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Original Research Paper

Experiments on the Rearing of Rainbow Trout *Oncorhynchus mykiss* Walbaum in Kashmir

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ABSTRACT

Rainbow trout is the native of rivers and lakes in the western half of North America. However, it has been transplanted across the world including Kashmir, India. Experiments conducted to study the rearing success of the fish at Dachigam Trout Fish Farm, Laribal, Kashmir, India during 2004-07 revealed that the fish attained tablesize (250 g) within 24 months. Fish were fed with formulated feed (having 40% protein content) at the rate of 4% of body weight daily in split doses. Early stages of the fish (up to advanced fry) were fed with higher protein content feed (48%) at the rate of 8% of body weight. Eggs were obtained by stripping (dry) and incubated in spring water. The eyed ova stage was reached within 14-20 days of stripping. The hatchlings appeared after another 10-15 days and these accepted artificial feed within another 14-20 days. The fish were reared up to advanced fry stage in spring water and the latter stages in stream water. The spring water at Dachigam showed a temperature range of 10.6-13.8°C, pH of 7.0-8.0, dissolved oxygen of 7.0-10.2 mg/L and free carbon dioxide of 0.6-1.7 mg/L, whereas the stream water showed a temperature range of 5.5-15.6°C, pH of 7.2-8.0, dissolved oxygen of 7.7-11.9mg/L and free carbon dioxide of 0.7-1.6mg/L. The saleable table sized trout showed feed conversion ratio (FCR) of 1.45 to 1.80. Males attained full maturity after 2 years, while females after 3 years.

INTRODUCTION

Salmonid culture has a relatively long history in Europe and North America. It started much later than carp culture (Pillay 1990). Among European salmonids, brown trout is the first fish to be artificially reproduced and reared. However, a greater focus is being given, nowadays, on rainbow trout farming. Rainbow trout are best suited for culture as they accept artificial feed easily. They are eurythermal and can withstand higher temperature fluctuations, their incubation is shorter and growth faster, and they are more resistant to certain diseases. Rainbow trout are native to cold water environments in the north temperate zones and are distributed from southern California through Alaska, the Aleutians, and the Western Pacific areas of the Kamchatka Peninsula and Okhotsk sea drainages. They have been widely transplanted around the world and are well established in South America, Japan, China, Europe, Africa, Australia, New Zealand, India and Pakistan.

The credit for transplantation of rainbow trout in Kashmir goes to F. J. Mitchell, a carpet dealer, also known as “the father of Kashmir trout fishery”. Mitchell in 1912 succeeded in hatching and rearing rainbow trout eggs from a consignment presented by the Bristol Waterworks from their head works at Blagdon, England (Mitchell 1918).

A lot of work has been carried out on the techniques of artificial propagation and other cultural practices of rainbow trout by different workers. Sehgal (1967) studied the causes of mortality of

trout eggs, alevins and fry at Achabal hatchery in Kashmir during 1966-67. The optimum range of various physico-chemical parameters of water required for the culture of trout were also studied in 1974 (Sehgal 1974). Sehgal & Joshi (1975) conducted experiments on the improved techniques of artificial feeding of brown trout and rainbow trout. So, keeping in view the cultural scope of rainbow trout in Kashmir, the present investigation was carried out to study the different aspects of artificial breeding and rearing of rainbow trout. The study has the following objectives of rearing of rainbow trout up to tablesize (>250 g) and measurement of physico-chemical characteristics of water.

MATERIALS AND METHODS

The Dachigam Trout Culture Farm near Srinagar is one of the oldest trout hatcheries established by the Jammu and Kashmir State Fisheries Department. It lies at an elevation of 1708 metres above mean sea level at a distance of about 22 km from the city centre, amidst the world famous Dachigam National Park, abode of the Kashmir stag, the *Hanglu* (*Cervus elaphus hanglu*). Female and male brooders of rainbow trout, reared at the farm itself, were stripped in the second week of November by dry stripping method after anaesthetizing with clove oil @ 50mg/L. 50,000 eggs were obtained from healthy and disease-free broodfish and transferred to hatching troughs after water-hardening. Each hatching trough (2485 × 355 × 127 mm) housed four perforated hatching trays (508 × 330 × 101 mm) in series. The stocking density of eggs in the hatching tray was 8000 per tray. The incubation was carried out in continually flowing spring water. Alevins and swim-up fry were reared in the hatching troughs itself for some days and latter in fibreglass tanks (1065 × 1065 × 635 mm diagonally 1370 mm) inside the hatchery at stocking density of 3000 fry per tank. Advanced fry were reared in bigger fibreglass tanks (1930 × 1930 × 760 mm; diagonally 2180 mm) inside the hatchery for about 4 months, at the rate of 1200 fry per tank, before being transferred to concrete European type raceways (30 m × 5 m × 1.5 m). The broodfish were reared in concrete European type raceways (30 m × 5 m × 1.5 m). The initial stages of the fish (up to advanced fry) were fed at the rate of 8% of body weight split in eight equal doses, whereas the bigger stages were fed at the rate of 4% of body weight split in four equal doses. The ingredients used in the fry feed and that of the feed given to the other stages are given in Table 1. The initial stages (swim-up fry and advanced fry) were raised on feed having higher protein content (48%) as compared to the later stages (fingerlings and above) which were raised on feed containing 40% protein content. Proper farm management practices were observed with respect to the cleaning and disinfection of tanks, troughs and raceways. The broodfish were given bath in $KMnO_4$ both before and after stripping. The eggs were treated with malachite green @ 0.2mg/L as a prophylactic measure against fungal infection. The water quality parameters were estimated at regular intervals as per the standard methodology (APHA 1998).

For determining FCR (feed conversion ratio), the fish were sampled randomly taking about 5% of the population and weighed individually every month. FCR was calculated from the formula:

$$FCR = \frac{\text{Mass of food consumed (dry)}}{\text{Increase in biomass (wet)}}$$

RESULTS

The eggs collected by wet stripping method were transferred to the perforated hatching trays inside the hatchery with flow-through water facility. The eyed ova stage was observed after 14-20 days of stripping. The alevins hatched out after another 10-15 days. Incubation was carried out in spring water. It took another 14-20 days for the alevins to absorb its yolk completely to produce the swim-

Table 1: Ingredients used in formulating feed.

S.No.	Name of the Ingredient	Fry Feed		Above Fry stage	
		Qty. (g/kg feed)	%	Qty. (g/kg feed)	%
1.	Fish meal	680	68	500	50
2.	Soya meal	100	10	230	23
3.	Whole wheat	80	8	200	20
4.	Yeast	40	4	10	1
5.	DL methionine	5	0.5	5	0.5
6.	Choline chloride	5	0.5	5	0.5
7.	Mineral mix	5	0.5	5	0.5
8.	Vitamins	20	2	1	0.1
9.	Linseed oil	60	6	40	4
10.	Algenite	5	0.5	4	0.4

up fry. Artificial feeding was commenced when even one swim-up fry was observed in the trays. The hatching trays were removed from the hatching troughs and the swim-up fry were reared in the troughs for a period of 10-15 days. The rate of survival from egg to early fry was 94%. Proper management practices were followed during the incubation of eggs and rearing of alevin and swim-up fry. Regular picking of dead eggs was done in the morning by the help of a picking glass fitted with a rubber bulb, and eggs treated with malachite green @ 0.2 mg/L once a week as prophylactic measure against fungal diseases.

After 10-15 days of rearing in hatching troughs, the fry were transferred into fibreglass tanks (1065 × 1065 × 635 mm) at the rate of 3000 fry per tank. At the time of stocking the fry were about 250 mg in weight and 19 mm in length. The fry were fed with starter diet having higher protein content (48%). Feeding was done at the rate of 8% of body weight, split in eight equal parts and broadcast into the tank from morning to evening at regular intervals. The fry were reared in these smaller tanks for about one and a half months before being transferred to bigger tanks.

The fry were reared in spring water inside bigger fibreglass tanks (1930 × 1930 × 760 mm) having rounded corners for effective circulation of water for a period of 4 months, and fed at the rate of 8% of body weight in eight equal split doses. The stocking density was 1200 fry per tank. Feeding was done with higher protein containing fry feed. After rearing for a period of 4 months, the advanced fry were transferred from the hatchery to European type concrete raceway (30 m × 5m × 1.5 m) maintained on water from snow-fed Dachigam stream. The weight range of the advanced fry at the time of stocking was 8-15g. The fish were stocked at the rate of 10 fingerlings per m^2 and reared till tablesize (> 250g). Feeding was carried out at the rate of 4% of body weight split in four equal doses. It was observed that the average monthly weight increment was more in the summer months owing to the fact that the fish consumed more feed in the summer months as compared to the winter months. On completing one year of rearing, the fish were found to be in the weight range of 55-110g whereas on completing 2 years of rearing period the weight range was 265-315g. The feed conversion ratio (FCR) was estimated to be 1.45-1.80. It was observed that the farm reared female brooders were fully matured after completing 3 years of age while the farm reared male brood fish were in oozing condition after completing 2 years of age. For the spring water, the temperature was found between 10.6 and 13.8°C, pH 7.0 and 8.0, dissolved oxygen 7.0-10.2 mg/L, and free carbon dioxide 0.6-1.7 mg/L. The stream water showed a temperature range of 5.5-15.6°C, pH 7.2-8.0, dissolved oxygen 7.7-10.9 mg/L, and free carbon dioxide 0.7-1.6 mg/L.

DISCUSSION

Water temperature is the most important factor affecting fish farming. It plays a vital role in feed consumption thereby controlling rate of growth. Energy requirements of an organism increases at high temperature. In contrast, low water temperature decreases the metabolic rate and consumption of food. Each species has a water temperature range for optimal growth (Jhingran 1982). The rainbow trout requires an optimum temperature range of 10-15°C for best growth. However, the temperature tolerance limit is between 1 and 24°C. Edward (1978) reported that for most salmonids slightly lower temperatures are preferable. The upper lethal limit is around 24-27°C, but at temperatures above 20°C, appetite and growth are reduced, leading to attack by disease organisms. The lower lethal limit is around -5°C. However, little growth can be expected below 5°C. Bardach et al. (1972) reported excellent hatching results in trout with temperatures ranging between 8 and 13°C. Raina & Langer (1989), during their studies conducted on brown trout seed production in Kashmir from November to March, recorded a water temperature between 3.5 and 8.6°C. In the present experiment, the water temperature of the spring water fluctuated from 10.6 to 13.8°C, while that of stream water from 5.5-15.6°C which is suitable for growth of rainbow trout. The results are also in consonance with those of Sehgal (1974) when he reported the water temperature at the Laribal hatchery in Kashmir between 5.0 and 10.5°C.

Fishes grow well in waters having a pH of 6.5 to 9.0 (Swingle 1961). Ellis et al. (1946) reported that the pH values of trout waters ranged from 6.7 to 8.6. Sehgal (1974), while studying the various physico-chemical parameters of the water in different trout farms of India, concluded that the farms which receive snow-melt water from the streams always show a pH range of 7.2-7.8, while the spring fed hatcheries of the Himalayan region have a pH range of 7.9-8.4. Sunder et al. (1986), while rearing trout fingerlings to tablesize in Kashmir, recorded a pH range of 7.2 to 7.4 during the study period. Raina & Langer (1989) found a pH range of 7.0 to 7.4 from November to March in Kashmir waters. Bromage & Shepherd (1990), from their observations, reported the preferred pH range of trout between 6.4 and 8.4 with a pH between 7.0 and 7.5 as being optimal. In the present study, the pH of spring water and stream water was in the range of 7.0-8.0 and 7.2-8.0 respectively, which is within the optimum range as recommended by different workers.

Dissolved oxygen, being the most important key element in aquaculture systems, plays a pivotal role in fish production. The content of dissolved oxygen in water has an inverse relationship with its temperature. Brown (1983) reported a dissolved oxygen range of 5-7mg/L as being ideal for rainbow trout culture. Bromage & Shepherd (1990) pointed out that salmonids require high levels of dissolved oxygen, which should always remain above 5.5 mg/L. Gibson (1998) reported that a low level of dissolved oxygen (below 7.0 mg/L) affects feeding and feed consumption and consequently the growth of rainbow trout. Sunder et al. (1986) reported dissolved oxygen in the range of 6.4 to 10.5mg/L while rearing trout in Kashmir. Raina & Langer (1989) during their experiments on rearing of trout reported the range of dissolved oxygen between 8.4 and 10.8mg/L at Laribal and Harwan hatcheries in Kashmir. According to Sehgal (1974) the average dissolved oxygen values in stream-fed trout hatcheries of Kashmir ranged between 7.4 and 10.2 mg/L. In the present study, the dissolved oxygen content varied between 7.0 and 10.2 mg/L for spring water and between 7.7 and 10.9 mg/L for stream water, which is in consonance with the earlier reports of different workers.

Free carbon dioxide content of water also has a direct bearing on the growth of fishes cultured therein. Fish can withstand carbon dioxide content up to 60 mg/L in the presence of sufficient oxygen concentration (Huet 1975). Sehgal (1974) reported a carbon dioxide value of 0.7 to 1.8 mg/L for

stream-fed hatcheries of the Himalayas and 2.3 to 2.8 mg/L for spring-fed trout hatcheries. Raina & Langer (1989) recorded carbon dioxide in the range of 0.7 to 2.6mg/L at the Laribal Trout Culture Farm in Kashmir. The free carbon dioxide content in the present study was found between 0.6 and 1.8mg/L for spring water and 0.7 and 1.6 mg/L for stream water.

Joshi et al. (2005), while conducting rearing experiments of rainbow trout in Central Himalayas (Uttrakhand), reported that 26-30 days were taken for the fertilized eggs to reach the eyed ova stage at 4.5 to 6.5°C while from eyed ova to hatching out of the alevin (sac fry) it took another 10-12 days at 4.5 to 8.5°C. For complete absorption of the yolk and the appearance of swim-up fry, it took about 18-22 days at 5.0 to 8.5°C. In the present study almost similar results have been obtained with the fertilized eggs to eyed ova stage taking 14-20 days, the alevins hatched out after another 10-15 days and for complete absorption of yolk and appearance of swim-up fry another 14-20 days were taken.

Rainbow trout are best suited for culture because of a number of reasons. The ability of the fish to grow quickly makes it a profitable species for aquaculture (Sedgwick 1985). Bromage and Shepherd (1990) while studying the feed conversion ratio (FCR) in trout reported that most of the trout farms achieve FCRs of at least 1.5:1. The authors also reported that under ideal conditions FCR may be as low as 1:1. However, with low protein or poorly digestible diets, FCR may be as poor as 2:1 or even poorer. Stevenson (1987) stated that some farmers claim an FCR of about 1.15 for trout in tanks under optimal conditions, but a figure of 1.2 to 1.4 for growers is generally regarded as satisfactory. Austreng et al. (1987) while rearing atlantic salmon and rainbow trout on dry feed reported an FCR of 0.9-1.1. Uysal & Alpbaz (2002) reported an FCR of 1.39 to 1.86 for rainbow trout in pond culture. Carriquiriborde et al. (2004) while feeding rainbow trout with varying iron content feed reported an FCR of 2.03 ± 0.71 on feeding with normal levels of dietary iron. Joshi et al. (2005), while rearing rainbow trout in Uttranchal in Central Himalayas, India estimated the feed conversion ratio (FCR) at 1.95. Turker & Dernekbasi (2006) while subjecting rainbow trout to restricted feeding, obtained an FCR of 1.33 ± 0.03. In the present study the value of FCR was obtained between 1.45 and 1.80, which is fairly good and is in consonance with earlier studies of different workers.

The age at maturity is quite variable for the rainbow trout (Ross 2001). Rainbow trout mature in their 2nd or 3rd year. Moyle (1976) reported that the first maturity of rainbow trout can vary from 1st to 5th year of life. Joshi et al. (2005), while conducting rearing experiments of rainbow trout in Central Himalayas, reported that the females attained full maturity after 3 years. In the present study, farm raised brooders were quite amenable to artificial fecundation by stripping, with the males being in oozing condition after 2 years of age while females yielding good quantity of healthy eggs after 3 years of age.

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