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ORIGINAL ARTICLES

Oncorhynchus mykiss Walbaum Culture and Production

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ABSTRACT

Rainbow trout is native to the Pacific drainages of North America, ranging from Alaska to Mexico. Since 1874 it has been introduced to waters on all continents except Antarctica, for recreational angling and aquaculture purposes. Production greatly expanding in the 1950s as pelleted feeds were developed. Trout fisheries are maintained, or culture practised, in the upland catchments of many tropical and sub-tropical countries of Asia, East Africa and South America. As a result, several local domesticated strains have developed (e.g. Shasta and Kamloops), while others have been arisen through mass selection and cross-breeding for improved cultural qualities.

Key words: Rainbow trout, Oncorhynchus mykiss , Culture, Production

Biological features:

Elongate, fusiform body shape with 60-66 vertebrae, 3-4 dorsal spines, 10-12 dorsal soft rays, 3-4 anal spines, 8-12 anal soft rays, 19 caudal rays. Adipose fin present, usually with black edge. No nuptial tubercles but minor changes occur to the head, mouth and colour in spawning males. Coloration blue to olive green above a pink band along the lateral line and silver below. Back, sides, head and fins covered with small black spots. Colouration varies with habitat, size, and sexual condition. Tendency for stream residents and spawners tend to be darker with more intense colour, whereas lake residents are brighter and more silvery. Absence of hyoid teeth is the most easily distinguishing characteristic from cutthroat trout.

Historical background:

Rainbow trout is native to the Pacific drainages of North America, ranging from Alaska to Mexico. Since 1874 it has been introduced to waters on all continents except Antarctica, for recreational angling and aquaculture purposes. Production greatly expanding in the 1950s as pelleted feeds were developed. Trout fisheries are maintained, or culture practised, in the upland catchments of many tropical and sub-tropical countries of Asia, East Africa and South America. As a result, several local domesticated strains have developed (e.g. Shasta and Kamloops), while others have been arisen through mass selection and cross-breeding for improved cultural qualities.

Main producer countries:

Many countries were reporting rainbow trout farming production. Some of them have relatively insignificant output in comparison to the production from the larger systems that are located in the primary producing areas in Europe, North America, Chile, Japan and Australia.

Habitat and biology:

The rainbow trout is a hardy fish that is easy to spawn, fast growing, tolerant to a wide range of environments and handling, and the large fry can be easily weaned on to an artificial diet (usually feeding on zooplankton). Capable of occupying many different habitats, ranging from an anadromous life history [strain known as steelhead] (living in the ocean but spawning in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams) to permanently inhabiting lakes. The anadromous strain is known for its rapid growth, achieving 7-10 kg within 3 years, whereas the freshwater strain can only attain 4.5 kg in the same time span. The species can withstand vast ranges of temperature variation (0-27 °C), but spawning and growth occurs in a narrower range (9-14 °C). The optimum water temperature for rainbow trout culture is below 21 °C. As a result, temperature and food availability influence growth and maturation, causing age at maturity to vary; though it is usually 3-4 years.

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Females are able to produce up to 2 000 eggs/kg of body weight. Eggs are relatively large in diameter (3-7 mm). Most fish only spawn once, in spring (January-May), although selective breeding and photoperiod adjustment has developed hatchery strains that can mature earlier and spawn all year round. Superior characteristic selection is also achieved by cross breeding, increasing growth rates, resistance to disease, and prolificacy, and improving meat quality and taste. Genetic manipulation of the embryo sex chromosomes producing sterile, triploid females, hence avoiding the 'hook-like' jaw that does not appeal to the customer, and ensuring that introduced/escaped individuals cannot breed.

Trout will not spawn naturally in culture systems; thus juveniles must be obtained either by artificial spawning in a hatchery or by collecting eggs from wild stocks. Larvae are well developed at hatching. In the wild, adult trout feed on aquatic and terrestrial insects, molluscs, crustaceans, fish eggs, minnows, and other small fishes, but the most important food is freshwater shrimp, containing the carotenoid pigments responsible for the orange-pink colour in the flesh. In aquaculture, the inclusion of the synthetic pigments astaxanthin and canthaxanthin in aquafeeds causes this pink colouration to be produced (where desired).

Production systems:

Monoculture is the most common practice in rainbow trout culture, and intensive systems are considered necessary in most situations to make the operation economically attractive.

A potential site for commercial trout production must have a year-round supply of high quality water (without aeration - 1 l/min/kg of trout without aeration or 5 l/sec/tonne of trout with aeration),

Ground water can be used where pumping is not required but aeration may be necessary in some cases. Supersaturated well water with dissolved nitrogen can cause gas bubbles to form in the blood of fish, preventing circulation, a condition known as gas-bubble disease. Alternatively, river water can be used but temperature and flow fluctuations alter production capacity. Where these criteria are met, trout are generally on-grown in raceways or ponds supplied with flowing water, but some are produced in cages and recirculating systems.

Stripping and fertilization:

The reproduction of rainbow trout is well understood and the techniques are well-developed. The dry method of fertilization without admixture of water is the most common approach. Eggs are removed manually from females (under anaesthetics) by applying pressure from the pelvic fins to the vent area or by air spawning, causing the fish less stress and producing cleaner, healthier eggs. Insertion of a hypodermic needle about 10 mm into the body cavity near the pelvic fins and air pressure (2 psi) expels the eggs. The air is removed from the body cavity by massaging the sides of the fish. Up to 2 000 eggs/kg body weight are collected in a dry pan and kept dry, improving fertilisation.

Males are stripped in the same way as females, collecting milt in a bowl, avoiding water and urine contamination. Milt from more than one male (ensures good fertilisation) is mixed with the eggs. It is recommended that milt from three or four males is mixed prior to fertilization to reduce inbreeding. Water is added to activate the sperm and cause the eggs to increase in size by about 20 percent by filling the perivitelline space between the shell and yoke; a process known as 'water-hardening'. Fertilised eggs can be transported after 20 minutes, and up to 48 hours after fertilization, but then not until the eyed stage (eyes are visible through the shell). Direct exposure to light should be avoided during all development stages, as it will kill embryos.

A technique that has been developed to improve production output is the use of monosex culture of females, or triploids. Triploidy is induced by exposing the eggs to pressure or heat whilst monosex are produced by fertilizing normal female eggs (XX chromosomes) with milt from sex-reversed, masculinised females (XXX chromosomes). The mature testes of sex-reversed fish are large and rounded but have no vent. The testes are removed from the abdomen and lacerated to drain the milt into containers. An equal volume of extension fluid is added to make the sperm motile, and ready for fertilizing normal ova. One advantage of this technique is that only the broodstock is sex-reversed, and they can be grown separately, while the marketed fish are not exposed to hormonal treatment.

Feed supply:

Feeds for rainbow trout have been modified over the years and cooking-extrusion processing of foods now provide compact nutritious pelleted diets for all life stages. Pellets made in this way absorb high amounts of added fish oil and permit the production of high-energy feeds, with over 16 percent fat. Dietary protein levels in feeds have increased from 35-45 percent and dietary fat levels now exceed 22 percent in high energy feeds. Feed formulations for rainbow trout use fish meal, fish oil, grains and other ingredients, but the amount of fish meal has reduced to less than 50 percent in recent years by using alternative protein sources such as soybean meal. These high energy diets, are efficiently converted by the rainbow trout, often at food conversion ratios of close

to 1:1. Feeding methods vary for production systems. Hand feeding is suitable for small fish eating fine food. Mechanical feeders, driven by electricity or solar power, are frequently used to feed set amounts at set intervals depending on fish size, temperature and season. Demand feeders can be used for fish greater than 12 cm.

Harvesting techniques:

Methods of harvesting vary but water levels in the holding facilities are generally lowered and the fish netted out. In pens and cages, the fish are crowded using sweep nets and are either pumped from the holding pen alive and transported to the slaughter plant, generally by well boat, or slaughtered on the side of the pens. The whole process is carried out with the aim of keeping stress to a minimum, thus maximising flesh quality.

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