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Breeding Performance of Rainbow Trout, *Oncorhynchus mykiss* (Walbaum), the Raceways of Kathmandu, Nepal

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ABSTRACT

As the requirement of small farmers', artificial breeding performance of 1.0^{+} broods (first spawners) of rainbow trout, Oncorhynchus mykiss (Walbaum), was carried out in their own raceways. Fingerlings 5.433±0.06g and 6.70±0.02cm were stocked in the rac eways in water discharge of 0.083-0.3L sec^{-1} for one year. When they became 375±18.097g and 31.5±0.1 9cm after one year, they were selected as future broods. Future broods passing through the stages of broods (426±16.165g and 33±0.40cm), segregated broods (454±18.641g and 34±0.39cm), and current bro ods (513±17.678g and 36±0.38), after five months, were converted into gravid broods attaining 519±19.191g and 36±0.38cm. Gravid broods, which were 1.0^{+} broods (first spawners) and which were put under artificial breeding, when collected before spawning were found to be 519.83±12.243g and 36.06± 0.34cm. Induced breeding results under semi-intensive farming system of 12 female (520.±9.785g and 36.18±0.24cm) and 6 male (493.5±23.158g and 35.8±0.79cm) broods showed a total collection of 91 5g eggs (76.25±1.538g eggs female^{-1}) and 18391 number eggs (1532.58±38.88 number eggs female^{-1}) and 204ml milt (34±2.61ml milt male^{-1}) respectively. Eggs were yellow-coloured, each egg 0.0499±0.001g a nd 0.303± 0.0095cm (diameter). Eggs laid were 146.65±1.404g eggs kg^{-1} body wt. (1759.82g eggs 12kg^{-1} body wt.) and 2947.42±51.54 number eggs kg^{-1} body wt. (35369 number eggs 12kg^{-1} body wt.) of female broods. 1g eggs comprised 20.12±0.38 number eggs (241376 number eggs 12kg^{-1} of eggs and 20115 eggs kg^{-1} of eggs). Milt was cream-coloured, each ml comprising 5millions spermatozoa. Milting was 68.53±2.36ml milt kg^{-1} body wt. (411.17ml milt 6kg^{-1} body wt.) of male broods. Fertilization was done by dry stripping method with 70.18±4.05g fertilized eggs female^{-1} (842.1g fertilized eggs 12females^{-1}) and 1410.16±94.12 number fertilized eggs female^{-1} (16922 number fertilized eggs 12females^{-1}) ensuring fertilization percentage to be 91.99±0.5 8%. Fertilized eggs were transferred into incubation cum hatching trays put into incubation cum hatching raceways. Cleaning and readjustment of incubation cum hatching trays were done thrice. Incubation period was 25 days in average temperature of 10.89±0.21^{o}C day^{-1} and cumulative temperature (sum total of water temperature of 25 days) of 272^{o}C with hatching of yolk-sac fries or alevins (survivability 41.82±3.16%), each 0.0365±0.0016g and 1.46±0.086cm with 0.0136±0.0012g yolk-sac. Alevins were shifted into endogenous feeding cum hatching cages put into endogenous feeding cum hatching raceways. Endogenous feeding period was 5 days in water temperature of 9.1^{o}C liberating free swimming fries (survivability 76.92±4.91%), each 0.025±0.0007g and 1.65±0.083cm ready for exogenous feeding period. Results confirmed the utility of 1.0^{+} broods at small farmer's level.

Key words: *1.0^{+} (First Spawners) Rainbow Trout Broods, Eggs, Milt, Alevins, Free Swimming Fries*

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INTRODUCTION

Rainbow trout, *Oncorhynchus mykiss* (Walbaum)[4], primarily requires raceways in feasible location with suitable physico-chemical parameters; secondarily continuous seed supply in the form of fry and fingerlings; and ultimately the artificial feed. Seed supply in the form of fry and fingerling availability has become one of the main bottlenecks of rainbow trout production in Nepal. The fry and fingerling can be made available through induced method of breeding known as artificial breeding. Because, artificial method of propagation is the successful method of breeding of any fish species including rainbow trout therefore it is artificially bred for continuous seed supply, thus obtaining fry or fingerlings for culture practices.

Rainbow trout breed in winter season in Nepal. Rainbow trout survive 11 years[14] and a male become sexually mature at 1 year and a female at 2 years[8]. Rainbow trout breed attaining 2 years[15]. In general, a female rainbow trout spawns best at the age of 4-7 years while a male at 3-6 years[14]. However, 1.0^{+}broods (first spawners) and 2.0^{+}broods (second spawners) are used for breeding in Nepal at small farmers' level because of their constraints in brood management for such a long time of 3-6 years as mentioned above as best spawning age.

The main objective of this study was to examine the breeding performance of 17-18 months, i.e., 1yr and few months (from fertilized eggs to this stage) old male and female rainbow trout broods called 1.0^{+}broods (first spawners) for free swimming fries (FSFs) production also considering the fertilized eggs (number and size), incubation period, alevins (number and size), endogenous feeding, and FSFs (number and size) including their survivability and growth. Therefore, the study was conducted for 2 years from June 2009 to May 2011 on breeding performance of rainbow trout in farmer's raceways at Kakani, Kathmandu, Nepal situated at latitude 27°48' N, longitude 85°15' E and altitude 1550msl (mean sea level). Physico-chemical parameters were also recorded. Breeding performance of 1.0^{+}broods (first spawners) of rainbow trout starting from rearing of fingerlings to the attainments of broods and obtaining of FSFs from the same broods was assessed in raceways as the requirement of small farmers'.

MATERIALS AND METHODS

Culture method (normal, semi-intensive or intensive), water discharge (WD), depth of water (80-90cm) and stocking density (wt. m^{-2} and number m^{-2}) in raceways (having a dimension of 5m × 1m ×1m with water volume of 5m × 1m ×0.9m), crude protein (CP) % in the artificial feed, feeding rate (% in body wt.), feeding frequency (times day^{-1}), future brood selection, and brood, segregated brood, current brood, and gravid brood confirmation, etc., were done according to Anonymous[1], Basnet *et al.*[5], Bista *et al.*[6], Rai *et al.*[15] and Roy *et al.*[16]. Fingerlings (number) were stocked based on Rai *et al.*[15]; kept in WD as per both Basnet *et al.*[5] and Rai *et al.*[15]; and fed CP containing artificial crumble and pellet feed according to Basnet *et al.*[5], Bista *et al.*[6] and Rai *et al.*[15]. Fingerlings were stocked for 1 year from June 2009 to May 2010 to obtain them as future broods. Fingerlings were stocked @ 250g m^{-2} (50 fingerlings m^{-2}) in farmer's raceways in WD of 0.083L sec^{-1} m^{-2} (0.42L sec^{-1} in the raceway) and fed 45% CP containing diet @ 8-10% of their body weight 8-10 times day^{-1} for 3 months; in WD of 0.1L sec^{-1} m^{-2} (0.5L sec^{-1} in the raceway) and fed 45% CP containing diet @ 5-8% of their body weight 6-8 times day^{-1} for another 3 months; in WD of 0.2L sec^{-1} m^{-2} (1L sec^{-1} in the raceway) and fed 40% CP containing diet @ 3-5% of their body weight 4-6 times day^{-1} for the next 3 months; and in WD 0.3L sec^{-1} m^{-2} (1.5L sec^{-1} in the raceway) and fed 35% CP containing diet @ 2-3% of their body weight 3-4 times day^{-1} for the last 3 months (up to May 2010). Broods were selected (based on selection criteria through observation of the external appearance); confirmed (based on confirmation criteria through observation of the external appearance) and stocked (wt. m^{-2} and number m^{-2}) as per Basnet *et al.*[5]; kept in WD according to both Basnet *et al.*[5] and Rai *et al.*[15]; and fed CP containing artificial pellet feed based on Basnet *et al.*[5], Bista *et al.*[6] and Rai *et al.*[15]. Five months prior to breeding, future broods were selected (through observation of the external appearance); stocked @ 5-10kg m^{-2} (15-20 trout m^{-2}) in WD 0.42L sec^{-1} m^{-2} (2.08L sec^{-1} in the

raceway); and fed 35% CP containing artificial feed @ 2-3% of their live body weight twice day^{-1}. Three months prior to breeding, broods were noticed when they developed initial sign of sexual maturity (through monthly-wise observation of the external appearance including observation of the vent); stocked @ 5-10kg m^{-2} (15-20 trout m^{-2}) in WD 0.52L sec^{-1} m^{-2} (2.6L sec^{-1} in the raceway); and fed 40% CP containing feed @ 2-3% twice day^{-1}. Two months prior to breeding, segregated broods were separated when they developed complete sign of sexual maturity (through monthly-wise observation of the external appearance including observation of the vent); stocked @ 5-10kg m^{-2} (15-20 trout m^{-2}) in WD 0.63L sec^{-1} m^{-2} (3.13L sec^{-1} in the raceway); and fed 45% CP containing feed @ 1-2% twice day^{-1}. Segregated broods separation was done to increase sexual affinity between females and males by increasing quality and quantity of eggs and milt respectively. One month prior to breeding, the state of the ripeness of gonads was examined twice a week (through observation of the external appearance including observation of the vent). In the month of breeding, current broods were confirmed (through observation of the external appearance including observation of the vent and then with the help of inserting a catheter in the vent) by collecting eggs and milt from female and male broods respectively; stocked @ 5-10kg m^{-2} (15-20 trout m^{-2}) in WD 0.63L sec^{-1} m^{-2} (3.13L sec^{-1} in the raceway); and fed 45% CP containing feed @ 1% 4-5 times $week^{-1}$. Gravid broods were collected when they showed complete sign of readiness for breeding (when with a gentle pressure on vent a female and male brood started oozing ova and milt respectively). When ready for breeding, gravid broods were counted (manually) and measured (weight by electronic balance and length by measuring scale) and then wiped clean with the help of a towel before stripping.

Stripping (by applying mild pressure first on lower part of the ovary near the vent and then upward the ovary over the ventral side of the female towards the vent) was done to collect eggs from females and milt from males. Dark condition was created during stripping to assure more viability of both eggs and milt. Air temperature (AT) was also recorded at that time to further ensure the viability. Eggs were collected by simple hand stripping on a sieve with handle (to drip water from the roe) and then cleaned with 0.9% NaCl sol^{n} to remove stickiness and further observed (both through naked eye and compound microscope), counted (manually by random sampling taking 5 samples of 1g each), and measured (diameter with the help of vernier calliper and weight by the help of electronic balance). Milt was also observed (both through naked eye and compound microscope) and counted (under compound microscope using counting chamber slide). Dark condition was created during fertilization to ensure more rate of fertilization. AT was also recorded at that time to further assure more rate of fertilization. Eggs of 2 females were fertilized by milt of 1 male in a container by dry stripping method by stirring them well with the help of a bird's feather and then stand still for 1 min. 0.9% NaCl sol^{n} was poured carefully from the side of the container to remove any dirt, if present, and further cleaning the fertilized eggs to remove stickiness. To do that, the same procedure was repeated again and again until fertilized eggs became transparent. Fertilized eggs were segregated from unfertilized with the help of colour (fertilized eggs light-coloured and unfertilized dull-coloured) and then counted (manually by random sampling taking 5 samples of 1g each) to calculate fertilization percentage (fertilized eggs ÷ total number eggs × 100). 1.0^{+} spent up broods were procured and stocked for another year breeding to come.

Incubation was done in incubation cum hatching trays. All the procedure was done in the evening on the same day of fertilization creating dark condition. Dark condition was created in the hatchery, as the development would be better. Each tray contained 1000 eggs. Ten such trays were staked together in an atkin. Altogether three atkins were put into an incubation tank kept inside incubation cum hatching raceways. WD was maintained 0.017L sec^{-1} (for 1^{st} week), 0.033L sec^{-1} (for 2^{nd} week), and 0.05L sec^{-1} (for 3^{rd}, 4^{th} and rest weeks) per 10,000 fertilized eggs in the raceway according to Basnet *et al.*[5] and Rai *et al.*[15]. Water temperature (WT), power of hydrogen ion

concentration (pH), dissolved oxygen (DO), and free carbon dioxide (FCO) were also recorded as a routine work. All the trays were cleaned to remove dead eggs and readjusted weekly-wise to provide equilibrium in all the trays until observing eyed-eggs. Mortality was counted during cleaning and readjustment. When alevins were released they were counted (manually by random sampling taking 5 samples each) to calculate their number for survival percentage (alevins released ÷ total number of incubated eggs × 100) and measured (with the help of electronic balance and measuring scale) to know their weight (g), length (cm), and weight of the yolk-sac (g).

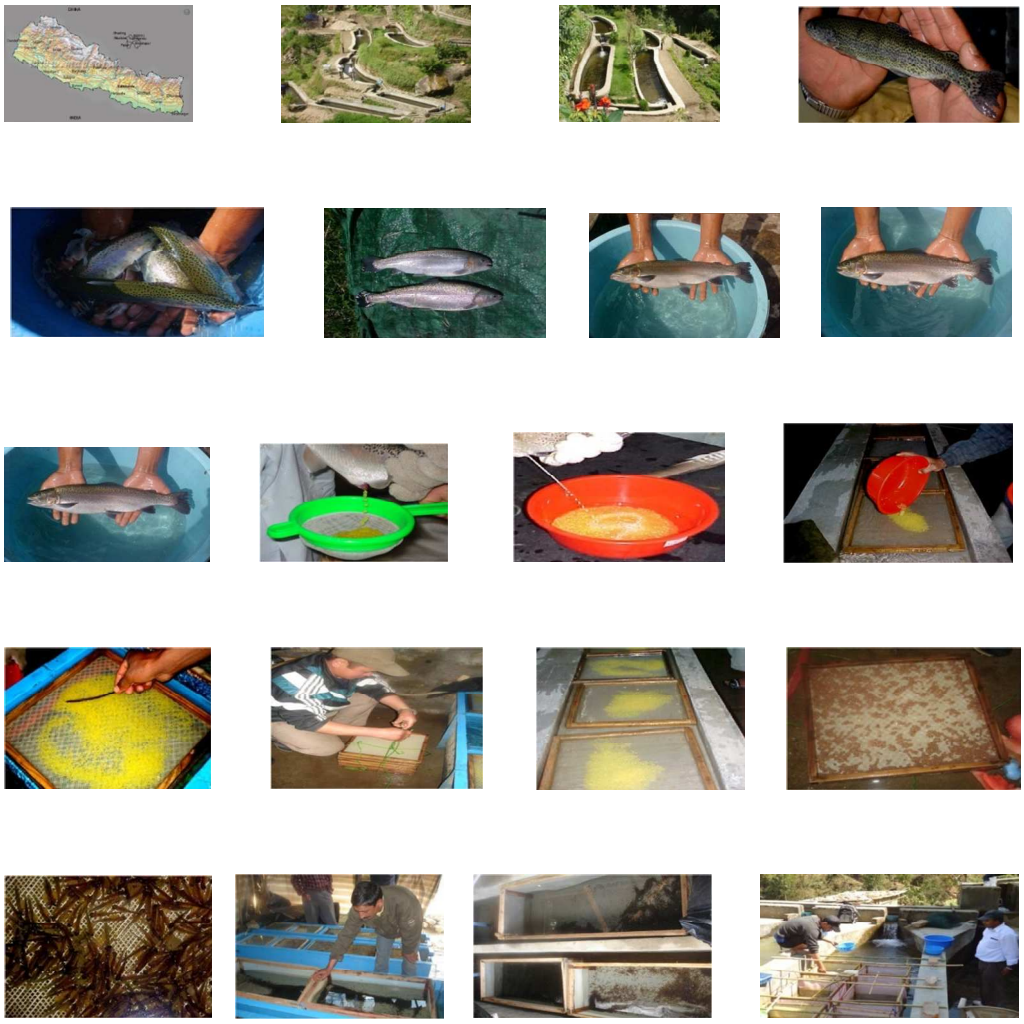

Figure-1 to 20: 1. Map of Nepal showing Kakani, Kathmandu, the site of breeding; 2. Raceways aerial view; 3. Raceways close view; 4. Future broods; 5. Broods; 6. Segregated broods (upper male and lower female); 7. Current broods; 8 Gravid male; 9. Gravid female; 10. Stripping of female to get eggs; 11. Stripping of male to get milt; 12. Putting fertilized eggs on incubation cum hatching trays; 13. Spreading fertilized eggs on incubation cum hatching trays; 14. Staking incubation cum hatching trays into atkins; 15. Putting atkins in the incubation cum hatching tanks/raceways; 16. Cleaning and readjustment of the incubation cum hatching trays; 17. Yolk-sac alevins released after 3rd cleaning and readjustment; 18. Setting of yolk-sac alevins in endogenous feeding cum hatching cages; 19. FSFs released after endogenous feeding period; 20. Setting of FSFs for exogenous feeding in nursing cum feeding cum rearing cages.

Alevins were set in hatching cum endogenous cages put into endogenous cum hatching raceways. WD was maintained 0.067L sec^{-1} per 10,000 alevins in the raceway according to Basnet *et al.*[5] and Rai *et al.*[15]. WT, pH, DO, and FCO were also recorded. Dark condition was created in the hatchery. After passing through endogenous feeding (in days) based on WT, FSFs would leave the substratum and start swimming after complete absorption of their yolk-sac. Mortality was counted during the time. When FSFs were released they were counted (manually by random sampling taking 5 samples each) and measured to calculate their number for survival percentage (FSFs released ÷ total number of alevins × 100) and measured (with the help of electronic balance and measuring scale) to know their weight (g) and length (cm). FSFs were then made ready for exogenous feeding for the feeding of formulated artificial feed.

RESULTS AND DISCUSSION

WT from June 2010 to May 2011 ranged 8.4-21.5 (15.84±0.98^{o}C), pH 6.7-7.9 (7.38±0.08), DO 7.2-10.5 (8.74±0.24mg L^{-1}), FCO 1.4-4.9 (3.34±0.22mg L^{-1}) and WD which was maintained as per mentioned in Materials and Methods was 37-92 (55.79±2.87L sec^{-1}). Rainbow trout mostly requires glacier water or clean cold spring water for its successful breeding (Basnet *et al.*[5]). Water resource (WR) supplying water in the raceways, in the present work, was permanent, dependable, and from perennial spring-fed stream. The prerequisite for rainbow trout culture is adequate volume of coldwater below 20^{o}C because feed consumption decreases when WT increases above 20^{o}C, resulting into slow growth and eventually death, if exposed to higher (always more than 20^{o}C) WT for a longer period (Rai *et al.*[15]). What so ever may be, rainbow trout require WT 0-25^{o}C (Swar[18]) but according to Yamazaki[20], it grows well in WT 10-18^{o}C, however, according to Anonymous[2], its best growth in Nepal occurs in WT 16-18 ^{o}C. According to Rai *et al.*[15], suitable WT for rainbow trout spawners for breeding and incubation is 9 to 14^{o}C. In the present work, WT during breeding and incubation (in November and December) was 9.1-13.1^{o}C.

The preferred range of pH for rainbow trout is 6.5-8.0 with optimum value 7.0-7.5 (Rai *et al.*[15]) for semi-intensive farming because at higher pH levels, relatively low levels ammonia (NH_3) can be dangerously toxic (Bromage and Shephard[7] and Sedgwick[18]). According to Huet[9], rainbow trout require DO above 7.0mg L^{-1}; according to Rai *et al.*[15], it requires DO more than 7.0mg L^{-1}; and according to Basnet *et al.*[5], its brood requires cold, clean and high DO containing water of 7.0-7.5mg L^{-1} for normal trout culture and 10-11mg L^{-1} for intensive culture for proper ripening of gonads and successful hatching of alevins and FSFs because according to Anonymous[1] the growth is retarded and the trout may die, if exposed to DO below 7.0mg L^{-1}. Rainbow trout require FCO below 20mg L^{-1} (Lawson[11]). So, induced breeding under semi-intensive culture was done in the present work because pH was 6.7-7.9 and DO below 11mg L^{-1}. Hence, parameters like WT, pH, DO and FCO, in the present investigation, were suitable for breeding and WD was such that it could be maintained from 0.017 to 3.13L sec^{-1} as per requirement as mentioned above.

One year and five months prior to breeding (in June 2009), 250 fingerlings total 1.358kg and each 5.433±0.06g and 6.70±0.02cm were stocked @ 250g m^{-2} (50 fingerlings m^{-2}) in WD 0.067-1.0L sec^{-1} after one year (in May 2010, i.e., five months prior to breeding) were obtained as experimental broods total 75kg each 375±18.097g and 31.5±0.19cm with survivability 90% (225 in number was obtained out of 250) and growth 30.345g $month^{-1}$ (369.57±18.06g and 24.8±0.17cm future broods were obtained from 5.433±0.06g and 6.70±0.02cm fingerlings with the growth of 364.14±18.02g and 18.09±0.16cm). Breeding performance and success of rainbow trout culture highly depend on selection, management, age, and maturation of brood, disease surveillance, feeding, and water quality (Basnet *et al.*[5]). Good selection of brood is one of the important aspects to increase the rate of hatchability and decrease rate of mortality of offspring, hence, quality, quantity and matured eggs and milt can be obtained by careful selection of broods (Basnet *et al.*[5]). Further, according to Basnet *et al.*[5], 1.0^{+}broods (first

spawners), should be selected based on external appearance and weight. So, most of the experimental broods (200 out of 225) were selected as future broods according to Basnet *et al*.[5] on the basis of general health condition, absence of deformities, good external appearance, rapid growth, good colouration, prompt activity, swiftness of reaction to stimuli and weight.

Five months prior to breeding (in June 2010), 200 future broods total 75kg each 375±18.097g and 31.5±0.19cm were stocked (7.5kg m^{-2}, i.e., 20 trout m^{-2}) and after two months (in July 2010, i.e., three months prior to breeding) when males developed rough upper surface on pectoral fins and females swollen belly along with slightly lined reddish vent, obtained as broods total 85.2kg each 426±16.165g and 33±0.40cm. When maturity of their gonads was checked monthly-wise during June and July, 2010, it was found in increasing trend. Survivability was 100%. Growth was 25g $month^{-1}$ in June and 26g $month^{-1}$ in July.

Three months prior to breeding (in August 2010), 200 broods total 85.2kg each 426±16.165g and 33±0.40cm were stocked (8.52kg m^{-2}, i.e., 20 trout m^{-2}) and after one month (in August 2010, i.e., two months prior to breeding) when males became bright and brilliant in colour with compressed abdomen and elongated lower jaw, curved upwards like a hook and some males appearing darker in colour, almost black and females comparatively light-coloured than males but with swollen and enlarged abdomen having slightly reddish vent, obtained as segregated broods total 90.8kg each 454±18.641g and 34±0.39cm. When maturity of their gonads was checked monthly-wise in August 2010, it was found in increasing trend. Survivability was 100%. Growth was 28g $month^{-1}$. Segregated broods were put into separate raceways to increase affinity between females and males so as to increase quality and quantity of eggs and milt respectively.

Two months prior to breeding (in September 2010), 200 segregated broods total 90.8kg each 454±18.641g and 34±0.39cm were stocked (9.08kg m^{-2}, i.e., 20 trout m^{-2}) and after two months (in October 2010, i.e., one week prior to breeding) when males oozed milt on pressing their abdomen and females eggs along with reddish vent, obtained as current broods total 102.6kg each 513±17.678g and 36±0.38cm. When maturity of their gonads was checked monthly-wise in September and October 2010, it was found in increasing trend. Survivability was 100%. Growth was 29g $month^{-1}$ in September and 30g $month^{-1}$ in October.

In the month of breeding (in the 1st week of November, 2010), 200 current broods total 102.6kg each 513±17.678g and 36±0.38cm were stocked (10.26kg m^{-2}, i.e., 20 trout m^{-2}) and after one week (in the 2nd week of November, 2010, i.e., two days before breeding) when both males and females developed complete sign of readiness for breeding, obtained as gravid broods total 103.8kg each 519±19.191g and 36±0.38cm. When maturity of their gonads was checked weekly-wise (in the last day of the 1st week of November, 2010), it was found in increasing trend. Survivability was 100%. Growth was 1g day^{-1} in the 1st week of November, 2010. The gravid broods of 1 year and 5 months were called 1.0^{+}broods (first spawners).

On the day of breeding (on Sunday, 7th November, 2010), one hundred 1.0^{+}broods (first spawners) total 51.9kg each 519±19.191g and 36±0.38cm were netted out and stocked (10.38kg m^{-2}, i.e., 20 trout m^{-2}) inside happa kept in raceways. Out of one hundred gravid broods, which were 1.0^{+}broods (first spawners) and which were put under artificial breeding, few gravid broods, when selected and collected before spawning were found to be 519.83±12.243g and 36.06±0.34cm. Among them 18 gravid broods (12 females and 6 males) were selected for the experiment.

Stocking density, CP (%) in artificial feed, feeding rate (%), feeding frequency (times day^{-1}), stocking duration (months/year) and WD (L sec^{-1} m^{-2}) maintained for fingerlings total 1.358kg and each 5.433±0.078g and 6.70±0.03cm and stocked @ 250g m^{-2} (50 fingerlings m^{-2}) following Basnet *et al*.[5] and obtaining them as future broods total 75kg each 375±18.097g and 31.5±0.19cm after 1 year (in May, 2010) with survivability 90% and growth 30.8g $month^{-1}$ (for 12 months); as broods total 85.2kg each 426±16.165g and 33±0.40cm from

future broods stocked @ 7.5kg m^{-2} (20 trout m^{-2}) after 2 months (in July, 2010) with survivability 100% and growth 26.5g $month^{-1}$; as segregated broods total 90.8kg each 454±18.641g and 34±0.39cm from broods stocked @ 8.52kg m^{-2} (20 trout m^{-2}) after 1 month (in August, 2010) with survivability 100% and growth 28g $month^{-1}$; as current broods total 102.6kg each 513±17.678g and 36±0.38cm from segregated broods stocked @ 9.08kg m^{-2} (20 trout m^{-2}) after 2 months (in October, 2010) with survivability 100% and growth 29.5g $month^{-1}$; as gravid broods total 103.8kg each 519±19.191g and 36±0.38cm from current broods stocked @ 10.26kg m^{-2} (20 trout m^{-2}) after 1 week (in the 1st week of November, 2010) with survivability 100% and growth 1g day^{-1}; and as 1.0^{+}broods (first spawners) 51.9kg each 519±19.191g and 36±0.38cm from all the gravid broods stocked @ 10.38kg m^{-2} (20 trout m^{-2}) gave similar results like Basnet *et al.*[5] because future brood selection and broods, segregated broods, current broods, and gravid broods confirmation were done accordingly. According to Bista *et al.*[6], survivability of broods was 95-97% whereas it was 100% in the present work. It might be due to proper management in the present work. The growth of fingerlings to gravid broods was similar to Marcel[12], Anonymous[3], Basnet *et al.*[5], Joshi *et al.*[10], Rai *et al.*[5], and Swar[19].

According to Crandell and Gall[8], a male rainbow trout spawns at 1 yr and a female at 2 yrs; according to Rai *et al.*[15], rainbow trout breed after attaining 2 yrs; and according to Basnet *et al.*[15], it matures at the age of 2-3 yrs, however, a female rainbow trout spawns best at the age of 4-7 years while a male at 3-6 years. However, 1.0^{+}broods (first spawners) and 2.0^{+}broods (second spawners) are used for breeding in Nepal at small farmers' level because of their constraints in brood management for such a long time of 3 to 7 years.

Rainbow trout breed from September to February in India (Santhanam *et al.*[17]) and November to February in Nepal (Basnet *et al.*[5]). Rainbow trout breeding successfully, in this research work, in November by induced breeding resembled both Santhanam *et al.*[17] and Basnet *et al.*[5] and also confirmed artificial method of propagation to be the successful method of breeding. Rainbow trout can be bred twice but it is bred only once during breeding season in Nepal (Basnet *et al.*[5] and Rai *et al.*[15]) because breeding twice gives poor spawning results with mortality of broods, incubated eggs, alevins, and FSFs, however, breeding only once gives good spawning results with comparatively more survivability of broods, incubated eggs, alevins, and FSFs.

Induced breeding results under semi-intensive farming system due to stripping of 12 female (520±9.785g and 36.18±0.241cm) and 6 male (493.5±23.158g and 35.8±0.79cm) broods in the evening showed stripping range of 69-85g eggs which came to be 1380-1848 number eggs $female^{-1}$ and 26-41ml of milt $male^{-1}$ respectively. In this way, in total of 915g eggs (76.25±1.538g eggs $female^{-1}$) and 18391 number eggs (1532.58±38.88 number eggs $female^{-1}$) and 204ml milt (34±2.61ml milt $male^{-1}$) respectively was collected. Eggs were yellow-coloured, each 0.0499±0.001g and 0.303± 0.0095cm (diameter). Yellow colour of eggs was due to the carotenoids present in the feed (Roy *et al.*, 1999). According to Basnet *et al.*[5], eggs vary from 3-5mm in diameter. Colour and size of eggs resembled Rai *et al.*[15] and Basnet *et al.*[5] respectively. Eggs laid were 146.65±1.404g eggs kg^{-1} body wt. (1759.82g eggs $12kg^{-1}$ body wt.) and 2947.42±51.54 number eggs kg^{-1} body wt. (35369 number eggs $12kg^{-1}$ body wt.) of female broods. According to Martiyshev[13], the older brood generally lays larger-sized and higher number of eggs and according to Morrissy[14], a 3-4 years female lays 3000-3500 number eggs kg^{-1} body wt. Less number of eggs (2947 eggs in number) each 3.03mm in diameter in the present work was due to the age of broods being 1 yr. and few months. 1g eggs comprised 20.12±0.38 number eggs (241376 number eggs $12kg^{-1}$ and 20115 number eggs kg^{-1} of eggs). Milt was cream-coloured, each ml containing 5 millions spermatozoa. Milting was 68.53±2.36ml. milt (411.17ml milt $6kg^{-1}$ body wt. of male broods).

Dark condition was created during stripping to ensure more viability and survivability of eggs and sperms; during fertilization to ensure more fertilization percentage of eggs; during incubation to ensure more survival of eggs so as to release alevins;

and during hatchability to ensure more survival of alevins releasing FSFs. Therefore, stripping, fertilization, incubation and hatchability were done in the evening.

1.0^{+} (first spawners) spent up broods were procured as future broods for the next year breeding and stocked @ 10kg m^{-2} (20trout m^{-2}) maintaining WD 6L sec^{-1} m^{-2} and fed 45% CP containing artificial pellet feed @ 2-3% of their body weight twice day^{-1}.

At the time of stripping and fertilization, AT was 16.8°C. Fertilization was done in the evening on Sunday, 7th November, 2010 with 70.18±4.05g fertilized eggs $female^{-1}$ (842.1g fertilized eggs $12females^{-1}$) and 1410.16±94.28 number fertilized eggs $female^{-1}$ (16922 number fertilized eggs $12females^{-1}$) ensuring fertilization percentage to be 91.99±0.58%. One male supplied required milt for the fertilization of the eggs of two females after stripping because according to Basent *et al*[5], one male can supply enough milt for the fertilization of eggs of two females. Hence, fertilization was 2:1::eggs:milt also reported by Basnet *et al.*[5].

Fertilized eggs were transferred in the evening into incubation cum hatching trays put into incubation cum hatching raceways on Sunday, 7th November, 2010 maintaining WD 0.033L sec^{-1} @ 10,000 eggs in WT 13.1°C, pH 8.0, DO 9.8mg L^{-1}, and FCO 2.9mg L^{-1}. Cleaning and readjustment of incubation cum hatching trays were done thrice – 1st on Sunday, 14th November, 2010; 2nd on Sunday, 21st November, 2010; and 3rd on Sunday, 28th November, 2010 so as to remove dead eggs. During 3rd cleaning, eyed-eggs were seen confirming hatching to occur after 3-4days. Hatching of fertilized eggs occurred on Thursday, 2nd December, 2010 after 4 days of last cleaning and readjustment. Incubation period was 25 days in average temperature of 10.89±0.21°C day^{-1} and cumulative temperature (sum total of WT of 25 days) of 272°C with hatching of yolk-sac alevins (survivability 41.82±3.16%), each 0.0365±0.0016g and 1.46±0.086cm with 0.0136±0.0012g yolk-sac.

Alevins were shifted in the evening into endogenous feeding cum hatching cages put into endogenous feeding cum hatching raceways on Thursday, 2nd December, 2010 maintaining WD 0.033L sec^{-1} in WT 9.1°C, pH 8.0, DO 10.1mg L^{-1}, and FCO 1.8mg L^{-1}. Hatchability occurred on Tuesday, 7th December, 2010 after 5 days. Endogenous feeding period was 5 days in WT of 9.1°C liberating FSFs (survivability 76.92±4.91%) each 0.025±0.0007g and 1.65±0.083cm ready for exogenous feeding. Results confirmed the utility of 1.0^{+} broods at small farmer's level.

CONCLUSION

In the present work, 1.0^{+} broods (first spawners) performance due to its size and age with regards to size, survival and change of eggs and size, survival and growth of alevins and FSFs, although less initiative in comparison to large-sized and aged (3-7 years) broods was found to be satisfactory and even economical for the small scale farmer's. Hence, 1.0^{+} broods (first spawners) of rainbow trout were suitable for breeding at the level of small farmers' because of their requirement.

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