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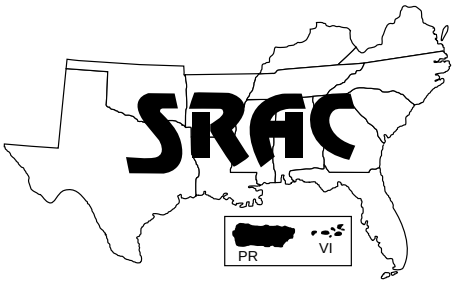

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Species Profile: Koi and Goldfish

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Most people are familiar with the beautiful and often strikingly unusual koi and goldfish used as ornamental fish in ponds and aquaria. Both are species of carp whose wild types are an unspectacular grey-green or brownish color with deep bodies and unremarkable fins. It is believed that the koi and goldfish varieties we recognize today originated with the breeding of uncommon golden-colored carp in China 1,000 to 2,000 years ago. This early selective breeding eventually led to the production of more than 100 varieties of koi and goldfish.

"Fancy" varieties exhibit body parts in unusual shapes, positions or colors. For example, a goldfish may have a cap on its head—a variety called an Oranda—or large sacs under its eyes—a Bubble Eye goldfish. Koi and goldfish may have various scale patterns and color markings that range from solid black to blue, red, yellow, orange, white, or any combination and pattern of these colors. Fin number, size and shape also can be different from one variety to another, especially in fancy goldfish. Koi generally have elongated bodies, but goldfish may have bodies that are short and round like an egg or ball.

In addition to the ornamental varieties, both species are produced, with much less attention to color and shape, as feeder fish; goldfish are also produced as bait. There are too many varieties to describe in this profile; however, many books are dedicated to the topic.

Taxonomy

Goldfish, *Carassius auratus* (Linnaeus 1758), and common carp, *Cyprinus carpio* (Linnaeus 1758), are members of the family Cyprinidae, or minnow family. Koi is an ornamental variety of the common carp. Goldfish are native to central Asia, China and Japan. Common carp are native to Eurasia, particularly the rivers draining into the Aral, Black and Caspian Seas. The ornamental koi variety was developed in China. Japan also has had a great deal of influence on the development of koi. Both species have been widely introduced around the world and the precise limits of their native ranges are uncertain. Both species are found in many types of fresh water. Goldfish are most common in small, vegetated lakes; common carp can be abundant in slow-moving rivers and reservoirs. Both are considered cool-water fishes, yet they can survive in a wide range of water temperatures.

Goldfish can grow to nearly 23 inches (58 cm) long and weigh 6 pounds (2.7 kg) or more. They can live 30 years or more. Common carp can grow to more than 4 feet (122 cm) long and weigh 80 pounds (36 kg). Common carp have been known to live at least 50 years.

Marketing and economics

The marketing and production economics of koi and goldfish are as varied as the different strains of fish. At one extreme, feeder goldfish are sold by the pound or truck load as bait and as feeder fish for aquaria. At the other extreme, individual champion koi may be sold around the world and transported in private jets.

In the U.S., most goldfish production (by volume) is for bait and feeders. Most ornamental goldfish produced in the U.S. are at the middle to low end of the price level (examples are Black Moors, Shibunkins, Fantails, Calicos, Comets, etc.). The most expensive varieties (e.g., Orandas, Ryunkins,

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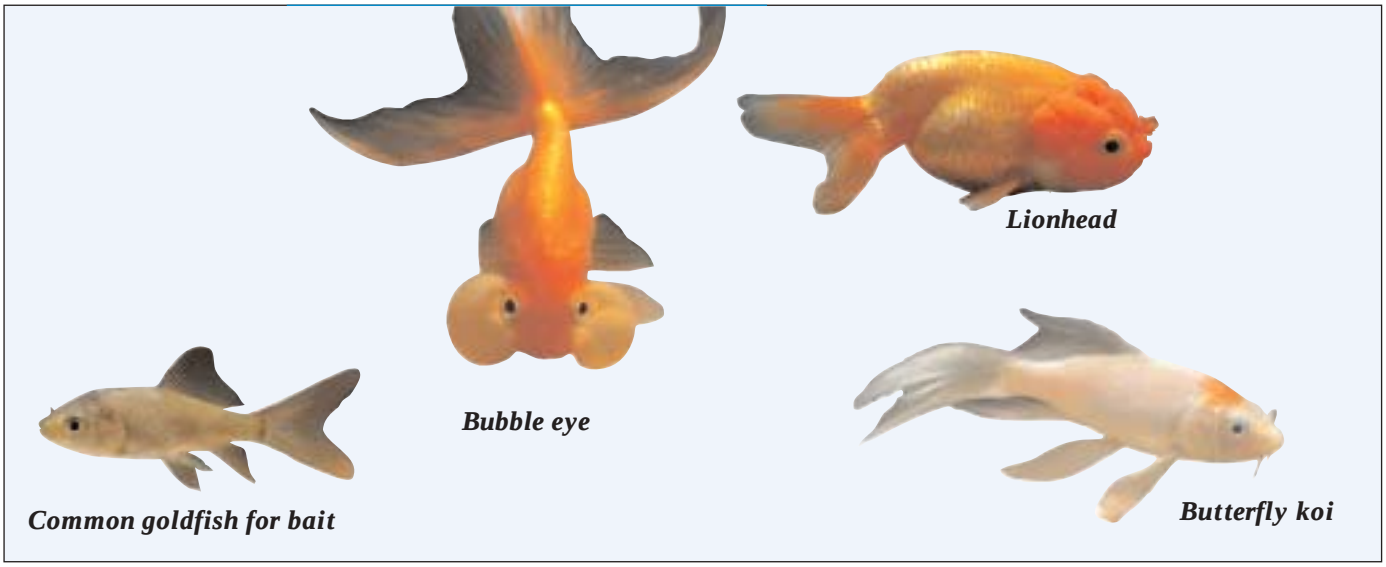


Bubble Eyes) are primarily imported from China. However, an increasing number of U.S. producers are specializing in exotic varieties that can sell for as much as $5.00 per fish wholesale.

Most U.S. koi production also has focused on the wholesale, large-volume, inexpensive level. However, with the growing interest in expensive outdoor garden ponds, more specialty producers are raising fish that sell for hundreds of dollars each. As the prices of goldfish and koi increase, the size of the market decreases, so most of the business is at the lower end of the price range.

As in all of aquaculture, the key to success is to thoroughly investigate the market before getting into production, so that you understand when buyers want fish, how many they want, and how much they will pay for them. Reports of someone paying $10,000 for an individual champion koi do not translate into a market strategy.

Culture systems

Goldfish and koi are cultured in ponds, flow-through tanks, and recirculating systems. The management of these systems is very different; so are the costs and intensity of production.

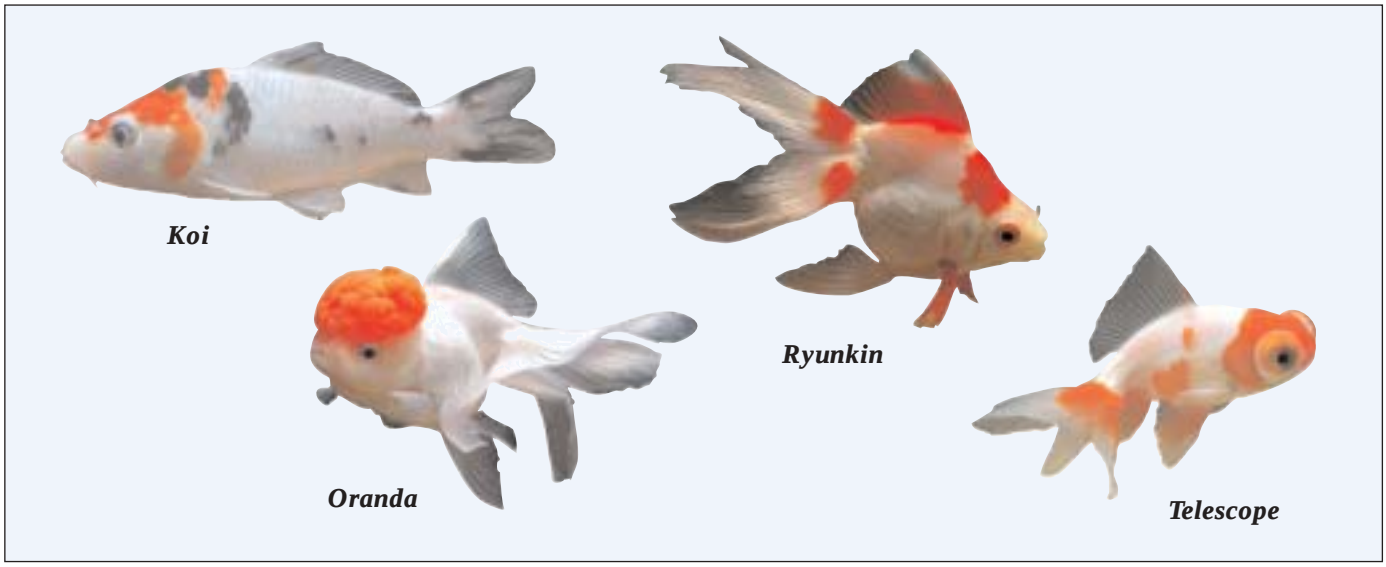
Earthen ponds are often used, especially for koi and for low- to mid-value goldfish. Pond construction must be carefully planned in consultation with the appropriate agencies responsible for permitting. Pond management concerns include managing dissolved oxygen and phytoplankton blooms, managing aquatic plants, controlling disease vectors such as snails, and controlling or excluding predators. Aeration can make pond management easier and increase production.

Tank culture systems may be flow-through or recirculating systems. Flow-through tanks have a constant flow of new water. This flow dilutes and flushes fish wastes from the system. The water source is usually well water, but surface water is sometimes available. Recirculating systems reuse water, filtering it to remove particles and fish waste products such as ammonia before returning it to the tanks. Some systems also use ultraviolet sterilizers, chemical filters and pure oxygen to increase production. Flow-through systems are usually cheaper to build and operate than recirculating systems. However, recirculating systems use far less water and make it easier to maintain temperature and administer disease treatments. Recirculating systems with high production densities are the most challenging systems to manage.

Water quality

Koi and goldfish are considered “hardy” fish because they can survive in poor water quality. However, for optimal growth, appearance, reproduction and health, maintaining good water quality is essential. Unlike most other ornamental fish, which are tropical, koi and goldfish are temperate species. Their optimum temperature range is about 65 to 75 °F (18 to 24 °C), although they can survive at temperatures as low as 32 °F (0 °C) and as high as 95 °F (35 °C), especially if the temperature change is gradual (seasonal). Temperatures outside the optimal range may suppress the fishes’ immune systems and cause decreased feeding and growth.

Oxygen level should be at least 5 mg/L, though koi and goldfish will tolerate much lower dissolved oxygen for short periods. Un-ionized ammonia and nitrite levels should be kept below 0.05 mg/L. The pH should be kept as close to 7 (neutral) as possible, though koi and goldfish may tolerate a pH between 5 and 9.



Brood stock

Although koi and goldfish become sexually mature at 1 year of age, fish used for commercial brood stock are usually at least 2 years old. The larger the female, the more eggs she will produce. Also, some of the more elaborate characteristics of exotic varieties do not fully express themselves until fish have reached a certain age or size.

Brood fish should be carefully selected for certain traits such as size, color, health and finnage. This publication is too brief to describe all the different breeding practices used to create certain varieties, but suffice it to say that the quality of the offspring is directly related to the quality o the brood stock.

In koi, the most important characteristics to select for are color, body shape, finnage and scales. Koi are typically viewed from above, so brood fish should be selected from this vantage point. The color should be vibrant and distinct, with no bleeding between colors in multi-colored fish. Champion koi brood fish command a very high price and usually are accompanied by a pedigree to demonstrate the purity of their blood lines. Common, inexpensive koi will produce offspring with a wide variety of characteristics, so producers who want high-quality brood stock should select breeders very carefully.

Goldfish genetics and brood stock selection are even more complicated because of the large number of strains and varieties available. Goldfish brood fish should be selected for color, body shape, absence or presence of dorsal fins, single or multiple caudal fins, eye shape and orientation, and absence or presence of head growths and nostril folds. This diversity may be one reason U.S. production has focused on the common, less extravagant varieties.

Spawning

Koi and goldfish generally spawn in the spring, although they can be conditioned to spawn throughout the year if kept in the proper environment. The fish spawn from February to May (depending on the location in the U.S.) when water temperature approaches 68 °F (20 °C). To reduce spontaneous breeding, male and female fish should be separated until time for spawning.

During spawning, females will be pursued and “bumped” by several males in shallow water. Several males fertilize the eggs as they are released. The eggs are adhesive and under natural conditions they are broadcast in grass and other vegetation along the water’s edge. Because of this, producers often use spawning mats in koi and goldfish culture. Spawning mats are placed around the edges of culture ponds or tanks. When spawning is completed the mats are moved to another pond or tank where the eggs are hatched. Spawning most often occurs during the early morning hours. Both koi and goldfish consume their eggs after spawning, so brood fish and mats with eggs should be separated quickly.

Many producers also induce spawning so that all females and all males will spawn at the same time. Spawning agents such as human chorionic gonadotropin (HCG), carp pituitary extract (CPE), and releasing hormones (LHRH and GnRH) are all effective. Koi and goldfish females injected with these agents at 68 °F (20 °C) will ovulate within 12 hours. The standard dry method of mixing the eggs and sperm is used (i.e., eggs and sperm are mixed in a bowl and then water is added). However, because they are adhesive, eggs must be transferred quickly to a spawning mat or some other flat surface to keep them from clumping. Eggs can be

treated with a solution of 4 grams of salt and 3 grams of urea per liter of water, which allows fertilization and "water hardening" without activating the adhesive layer. This procedure can be followed by a 10- to 20-second rinse in a solution of 0.5 grams of tannic acid per liter of water, which effectively eliminates the adhesiveness. These eggs can then be hatched in upwelling jars.

Eggs hatch within 2 to 9 days depending on temperature. They hatch in 46 to 54 hours at 84 °F and in 5 to 7 days at 70 to 75 °F. The larva has a yolk sac but begins to take feed on the second or third day post-hatch. Koi and goldfish are relatively large when they first start feeding and will immediately accept *Artemia* nauplii or other foods 200 to 300 micrometers in size. In large-scale production, eggs on mats or in hatching jars are hatched indoors and the fry transferred to fertilized ponds where natural foods (such as plankton) are available.

Feeding

Goldfish and koi are omnivorous and can be grown on various natural and prepared feeds. Most producers use a standard 25 to 32% protein diet throughout the growout period. The particle size should be increased from a fine meal up to about a ¼-inch pellet as fish grow. Color is not a major factor in fish produced for feeders, bait and inexpensive ornamentals. However, color is critical in more expensive ornamental fish. Like most fish, koi and goldfish will have better coloration when fed a diet with lots of pigments. The koi and goldfish diets that are designed to enhance the coloration of extremely expensive fish are among the most expensive feeds used in aquaculture.

Goldfish and common carp lack true stomachs, so they benefit from multiple feedings each day. Using automatic feeders will reduce labor costs, but the capitol cost of purchasing them may exceed the benefits.

In pond culture, some feed is eaten by the fish and some serves as fertilizer for the pond, helping to produce natural foods such as algae, zooplankton and insects. Such natural foods can be very important to the nutrition of goldfish and koi. Therefore, pond feeds often are not complete diets (providing all the nutritional needs of fish) and may cost much less than complete feeds. In tank culture, complete feeds must be used.

Because the cost of feed is a significant percentage of the total production cost, feed should be stored carefully to keep it fresh. Heat and humidity rapidly degrade feeds, so an air-conditioned room or building is best for storage. In old feeds, the levels of vitamins (especially vitamin C) may be reduced and the lipids (fats) may be rancid. Never give moldy feeds to fish; molds may produce toxins that can harm fish.

Growout

The market will determine the proper time for harvesting koi and goldfish. If fish are being produced as small feeders or bait, they may reach market size in as little as 3 to 4 months. Many ornamentals can take a full year to get to market size or quality. The deep red color of some koi can take more than a year to fully develop. Orandas, Lionheads and Pompons also need more time for development of the characteristic head or nostril growths. This potential delay in return emphasizes the need for producers to analyze the markets they wish to enter before developing their business plans.

Grading and culling

Ornamental goldfish and koi are often sold as individuals, so grading and culling are very important. Size, color (and pattern), fins and body shape all help determine a variety and the price a fish will bring.

Goldfish bred to have multiple caudal fins or no dorsal fin can be culled very early on, but most other varieties (especially those dependent on color) must grow for several months before their true appearance can be known. Grading for size is done both mechanically—using grader boxes—and by hand. Grading and culling for appearance are done manually; this labor is a significant cost of production and expertise in grading and culling ornamental fish takes time to develop. In systems producing the most expensive varieties, as many as 90 percent of the fish may be deemed unmarketable.

Disease

Koi and goldfish are susceptible to many infectious (parasitic, bacterial, viral and fungal) and noninfectious (environmental, nutritional and genetic) diseases. Poor environmental conditions and nutrition can weaken their immune systems and make them more susceptible to disease.

Goldfish and koi are especially prone to anchor worm (*Lernaea*), fish louse (*Argulus*), and monogenetic trematodes (*Dactylogyrus* and *Gyrodactylus*), as well as many protozoan parasites such as Ich, *Trichodina* and *Chilodonella*. Fish are more vulnerable to parasites when water quality is poor. Anchor worm and fish lice are visible to the naked eye and can be identified easily. The presence of monogenes and protozoans must be confirmed by microscopic examination. Chemical treatments may be necessary to treat each of these parasites, although improving environmental conditions is also important in decreasing the numbers of pathogens and improving fish health.

"Goldfish ulcer disease" or "koi ulcer disease," commonly caused by the bacterium *Aeromonas salmonicida*, can cause open sores and may kill up to 50 percent of the fish population. The disease is

most prevalent when temperatures range from 55 to 75 °F (13 to 24 °C) and when fish have recently spawned or been handled. Overcrowding also helps spread the disease because of fish-to-fish contact and poor water quality. If this or any other bacterial disease is suspected, fish should be submitted to a fish health diagnostician whenever possible. Only a diagnostician can confirm any bacterial diseases that are present because other infections may have similar symptoms. Fish also should be tested for antibiotic sensitivities so that the appropriate treatment can be determined.

Two viral diseases—koi herpes virus (KHV) and spring viremia of carp (SVC)—are of particular concern. KHV affects only koi, while SVC affects both koi and goldfish. Both viruses are highly contagious and can cause significant mortality. Fish infected with these viruses often have external parasites and bacterial infections also, which can mask the presence of viruses. KHV occurs most often when water temperature is 64 to 81 °F (18 to 27 °C). SVC is more common when water is 41 to 64 °F (5 to 18 °C). Young fish are more susceptible to these diseases than mature fish, though all ages can be affected. Fish with KHV may be lethargic, swim close to the surface, and exhibit breathing distress and erratic behavior. They may have dead tissue in their gills and sunken eyes Fish infected with SVC are often lethargic, stay near the bottom of the pond or tank, and swim awkwardly. They also may have exophthalmia ("pop eye"), pinpoint bleeding on the skin, a bloated abdomen, and bloody mucus coming from the vent. It is very important to remember that all of the symptoms of KHV and SVC can be caused by other diseases or water quality problems, so both diseases must be confirmed by a laboratory diagnostician skilled in identifying viral diseases.

SVC is a reportable disease; federal authorities must be notified if it is diagnosed. If SVC is confirmed, the facility will be quarantined while it is determined how and to what extent depopulation, cleaning and disinfecting will be required.

KHV is not a reportable disease. However, it can kill many—or even all—of the fish in a facility. If it is confirmed, the facility should be depopulated, cleaned and disinfected as quickly as possible.

Fish that survive KHV or SVC infection may be carriers of the virus. Fish suspected of having either disease should be submitted as soon as possible for laboratory diagnosis.

Summary

Goldfish and koi have been produced in captivity for a very long time. They trace their lineage back to hardy, temperate water fish in the carp family. Production in the U.S. is focused on bait feeder fish and common, less expensive varieties that have a high volume in the trade. However, there is growing interest in producing (and a growing market for) the fancy strains from which international champion individuals may be worth thousands of dollars. The global trade in koi and goldfish is complex, so potential producers should spend considerable time investigating the market before investing in production.

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