



# History, Present Status and Strategies of Rainbow Trout (*Oncorhynchus mykiss*) Farming in Jammu and Kashmir, India-A Review

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## Abstract

Jammu and Kashmir, particularly the Kashmir valley, contributes extensively to trout production in the Indian subcontinent. This cold-water fish species was successfully introduced into the region in the early 20<sup>th</sup> century from Europe. Eventually, trout fishery gained recognition within the Union Territory (UT) of Kashmir as a commercial and recreational venture. Being healthier and genetically superior to their counterparts from other Indian states, Kashmiri trout are in high demand, particularly for their eggs. Consequently, in 2021 alone almost 700,000 trout eggs have been transported to the North-Eastern states of India. Presence of trout in the waterbodies has made Kashmir one of the world's major angling destinations. At present, the UT has 583 private and state-aided trout farms producing 650 tonnes of trout, making trout farming a sizable industry in the landlocked valley of Kashmir. Due to the unnatural conditions created by intensive rearing, farmed trout are more susceptible to disease agents than their wild counterparts, which is one of the main limitations to trout farming. After the initiation of cold water fish disease surveillance programme with the funding of the National Fisheries Development Board, more than 350 trout farmers had availed the facility for diagnosis and treatment of various fungal, bacterial, and parasitic infections. Besides fish health, there are many bottlenecks in the intensification and propagation of trout farming which have been discussed in detail in the paper.

**Keywords:** Rainbow trout, Jammu and Kashmir, fish health, recreational, raceway, surveillance

## Introduction

The history of "trout farming in Kashmir" dates back to 1898 when F.J. Mitchell, a Scotsman and Pandit Sodhama Miskeen and Khwaja Gafarjoo worked together to introduce trout in Kashmir. The trout seed was acquired from the United Kingdom. The first batch of 10,000 eggs arrived from the United Kingdom in 1899 as a gift from the Duke of Bedford. The first attempt to introduce trout in Kashmir was a failure. Then, in December 1900, the second cargo of 1800 trout fry came in excellent condition from Scotland. F. J. Mitchell, known as "the father of Kashmir trout fishing," is credited with transporting rainbow trout to Kashmir. Of this, 1000 fry were relocated to Panzagam Dachigam (Harwan), about 24 km from Srinagar and the remaining 800 fry were reared in his premises at Baghi Dilawar Khan, near Khanqah-e-Moulla, in the heart of the city. Mitchell was also successful in hatching and surviving fertilized trout ova of rainbow trout (*Oncorhynchus mykiss*) from a batch provided by the Bristol Waterworks' headworks in Blagdon, England, in 1912 (Kaul, 2015).

Mr. Sodhama, known as "Gada Sodhama" (Sodhama, the Fisherman), built a hatchery at Achabal, Anantnag District, from where eyed-ova of brown trout were distributed all over Kashmir (Kaul, 2015). Consequently, trout beats were developed in the valley's snow-fed streams like Bringhi, Lidder, Sindh and Madhumati. Trout were stocked in high-altitude lakes, including Verinag, Kokernag, Achabal, Gangabal, Vishensar, Kisenar, Satsar, Gadsar, Sheshnag and Kounsarnag. The introduction of trout into the Jammu division's cold-water hill

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streams was also a big success (Sehgal, 2012). Trout has been introduced in Dhaggar Nallah at Bani in Kathua district, in Kirchi stream at Daddu-Basantgarh in Udhampur district, Thanala in the upper reaches of Neeru Nallah in Doda district, in Fember Nallah, Keshwan Nallah, Singhpora Nallah and Marwah-Wardwan Nallah in Kishtwar district, at Budhal in Rajouri district, in Bhadora stream and Sui Devta Nallah in Reasi district and Mohu-Mangat and Kheet Streams in Ramban district (Kaul, 2015).



Fig. 1. Map showing the geographical distribution of rainbow trout across India

### Trout farming in Kashmir

In India, due to climatic constraints trout farming is limited to the upper Himalayan region and the Western Ghats. The state of Jammu and Kashmir, particularly the Kashmir region, contributes significantly to trout production. Kashmir Province is composed of 486 kilometers of rivers, 447 kilometers of streams and 157 square kilometers of lakes (Sodhi et al., 2013). The topography and climate of Jammu and Kashmir (J&K) are well suited for breeding, rearing, production and promoting trout fish. The state's snow and glacier-fed streams, mountains, lakes, and springs contribute to trout fish health. Trout is a cold-water fish that prefers clear, torrential streams and transparent, high-altitude lakes. These streams have high oxygen level, little vegetation and trout survive in water between 0 °C and 20 °C, with an ideal range of 5 °C to 15 °C. Furthermore, there

is a sizable population of insects in these water bodies that serve as food for trout. Brown trout (*Salmo trutta fario*) and rainbow trout (*Oncorhynchus mykiss*) are both popular in the state of J&K (Ali, 2017). The first trout farm was established at Harwan, which is a suburb area of district Srinagar, in 1901 and Achhabal, a rural area of district Anantnag in 1908. Anantnag district was designated as India's "Trout District" in June 2018. With government assistance, several fish farms have been established here. Asia's largest trout farm spread over eight-hectare, Kokernag fisheries farm, is also located in Jammu and Kashmir (Fig. 2). With the initiation of the European Union-funded Mother Trout Fish Farming Project at Kokernag, in 1984, trout fisheries in Jammu and Kashmir have got a substantial boost. The farm has quickly established itself as one of the leading producers of rainbow trout. It now offers customers, including private fish farmers, millions of eyed-ova as well as rainbow and brown trout seeds. Every year eggs are harvested from trout fish between November and February. It has a 51-day hatchery operation breeding cycle. Before being relocated to water reservoirs, the fingerlings are fed in tanks. The trout takes 12-15 months to achieve a weight of 250 grams. These are then ready to be sold to trout farms and reared to a weight of three kilograms before being sold (Department of Fisheries, J & K, 2015).



Fig. 2. Trout raceways at Kokernag Fisheries Farm, Jammu and Kashmir

Trout-raising units/hatcheries have now been installed in nearly all the districts of the Union Territory. To promote improved survival at various stages of the fish and to generate sufficient quality table-size trout, advanced breeding and rearing technology are used in trout culture. Broodstock is also managed by the fisheries department to promote spawning fertility. At Laribal, the fisheries department runs a trout hatchery that produces

high-quality brown trout and rainbow trout seed. The use of modern technologies in fish breeding and rearing has completely transformed the sector.

In addition, the department established a trout feed mill in 2012 with state-of-the-art facilities imported from Holland, which produces high-quality trout feed to improve conversion ratios and maintain a healthy population. Both projects have a combined production capacity of around 13.2 million eggs per year. The state Department of Agriculture has built a network of 59 trout-rearing centers in the public sector, along with the private sector (Government of Jammu and Kashmir, 2019). The UT of Kashmir has 583 private and state-aided units producing 500 tonnes of trout by 2020. Apart from that, trout beats have been set up in 142 rivers, lakes and streams in the Union Territory.

### Supply of trout fish seed to various states of India

Kashmir's trout are in high demand, from all the hill states from all over India. In January 2021, 500,000 trout ova were shipped from the Kokernag farm in Anantnag district to Arunachal Pradesh, Nagaland and Uttarakhand (Mahale, 2021). The Kashmir trout are believed to be healthier and genetically better to trout from other states. It also grows swiftly and

accepts feed readily, which is why it is so popular both inside and outside of the state (DCFR, 2011). As a result, trout farming has become an important source of income for Kashmiri farmers (Mahale, 2021).

### Recreational fishing

The regions of Jammu and Kashmir attract tourists for a variety of reasons, including its breathtaking beauty and soothing climate. Anglers opt for Kashmir as a stop destination, with a network of well-stocked hill streams and high-altitude lakes.

With time, the Kashmir trout gained popularity both within the state and in other states. Mostly the rainbow trout is raised for commercial purposes while the brown trout attracts anglers and is an important part of the Union Territory's tourism industry. Brown trout can be found in the wild in the Lidder River, the Brengi River, and streams such as Madhumati and Ferozepur, among others. Trout are tricky sportfish that need all of an angler's abilities to catch. Brown trout populations have unfortunately declined due to a combination of pollution, human interference, and climate change. As a result, it's now grown on state-run farms and released into streams and rivers (Hassan & Pandey, 2012).

Table 1. Trout Production/revenue trends in Jammu and Kashmir

Sector	Units	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Revenue from Trout Sale (Department Units)	lacs	276.01	221.56	294.52	329.05	360.16	403.13	422.79
Trout Production (Biomass)	Tonnes	298	302	482	598	650	650	697
Trout egg production	Lacs	120.0	130.00	132.00	137.00	145.00	147.50	147.80
Trout Rearing Units/Hatcheries established (Cummulative)	Nos.	53	57	58	58	59	51	51
Trout Units established in the Private sector (Cummulative)	Nos.	388	485	513	533	534	718	936

Source DOF, 2021

### Trout farming in Kashmir: An economical venture for entrepreneurs

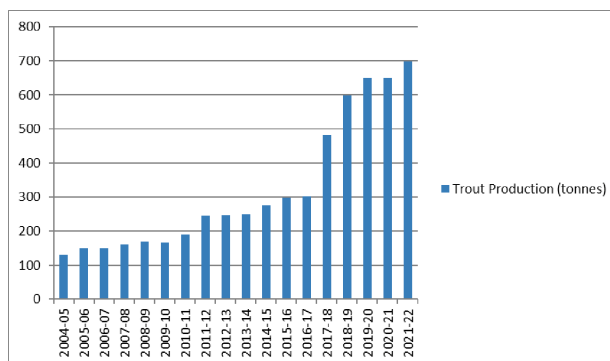
Trout farming has emerged as a significant source of income for Kashmiri farmers. With the launch of the Pradhan Mantri Matsya Sampada Yojana (PMSSY), a scheme by Government of India for increasing fish production in 2020, it received a significant boost. So far, around 200 units have been established under the PMSSY. Due to higher profits from trout farming, some farmers have switched from agriculture to aquaculture entrepreneurship (Kuloo, 2021). Consequent to improved trout production in the state, there is enhanced availability in local markets, improving people's nutrition and food security while also providing employment and income opportunities for the state's unemployed youth (Gawa et al., 2017).

#### Production trends

The trout and salmon are the world's second most traded fish species in terms of value accounting for 14 percent of global trade. Atlantic salmon (*Salmo salar*) and rainbow trout are the two commercially important fish species. Despite a long history of introduction and flourishing aquaculture practices, commercial trout farming is not widely practiced in India. Trout farming in India is limited to the upper reaches of the Himalayan region. Jammu and Kashmir has shown a progressively increasing trend in rainbow trout farming and seed production. The State Fisheries Department has consistently worked for the development of trout farming and production enhancement through excellent infrastructure (Hassan & Pandey, 2012). The production of trout has increased from 90 tonnes during 2002-03 to 580.12 tonnes in 2016-17 and presently it is around 697 tonnes (Table 1 and Fig. 3).

#### Market and trade

Rainbow trout culture has many commercial outputs, including the sale of fresh fish to consumers, fingerlings for restocking rivers and lakes (ranching), and hatchery products such as eggs and juveniles that are sold to other farms. Another important upcoming activity is the distribution of formulated aquafeed to growers. Currently, the sale of fish is confined to local markets. New trade channels are expected to emerge soon as production expands with the addition of new infrastructure.



Source: Pandey & Ali, 2015; DOF, 2022

Fig. 3. Trout production of UT of Jammu and Kashmir from the year 2004-2022

#### Industry issues and perspectives

A SWOT analysis of trout farming in India is a significant basis for developing future action plans for the growth of the trout fishery. Untapped cold-water natural resources in the form of rivers, springs, streams and lakes; well-tested, proven technologies backed by field-oriented projects; institutional support and basic infrastructure; sufficient funds for investment with guaranteed financial returns; and an adequate gap in demand to supply local consumption as well as exports are among the industry's strengths. The lack of cold chain, processing, value addition, and marketing channels, insufficient extension machinery in potential states, the need for high-tech breeding and capital-intensive culture methods, as well as distrust among potential farmers, are among the limitations. Prospects include the deployment, programmes, and schemes by various funding organizations; rural job opportunities; the availability of breeding/seed production infrastructure; and acceptable local consumer needs (Shefat et al., 2018).

The current price of trout feed is the major constraint faced by the farmers during the culture period. In the entire valley, there are only two feed mills manufacturing trout feed, and because trout culture is completely reliant on artificial feed, feed costs make for a significant portion of the total cost of trout culture. The price of input seed is the second most critical constraint, and the price of trout seed (Rs 5-10/piece) is expensive when compared to the seed of carp. The findings of Gawa et al. (2017) estimated the average cost of producing trout seeds was Rs.55.24 lakh per farm, ranging from Rs.4.79

lakh per farm in Laribal to Rs.15.92 lakh per farm in Mammam and Rs.1.02 crore per farm in Kokernag. According to Tuburan et al. (2001), fish seed and formulated feed are the most expensive components in trout farming, accounting for over 70 % of the total cost. The third most significant limitation for farmers is transporting seed from the hatchery to the farm, which necessitates some technical skills as fingerlings require high oxygen. Other constraints faced by trout farmers were the continuous availability of clear and continuous water, contamination of water during the rainy season, high cost of inputs, high rate of mortality, lack of crop insurance and the distance to fetch fish. Encouraging trout production in the state will increase its availability in local markets, resulting in improved nutrition and food security for people, as well as employment and income-generating opportunities for the state's poor. Besides these, the negative effect of effluent from intensive and semi-intensive farms, deteriorating water quality, construction of dams on water bodies, the risk of transmission of contagious ailments, and lack of collaboration among research institutes, government departments, and other organizations are among the threats. There is a need to develop strong linkages between these key actors which will help to improve the trout value chain in Kashmir Valley (Gawa et al., 2017).

### Bottlenecks in trout farming

#### Flash floods

Fish kills due to flash floods/cloud bursts are events that cause a considerable negative impact on trout farming as depicted in Fig. 4. The occurrence of flash floods is becoming more common. As a result of

this, the majority of private trout fish farms have become dysfunctional. In the recent flash flood of 2021 in Kulan Village, district Ganderbal, Kashmir, a private fish farm had severe damage and lost all fish (Kashmir Reader, 2021).

#### Fish losses due to disease outbreaks

According to the survey conducted during 2014-20 under a sponsored fish disease surveillance programme, the annual losses due to various diseases in trout farming is about 20-30 %. Rainbow trout farming is affected by several diseases and parasites (Table 2). The most critical factor for optimal culture is prevention of diseases by adequate hatchery sanitation, use of high-quality seed and feed and disinfection of equipment.

#### Importance of health management in trout farming

Disease outbreaks can ruin any fish farm, thus farmed fish health management is extremely important. Knowing how to deal with disease outbreaks could be the difference between a prosperous company and one that goes bankrupt. During outbreaks, underlying causes can be difficult to determine because they might be the consequence of a series of events and circumstances such as the environment, fish health, handling and management techniques, and the presence of infectious organisms. Surveillance of aquatic animals has an important role in minimizing the danger of disease spread and controlling endemic diseases. Surveillance is also useful for risk assessment, early detection of disease and planning. This requires active vigilance for signs of disease outbreak, rapid



Fig. 4. Trout fish farms affected by natural calamities

Table 2. Commonly encountered diseases in the trout farming of Jammu and Kashmir as per NSPAAD surveys (Shah, 2022)

Disease	Causative Agent	Type of disease agent	Symptoms
Bacterial Dropsy	<i>Aeromonas hydrophilla</i>	Bacterium	Lack of appetite, hemorrhagic lesions on the skin, lethargy and abnormal swimming patterns, pale gills, skin ulcerations, bloated appearance due to ascites
Fish Ich (Ichthyophthiriasis)	<i>Ichthyophthirius multifiliis</i>	Protozoan	White body spots, erratic swimming behavior and rubbing of body against hard surfaces of the raceways
Dermatomycosis (Saprolegniasis)	<i>Saprolegnia parastica</i>	Fungus	White cottony tufts/fuzzy patches on the skin, the affected trout show lethargy and loss of equilibrium
Acanthocephalosis (Pomphorhynchosis)	<i>Pomphorhynchus kashmirensis</i>	Acanthocephalan	Pale gills, loss of appetite, and abnormal swimming
Cestodiasis (Adenoscoliasis)	<i>Adenoscolex sp.</i>	Cestode	Emaciation, anemia, discoloration of the trout skin and susceptibility to secondary infections especially bacterial and fungal
Argulosis	<i>Argulus sp.</i>	Crustacean	Pale gills, excessive mucus secretion, erratic behavior, scratching against hard surfaces, gulping of air at pond surface, low feed intake and emaciation
Dactylogyriasis	<i>Dactylogyirus sp.</i>	Monogenean trematode	Parasites attach to trout gills and cause light yellow lining in the gill filaments and fading of gill color, increased mucus secretion

diagnosis of its infectious etiology and can only be achieved through a structured surveillance programme (Pandey et al., 2012).

The National Surveillance Programme for Aquatic Animal Diseases (NSPAAD) was conceived by the Department of Animal Husbandry, Dairy and Fisheries, Ministry of Agriculture, Government of India, to safeguard the interest of the aquafarming community (Sood et al., 2021). Under NSPAAD project, more than 350 fish farm surveys have been conducted by scientists of Aquatic Animal Health Management, Faculty of Fisheries, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Rangil, Ganderbal, across Jammu & Kashmir UT, including the Ladakh region. During these surveys, 07 major diseases caused by bacterial, fungal, and parasitic agents have been identified as causing significant losses to trout production as depicted in Table 2 and Fig. 5 (Shah, 2022).

### Nutritional importance of rainbow trout and its scope

Rainbow trout is rich in protein that is well-balanced, and it also contains polyunsaturated fatty acids, minerals, and other nutrients. Additionally, it contains high-quality lipids that contain significant amounts of n-3 PUFA. The rainbow trout has 74 % moisture, 19.44 % crude protein, 5.18 % crude fats, and 1.37 % ash, respectively. The rainbow trout is a medium-fat fish with a fat content of 5–10 % by weight based on moisture and fat content. Ca, Fe, Na, Se and Mn are the minerals that are most abundant in rainbow trout, after potassium (Singh & Sharma, 2014).

### Conclusion and the way forward

Trout is high-value species that require specific environmental conditions, and it has been noted that trout have adapted well to the conditions in



Fig. 5. Clinical symptoms found in rainbow trout during active surveillance of different fish farms across Jammu and Kashmir.

A. Bacterial hemorrhage caused by *Aeromonas hydrophila*, B. Saprolegnia infected rainbow trout, C. Corneal opacity in infected trout, D. Skin hemorrhages in a diseased rainbow trout.

Kashmir. Thus there is ample scope for increasing the production and productivity of trout in Kashmir. This can be achieved by increasing the number of hatcheries to provide sufficient seeds for stocking in various public and private farms and open water bodies.

To handle different challenges, notably logistics that frequently arise when working in challenging topography, a cluster-based, holistic approach should span all industry segments, including pond building, fingerling production, feed manufacture and marketing. To make the business more competitive and robust, increased private sector involvement is critical, particularly in the production of seed and feed. Considering formulated, high-protein feeds are the most expensive input, local formulations with indigenous components are required to improve the cost-benefit ratio of culture operations.

Another key consideration in the business is long-term guidance and more effective extension assistance for all stakeholders' capacity and confidence building, as well as a way to exhibit accomplishments to potential investors and entrepreneurs. Lastly, in addition to supporting smaller and local farmers, large-scale businesses of trout shall be roped in to utilize and avail benefits of economies of scale (Anonymous, 2019).

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