thus, banned, in some other animals than fishes (see Table 4):

<b>Table 4: Breed Traits Regarded as Unacceptable in Germany</b>		
<b>Dogs</b>		
Blue-Dog-Syndrom	Dobermann, Greyhound, Irish Setter, Poodle and others	A bluish grey colour, which comes from abnormal development of the hairs
Abnormal tail development	Cocker Spaniel, English Bulldog, Mops and others	Irregular tail development, bent or corkscrew-shaped, often related to other problems with the vertebral column
"Naked dog", hairlessness	Chinese Crested and others	Lack of fur, involving highly sensitive skin, often coupled to other problems like jaw/tooth problems
Abnormally rounded head shape (brachycephaly)	Boxer, Bulldog, Chihuahua, Mops, Pekingese and others	Disposition for brain tumours, nasal stenosis with breathing difficulties, problems with thermoregulation and eating disorders
<b>Cats</b>		
Shortened or missing tail	Manx, Cymric and others	Reduced balance and abnormal movements, often related to vertebral column and other skeletal disorders etc.
Abnormally rounded head shape (brachycephaly)	Persian, Exotic shorthair and others	Nasal stenosis, blocked lacrymal ducts, and more.
<b>Pigeons</b>		
Abnormal feathers with a silky appearance	Silky, Lace Pigeons	Strongly reduced or lacking flying capabilities
Extremely large muffs (foot feathers)	Several breeds	Long feathers on the feet that may lead to reduced mobility and problems in nesting

When, sooner or later, governments move on to defining what traits are acceptable or not in ornamental fish breeds, it is clear that they will be looking to single out variations that are believed to suffer or have a disposition for damage related to a particular trait in the breed. Although it may be difficult to find objective criteria for an animal's suffering (and it certainly is when it comes to a fish's suffering), people are, increasingly, judging ornamental fish varieties by what some consider as objective criteria for suffering. From discussions in various articles<sup>30/31/32</sup>, it seems clear that extreme developments of the following traits in fishes are particularly open for criticism (Table 5):

**Table 5: Criticised Traits in Some Fishes**

Lyretail and Veiltail	Breeds of many species	In extreme cases, swimming difficulties and reduced vitality, in some livebearers also enlarged gonopodium, leading to reproduction problems
Helmets, caps and crests	Lionheads and other goldfish breeds	In extreme cases, swimming difficulties, sometimes blindness through covering of eyes.
Telescope and bubble eyes	Several goldfish breeds	Possible vision problems, risk of damage
Skeletal modifications	Balloon forms of many species, goldfish varieties, parrot cichlids	In extreme cases, swimming difficulties and reduced vitality
Deformation of mouth	Parrot cichlids and others	In some cases, deformed mouth, leading to eating disorders
Lack of tail	Various cichlid varieties	Lack of tail makes swimming difficult

### When Genes are Not Enough

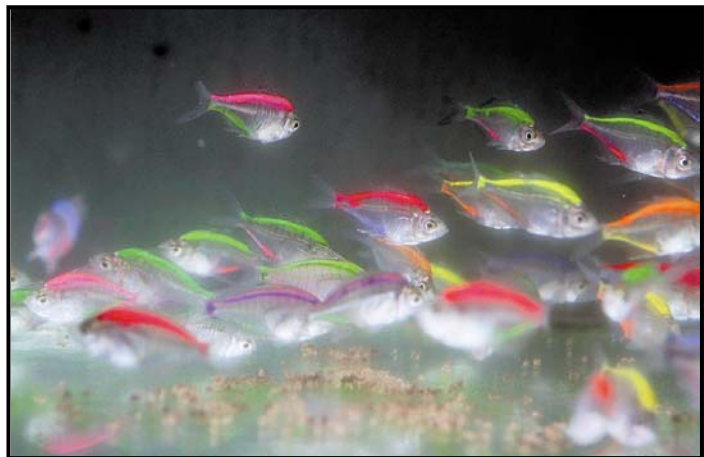
Improving the appearance of animals and plants by selective breeding has its obvious limitations. If no gene for a certain character can be found, not even in mutations, it might be necessary to use physical manipulations to satisfy man's longing for the unusual. This is not really a question of domestication, since it can be done on any animal or plant, also wild ones, but for all practical cases, it is an example of 'man-made' organisms, and thus relevant for this presentation.

Shaping bushes and shrubs into geometrical figures or sculptures, or creating bonsai trees, is one way of physically manipulating nature, which is not controversial in any way since it relates to plants. There are, however, many more opponents when one starts to manipulate animals. Shaping the fur of dogs, like giving lion cuts to poodles, is generally accepted, but dyeing them is more disputed. The same goes for dyeing other animals, like mice,

budgerigars and canary finches. It might primarily be a question of good or bad taste, but many people make it into a question of animal rights: "Are you degrading the animal if you dye it in fancy colours?" Depending on the way the artificial colour is applied, it may also be seen as a question of animal welfare.

The first description of artificial colour being applied to ornamental fishes, that I have come across, is in Sauvigny's fascinating account of how the 'Wên-yü', "Poisson lettré" or "Lettered Fish" – goldfish that were painted with Chinese characters – were produced in 18<sup>th</sup> Century China. In *Histoire Naturelle des Dorades de la Chine*<sup>33</sup>, published in 1780, Sauvigny explains that the Wên-yü were painted with arsenic diluted in tortoise urine. He says that the parts of the fish skin that had been touched by the pencil immediately changed colour and never faded. Whether this description of the production method has an element of truth in it, or if it is pure imagination, is hard to tell.

In modern times, the first artificially coloured fishes began appearing on the market in the late 1970's. The first written account, to my knowledge, was in the American magazine *Freshwater and Marine Aquarium* in October 1980. Under the heading "Somewhere over the Rainbow", Jim and Nancy White<sup>34</sup> wrote about painted fish, specifically Glass Fish and albino Red-tailed Sharks, appearing in US aquarium shops. It is safe to say that this very first article on the phenomenon of painted fish was coloured more by a curiosity for the subject, rather than criticism, but also here, times have changed.



An increasing number of trade associations recommend their members not to sell any fish that have been artificially coloured. Photo of colour injected glass fish, by BIOQUATIC Photo, Alf Jacob Nilsen.

A search on the Internet, or leafing through aquarium literature, yields many attacks on the practice of dyeing fishes, but very little support. In particular the practice of injecting fishes with dye is a target for many campaigns and written attacks on the industry<sup>35/36/37/38</sup>. Studies have been carried out, which conclude that, besides being cruel, the painting process increases the risk of disease and shortens the lives of the fishes<sup>39/40</sup>.

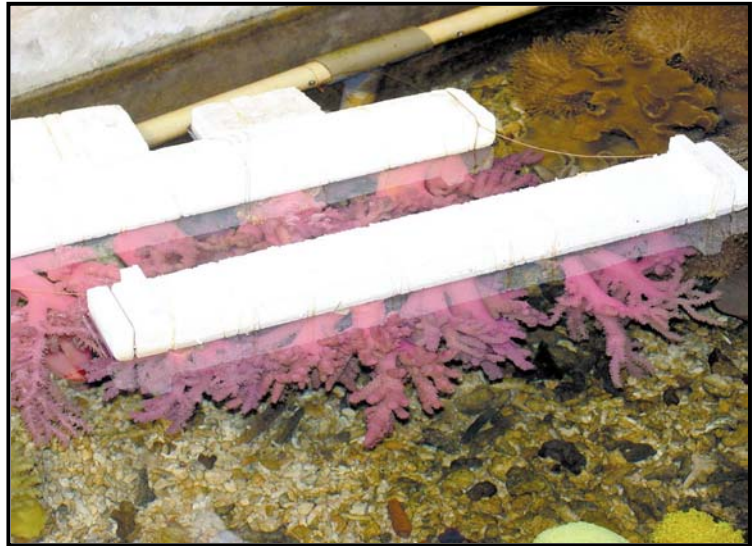
In 1996, the British magazine *Practical Fishkeeping* ran a massive campaign, asking aquatic retailers to sign a pledge that they would not sell dyed fish. Also, Pet Trade Associations in some countries, among others PIJAC Australia and the British OATA, have recommended their members not to trade in any dyed fishes.

Several different techniques, besides injection, are now obviously used for artificially dyeing fishes, and the available number of species and varieties that have been manipulated in such a way appears to be increasing. Artificial colouring is also gaining a foothold with



corals, anemones and other invertebrates for the marine aquarium. I can assure you that the criticism from within the marine aquarium hobby sector<sup>41</sup> is by no means smaller than what we find in the freshwater fish area.

While Sauvigny's account of how fish were painted 200 years ago may be imaginative, there is also no lack in fantasy when activists of today describe how modern dyeing processes are carried out. Besides the injection method that we know for sure is being used, many authors have suggested fanciful methods that sound like exercises in barbarism rather than practically usable technology. I will not go into detail on the methods that are described here, out of fear of aiding to the spread of misinformation.



Artificially coloured soft corals at an Indonesian export facility.

Photo: ANDRÉ JANSSENS

However, I want to point out that we in Ornamental Fish International have tried to gather information about the true methods employed, without any success whatsoever. As long as the production methods of nearly all types of artificially coloured fishes remains an industry secret, there is, of course, no way anyone can defend themselves from false accusations. And the conclusion reached by an increasing number of trade associations seems to be to advise their members not to sell any fish that can be suspected of having been artificially coloured.



Amputation of tail fins is suspected to be used to produce "heart-shaped" varieties of fishes.

Photo: BIOQUATIC / Alf Jacob Nilsen

Another area where physical manipulation may be applicable is when one wants to change the shape of the body. I haven't found conclusive evidence that this is done in fishes, but it is not completely unthinkable. After all, cropping of tails and ears in dogs has been common all over the world for centuries – although it is gradually becoming illegal in an increasing number of states.

In Internet discussions, as well as in aquarium hobbyist magazines, I have come across suggestions that the peculiar head shape of parrot cichlids comes about by tying rubber bands around the fish's neck at a young age, and that the tail-less varieties have their tail





fins amputated when they are still fry. It seems too strange to be true, but I cannot offer evidence to the contrary. The people in the markets that are faced with accusations of supporting what many people regard as cruelty to animals, cannot provide evidence against this.

## Modern Technology

Let us move on from "where genes are not enough", to where "genes are too much". I am, of course, thinking of modern genetical modification techniques. There is absolutely no question that genetical engineering is a fascinating technology, and I say that based on my own background as a biologist. Like all technology, or anything man does, in a sense, genetical engineering can, of course, be misused or used with thoughtlessness – but that is not the main issue. It is more interesting that people who are against GM techniques repeatedly describe themselves as being in the middle of a global war<sup>42</sup>.

The creation of GMO's (or Genetically Modified Organisms) has become a welcomed tool in medical production (various medicines, antibiotics, human spare parts, etc.), and it finds increasingly more uses in agriculture and food production. We get faster-growing crops, plants with integrated biological pest controls and disease resistance, plants with reduced need for fertilisers, as well as extended environmental tolerance and increased nutrient values in plants, as well as animals.

Although one should easily be able to see the good intentions behind most of the biotechnological research and GMO production, this does not come without controversy. Medical uses do not get too much attention, as long as they stay away from incorporating human genomes or using higher vertebrates as test or production animals. GM foods, however, raise considerable scepticism and resistance - enough for Greenpeace to label them 'Frankenfoods' in a 2001 television commercial. The term 'Frankenfish' for genetically engineered salmon has been widespread for some years already and, recently, I noticed that it is also starting to be used for genetically modified ornamental fishes<sup>43</sup>.

Opponents of GMO's have arguments against them, some of which are valid. It is not uncommon, though, that facts alone are insufficient for the opponents' needs. One can hardly deny that falsehoods and lies have been, and are being, spread in campaigns of vilification. Public press and the Internet are filled with campaign initiatives against genetical engineering, and, again, genetically engineered ornamental fishes are no exception.

## GMO's in the Aquarium Industry

Research on the genes of ornamental fishes has become increasingly important in many of the countries where this industry has major representation. Different colour varieties are studied to establish what genetic markers are involved, in order to improve breeding results. As many of those present know better than I, the National University of Singapore, in particular, has many years of experience with studies in molecular genetics aimed at a better understanding of what factors regulate different characteristics.



That modern biotechnology would, sooner or later, be put to use on aquarium fishes was inevitable. It began, as I see it, in scientific communities where the commercial potential of the fishes was of only secondary interest.

Scientists all over the world have used green fluorescent protein (GFP) from the jellyfish *Aequorea victoria* to create fluorescent varieties of plants and animals for research purposes<sup>44/45</sup>. The Zebra Fish (*Danio rerio*) was a relevant target for introduction of GFP-genes because it was already well established as a laboratory animal and had a short life cycle. For the same reason, another laboratory fish, the Japanese Ricefish or Medaka (*Oryzias latipes*), was targeted for the same kind of research. Coincidentally, this species was also well known as an aquarium fish, although it is not particularly popular in its natural colour morph.

So far, it is only from Taiwan that GM fishes are commercially available to the aquarium trade, in the form of fluorescent Medakas (*Oryzias latipes*). [EDITORIAL NOTE: Since this presentation was made, GM Zebra Danios have become available within the United States, except California, which has a ban on such fishes]. The producer, Taikong Corporation, promises that other varieties will soon be available, while research on new varieties is also being carried out in other countries, involving not only green fluorescent protein, but also other genes from other organisms.

In places around the world, aquarium hobbyists are protesting against genetically engineered fishes. This is particularly obvious on the Internet, but also in international aquarium magazines, like the British *Today's Fishkeeper* which has launched protest campaigns. The argumentation is typically highly emotionally motivated and takes little account of the potential problems in dispersal of GMO's that legislators are worried about.

In Europe GMO-protesters have also received support from the trade itself. In Great Britain, for example, the Ornamental Aquatic Trade Association has taken a negative stand on the use of genetic modification as a means of producing aquarium fishes. "Interfering with the genome is unnecessary," said their Chief Executive, Keith Davenport, in an interview quoted by The Pew Initiative on Food and Biotechnology<sup>46</sup>. He continued: "We don't want animals to become fashion accessories". In a communication to their members, dated 5 August, 2003<sup>47</sup>, OATA emphasises the difficulties involved in importing GMO's legally, and concludes that "OATA has previously stated that it feels that GM ornamental fish are an unwelcome addition to the market place".

The Norwegian Pet Trade Organisation (NZB) has advised their members not to trade in GM fishes, even after a potential future governmental import approval. According to the organisation's chairman, Tom Granheim, "The wide ranging ethical challenges that are raised by such a manipulation of animals, does not appear to be in line with the views on animals that the pet trade should be associated with"<sup>48</sup>.

There is very little reason to suspect that GM ornamental fishes are particularly dangerous in any sense, in comparison to other GMO's. Still, we are talking about what, in some people's eyes, are unnecessary and superfluous luxury products. Will logic apply at all in the debate we are facing?



## The Cartagena Protocol

Another important question is whether the aquarium trade is willing, or even able, to handle all the bureaucratic fuss that is involved in trading GM aquarium fishes legally. Will it be worth it, from an economical point of view?

For one thing, many countries have individual strict regulation of imports of modified organisms. Confiscations of shipments of GM aquarium fishes have already occurred, for instance, in Singapore<sup>49</sup>. Furthermore, international law is regulating the trade. To this date, 65 states have ratified the United Nations' *Cartagena Protocol on Biosafety*<sup>50</sup>, which entered into force on 11 September, 2003.

In accordance with the precautionary approach contained in the Rio Declaration on Environment and Development, the objective of the Cartagena Protocol is to contribute to ensuring protection in the field of the safe transfer, handling and use of living modified organisms. In principle the protocol applies to the transboundary movement, transit, handling and use of all living modified organisms, including ornamental fishes.

Parties to the Protocol must ensure that living modified organisms are handled, packaged and transported under conditions of safety. Furthermore, special procedures and requirements must be followed to provide importing Parties with the necessary information needed for making informed decisions about whether or not to accept import of such organisms and for handling them in a safe manner.

The Party of import of such organisms makes its decisions in accordance with scientific risk assessments according to principles and methodologies defined in the protocol. In case of insufficient relevant scientific information and knowledge, the Party of import may use precaution in making its decisions on import. Parties may also take into account socio-economic considerations in reaching decisions on import. In other words, if there is little socio-economic incentive for allowing import, rejection is more likely.

Even though the most likely export countries for GM aquarium fishes have not yet signed the Cartagena Protocol, several important importing countries, including the EU have. It is important to note that Parties are obliged to ensure that the transboundary movements between Parties and non-Parties must be carried out in a manner that is consistent with the objectives of the Protocol.

## The future: Nature or Art?

Although there are problems facing the industry in the areas of artificially coloured fishes and GMO's, I am quite convinced that the real challenges for some time yet will lie in defending the market for traditional varieties produced by classical breeding techniques.

In a recent article in the *OFI Journal*<sup>51</sup> I discussed the bewildering situation our industry is facing as more and more of the truly dedicated aquarists of the world are in the hobby mainly because of their love for, and interest in, wild type fishes. They are by no means in a majority, not even near being a majority, but they are knowledgeable and, more often than

not, they are the very people who get to write magazine articles and books. Thus, they are able to influence public opinion - as we see them doing in several countries.

If you are a dog or cat breeder, there is no doubt that you are involved in a cultural activity. Dogs and cats that are human companions are no part of nature, but have been created by man through thousands of years of selective breeding. They are products of human culture; actually, a form of art. Such is the case with practically all animals that we surround ourselves with, be it horses, cattle and sheep, or pigeons, budgerigars, guinea pigs, dogs and cats. Animals kept by man are, normally, domesticated forms, rather than wild type animals, but the aquarium hobby has been, and increasingly is, a noteworthy exception to this rule.

There are actually a lot more wild type fish species than cultured forms in the hobby, and this is something that attracts people with a genuine interest in wild fauna, and often (sadly) a corresponding scepticism towards human culture. In Europe, in particular, but increasingly also in USA, more and more fishkeepers are expressing their dislike of 'man-made' fishes. They may, at first, love the new variety of fish that they see in the shop, but the very instant someone tells them this fish doesn't occur in nature, it becomes a symbol of evil!



Albino form of *Pseudochromis sankeyi* developed by the Dutch marine fish breeder Robert Brons.

Photo: ROBERT BRONS

The aquatic industry cannot afford to sit passively watching this development. I think the time has come for the industry to take note of the potential negative consequences that could arise from the diverging directions that our market is heading towards, Nature and Art, and take appropriate steps to emphasise the positive qualities of both camps. There are still, even in the West, millions of people who appreciate cultured fish - just as there are people who appreciate the other cultured animals in their possession. Indeed, I think we could get many more people interested in both wild and cultured forms if we were to focus more on both, become more open about the differences between them and help enlighten hobbyists about the beauties and qualities of every type of aquarium fish.

### What are we selling?

The number of fish species and varieties is constantly increasing. The 410 species and 40+ domesticated varieties of exotic fishes that Axelrod and Schultz described in 1955<sup>23</sup> is no match for the thousands of species and varieties that are available today. Both the aquarists who want wild type fishes and those who are interested in cultivated varieties, should have plenty to choose from.

Still, an increasing number of aquarists are perceiving domesticated forms as a threat against their hobby. Campaigners against domesticated fishes have some arguments that are constantly repeated. They fall into five main groups. Let us have a quick look at these arguments and what challenges they raise (Table 6):

**Table 6: What are we selling?**

***Creating fish varieties is against the rules of nature***

***Man-made fishes are aesthetically inferior to wild type fishes***

Arguments of this sort are obviously impossible to contradict. Beauty is in the eyes of the beholder, and whether one will include man in the rules of nature depends on religion and philosophy. I can, to a certain extent, understand that people want only what they are interested in to appear on the market, but I do not see these as arguments we should be worried about.

***Man-made fishes suffer (animal welfare)***

Here we are, indeed, facing something that is likely to become an increasing problem in many countries in years to come. The industry should look closely at ways of removing certain traits from fish stocks. I have already discussed some problem areas, but I will be happy to have a dialogue with any interested parties.

***Man-made fishes squeeze the wild types out of the shops***

This is a commonly repeated argument. Everyone seems to believe that the more domesticated breeds a wholesaler has, the poorer is his selection of wild type fishes. I have not been able to find any such link whatsoever. On the contrary; it seems that the outlets that carry most domesticated varieties also have the largest selection of wild type fishes. I have already exemplified this with figures from Singapore exporters. In a recent study that I carried out among Norwegian retailers<sup>52</sup>, there was equally clear evidence that the shops with the highest number of domesticated varieties were the same as those who had the largest selection of wild type fishes.

***We do not distinguish between domesticated/hybrid fishes and pure wild type fishes***

This is an argument that I can understand. For the people who are genuinely interested in wild type fishes only, it may indeed be frustrating to risk buying a hybrid or man-made colour morph instead of the specific species or natural geographical morph he or she thought (s)he was offered.

This can be easily overcome by better marking of what we sell. When a particular new variety is, indeed, a variety, why not take full credit for that by marking it such that no risk of confusion with wild fishes exists? It should be fairly easy to extend price lists (and invoices) to include information on whether a fish is wild-caught or farm-bred, and whether it is a type found in nature or a cultured form.

### What will the future bring?

We are facing a dilemma. Today, the people who are most concerned about the distinction between domesticated versus wild type fishes are those who want to get rid of everything that isn't 'natural'. The people who are fascinated by the artful creation of culture forms remain silent, as if we are closing our eyes, hoping and praying that the problem will go away if we ignore it!

I am convinced that the future will bring us more domesticated fishes, and it will not be restricted to the freshwater side of the trade, as it is today. In the marine sector we are seeing more and more incentives for captive breeding appear, and there is absolutely no way anyone can prevent this from opening up for domesticated varieties for marine aquaria. The Dutch pioneer marine fish breeder, Robert Brons, once told me that simply reproducing what nature does would not give him enough of a challenge. Already, he has created an albino form of *Pseudochromis sankeyi*, as well as a hybrid involving *Pseudochromis fridmani*, for which he sees interesting market opportunities.

Robert Brons has also, however, allowed me to quote him saying that he is "more or less convinced that Europe isn't the place for introducing the new varieties"<sup>53</sup>. I hope that the trade, by being more active in informing of the qualities and age-old traditions of culture forms, will be able gradually to change this. The culture and keeping of domesticated fishes is, in many ways, different from breeding and keeping wild type fishes, but it is neither inferior nor superior. They are two different approaches to the aquarium hobby, but both should be equally valuable to their devotees. It is also a matter of cultural and national differences. Therefore, a common agreement of what is a good, versus a poor, fish will probably never be reached.

However, I expect that many breeders producing for the trade will continue to put increased efforts on producing more vital stocks; fishes that not only look good, but also have better health and vitality. I would hope that we will gradually see a reduction of traits and practices that are raising animal welfare issues. If we combine that with as much openness as possible on the origin of the animals, to avoid customers feeling they have been misled; a scenario where both the trade and the animals win seems a likely outcome.



As more and more incentives for captive breeding appear in the marine sector, there is absolutely no way anyone can hinder that this will open up for domesticated varieties also for marine aquaria. When will we see the first veiltail clownfish? Will it be a healthy variety?

Photo manipulation by SVEINA. FOSSA





## Acknowledgements

Several individuals and organisations have helped me with facts, references, illustrations and/or inspiration during the preparation of this paper and Keynote Address made at Aquarama 2003. I list them here in alphabetical sequence. Please accept my sincere apologies for any inadvertent omissions.

Svein Ole Antonsen – Betta fancier and breeder, Norway  
 Robert Brons – Brons Mariculture, The Netherlands  
 Mats Danielsson – The Swedish Pet Trade Association (ZOORF), Sweden  
 Rick Datodi – Aquarium Industries Pty Ltd, Australia  
 Keith Davenport – Ornamental Aquatic Trade Association (OATA), UK  
 John Dawes – Ornamental Fish International, Spain  
 Kjell Fohrmann – Fohrman Aquaristik AB, Sweden  
 Tom Granheim – The Norwegian Pet Trade Organization (NZB), Norway  
 André Janssens – Aquaspijk, The Netherlands  
 Daniel Knop – 'Koralle' Magazine, Germany  
 Derek Lambert – 'Today's Fishkeeping' Magazine, UK  
 Casper Linnestad – Norwegian Biotechnology Advisory Board, Norway  
 Marshall Meyers – Pet Industry Joint Advisory Council (PIJAC), USA  
 Alf Jacob Nilsen – Bioquatic Photo, Norway  
 Alex Ploeg – Aqualog Verlag ACS GmbH, Germany  
 Dietrich Rössel – Lawyer and fish keeper, Germany  
 Erik Slinde – Institute of Marine Research, Norway  
 Pauline Teo – Teo Way Yong & Sons (Pte) Ltd, Singapore

## References:

- <sup>1</sup> Caras, Roger A. 1996. *A Perfect Harmony: The Intertwining Lives of Animals and Humans throughout History*. (First Fireside Edition, 1997). Simon & Schuster, New York.
- <sup>2</sup> Dohner, Janet Vorwald. 2001. *The Encyclopedia of Historic and Endangered Livestock and Poultry Breeds*. Yale University Press, New Haven.
- <sup>3</sup> Darwin, Charles. 1868. *The Variation of Animals and Plants under Domestication*. Facsimile-edition, 1998, of the second revised edition (1883). The Johns Hopkins University Press, Baltimore.
- <sup>4</sup> Keller, Otto. 1913. *Die Antike Tierwelt, Zweiter Band: Vögel Reptilien, Fische, Insekten, Spinnentiere, Tausendfüßler, Krebstiere, Würmer, Weichtiere, Stachelhäuter, Schlauchtierre*. Verlag von Wilhelm Engelmann, Leipzig.
- <sup>5</sup> Banister, Keith & Tom Adams. 1977. *Aquarial Fish*. Frederick Müller Limited, London.
- <sup>6</sup> Fosså, Svein A. 1981. Fisk i det gamle Egypt. *Akvaret*, Gothenburg, **55**(2): 64-66
- <sup>7</sup> Higginbotham, James. 1997. *Piscinae: Artificial Fishponds in Roman Italy*. The University of North Carolina Press, Chapel Hill.
- <sup>8</sup> Wong, Margaret. 2002. Goodhearted Buddhists set animals free but inadvertently harm environment. *Associated Press. Environmental News Network*, [http://enn.com/news/wire-stories/2002/07/07052002/ap\\_47749.asp](http://enn.com/news/wire-stories/2002/07/07052002/ap_47749.asp). Accessed 05.07.2002

- <sup>9</sup> Chen, S. C. 1956. A history of the domestication and the factors of the varietal formation of the common goldfish, *Carassius auratus*. *Scientia Sinica*, **5**: 287-321
- <sup>10</sup> Hervey, George. 1950. *The Goldfish of China in the XVIII Century*. The China Society, London.
- <sup>11</sup> Smith, Hugh M. 1909. *Japanese Goldfish: Their Varieties and Cultivation*. W. F. Roberts Company, Publishers, Washington.
- <sup>12</sup> Pepys, Samuel. *Entry in Samuel Pepys Diary for May 28, 1665*. <http://www.pepys.info/1665/1665may.html>. Accessed 16.10.2003
- <sup>13</sup> Hawkins, John (ed.). 1784. *The Complete Angler...*, In two parts, the first written by Mr. Isaac Walton, the second by Charles Cotton..., To which are prefixed, the lives of the authors, and notes historical, critical, and explanatory, by Sir John Hawkins. 4<sup>th</sup> Edition. J., F. and C. Rivington, London.
- <sup>14</sup> Klee, Albert J. 2003. *The Toy Fish: A History of The Aquarium Hobby in America - The First One-Hundred Years. Revised and Expanded Edition*. Finley Aquatic Books, Pascoag, Rhode Island.
- <sup>15</sup> Gosse, Philip H. 1854. *The Aquarium: An Unveiling of the Wonders of the Deep Sea*. John Van Voorst, London.
- <sup>16</sup> Rothfels, Nigel. 2002. *Savages and Beasts: The Birth of the Modern Zoo*. The Johns Hopkins University Press, Baltimore.
- <sup>17</sup> Ritvo, Harriet. 1987. *The Animal Estate: The English and Other Creatures in the Victorian Age*. Penguin Books, London.
- <sup>18</sup> Wolf, Herman T. 1908. *Goldfish Breeds and Other Aquarium Fishes: Their Care and Propagation*. Innes & Sons, Philadelphia.
- <sup>19</sup> Arnold, Joh. Paul. (without year). *Alphabetisches Verzeichnis der bisher eingeführten fremdländischen Süßwasserfische*. Verlag Gustav Wenzel & Sohn, Braunschweig.
- <sup>20</sup> Fosså, Svein A. 1995. Zur Geschichte der Aquarienkunde - Die Liebig-Karten 3 und 4. *Das Aquarium*, Bornheim, **29**(10): 8-11
- <sup>21</sup> Innes, William T. 1935. *Exotic Aquarium Fishes*. Innes Publishing Company, Philadelphia.
- <sup>22</sup> Axelrod, Herbert R. & Leonard P. Schultz. 1955. *Handbook of Tropical Aquarium Fishes*. McGraw-Hill Book Company, Inc., New York.
- <sup>23</sup> Boulenger, E. G. 1925. *The Aquarium Book (Second Impression, 1927)*. Duckworth, London.
- <sup>24</sup> Holm, Sune. 1979. *Nya akvariefiskar till varje pris*. *Akvariet* **53**(2):63-64
- <sup>25</sup> Coleman, Ronald M., Michael K. Oliver, George J. Recks, Francesco Zezza, Patrizia Spinelli and Frank Panis: *Who Needs Another Hybrid?* <http://malawicichlids.com/mw01013.htm>. Accessed 18.10.2003
- <sup>26</sup> *Le musée des horreurs*. <http://perso.club-internet.fr/burnel/horreur.htm>. Accessed 15.10.2003
- <sup>27</sup> Schlüter, Michael. *Interzoo 2002 - Qualzuchten und Geschmacklosigkeiten*. <http://www.weichwasserfische.de/geschmacklos.htm>. Accessed 18.10.2003
- <sup>28</sup> The Norwegian Parliament, May 2003: Innst.S.nr.226 (2002-2003): *Innstilling fra næringskomiteen om dyrehold og dyrevelferd*. <http://www.stortinget.no/inns/inns-200203-226.html>. Accessed 24.09.2003
- <sup>29</sup> Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft. 1999. *Gutachten zur Auslegung von §11b des Tierschutzgesetzes (Verbot von Qualzuchtungen)*.
- <sup>30</sup> Hieronimus, Harro. 2002. BNA-Stellungnahme zum Thema Qualzucht bei Zierfischen. *BNA-aktuell*, **2002**(1): 27-31
- <sup>31</sup> Hieronimus, Harro. 2002. Antrag auf Anerkennung als Qualzucht. *BNA-aktuell*, **2002**(3): 61-63
- <sup>32</sup> Staack, Wolfgang. 2002. Papageienbuntbarsche und §11b TierSchG. *BNA-aktuell*, **2002**(2): 17-20
- <sup>33</sup> de Sauvigny, Louis Edme Billardon & François Nicolas Martinet. 1780. *Histoire Naturelle des Dorades de la Chine*. Louis Jorry, Paris
- <sup>34</sup> White, Jim & Nancy White. 1980. Somewhere over the rainbow... *FAMA* **3**(10): 39-41, 78-79

- 
- <sup>35</sup> Jones, Stacy: *Cruel and Unusual Punishment: Painted Glassfish*. Set Adrift. <http://jolieve.polestar.org/viewarticle.php?articleid=91>. Accessed 14.10.2003
- <sup>36</sup> *Painted Fish: A Horrible Torture!! For Profit*. <http://expage.com/juicingfish/>. Accessed 14.10.2003
- <sup>37</sup> Chen, Cecilia & A.K.A. Pandora. *Painted Glass Fish and Other Questionable Practices*. <http://badmantropicalfish.com/articles/article3.html>. Accessed 14.10.2003
- <sup>38</sup> Midgley, David. 2002. *The dyeing of fishes: A campaign to stop this cruel practice in the fishkeeping hobby*. <http://www.sydnevcichlid.com/dyeing.html>. Accessed 14.10.2003
- <sup>39</sup> MacMahon, Stan & Peter Burgess. 1998. *Why it's cruel to dye*. Practical Fishkeeping, UK, March 1998 (published on the Internet 14.02.03). [http://www.practicalfishkeeping.co.uk/pfk/pages/show\\_article.php?article\\_id=72](http://www.practicalfishkeeping.co.uk/pfk/pages/show_article.php?article_id=72). Accessed 25.10.2003
- <sup>40</sup> Greenwood, Jim. Letter referring to studies by Dr John Humphrey and Dr Malcolm Lancaster of the Victorian Institute of Animal Sciences (VIAS)
- <sup>41</sup> Siegel, Terry. 2002. *Editorial*. Advanced Aquarist's Online Magazine, June 2002. <http://www.advancedaquarist.com/issues/june2002/Editorial.htm>. Accessed 14.10.2003
- <sup>42</sup> Nærstad, Aksel. 2003. Opening Speech. *Benefit or harm? Power and politics behind GM food*. International conference on GM food, Oslo, 05.02.2003.
- <sup>43</sup> *Genetically Modified Glowing Fish On Sale in Asia*. Associated Press Story on the Fox News Channel. <http://www.foxnews.com/story/0,2933,93707,00.html>. Accessed 10.08.2003
- <sup>44</sup> Amsterdam, Adam, Shou Lin & Nancy Hopkins. 1995. *Transient and transgenic expression of green fluorescent protein (GFP) in living zebrafish embryos*. CLONTECHniques, July 1995.
- <sup>45</sup> Gong, Zhiyuan. 1998. *Transgenic Fluorescent Fish*. Asia Pacific Biotech News (APBN), **2**(16): 280
- <sup>46</sup> Taiwanese Scientists Create Ornamental Glow in the Dark GM Fish. *The Pew Initiative on Food and Biotechnology*. <http://pewagbiotech.org/buzz/display.php3?StoryID=60>. Accessed 01.08.2003
- <sup>47</sup> OATA. 2003. *Import of GM ornamental fish*. Circular to members, dated 05.08.2003
- <sup>48</sup> Granheim, Tom. 2003. Nytt fra Norge. *PetScandinavia* 2003(3): 6-7
- <sup>49</sup> *Genetically-modified glowing fish confiscated*. The Straits Times, Singapore, July 25<sup>th</sup> 2003.
- <sup>50</sup> *Cartagena Protocol on Biosafety Home Page*. <http://www.biodiv.org/biosafety/>. Accessed 20.10.2003
- <sup>51</sup> Fosså, Svein A. 2003. President's Report: Nature or Art: The Bewildering World of Aquatics. *OFI Journal*, Malaga, **2003**(42): 6
- <sup>52</sup> Fosså, Svein A. 2003. Fiskeutvalget i norske zoobutikker: Avlsformer og naturformer i skjønn forening? *PetScandinavia*, **2003**(3): 28-30, 32
- <sup>53</sup> Brons, Robert. 2003. Personal communication.