SUMMARY AND CONCLUSION

SUMMARY

Artificial feed with natural, non-conventional, low-cost, easily available, substitute, and required amino acids-containing animal proteins of silkworm pupae and silkworm moths and synthetic, unconventional, less costly, less available, alternative to animal proteins, and lysine and methionine (3 : 1) containing synthetic proteins of synthetic amino acids, both in replacement to natural, conventional, highly costly, available, traditional, and required amino acids-containing animal protein of shrimp meals, were formulated for the free swimming fries, fries, and fingerlings of rainbow trout, *Oncorhynchus mykiss* (Walbaum) and their impact on survival and growth during exogenous feeding in farmer's raceways were evaluated. Again, impact of the diets with natural and animal proteins (silkworm pupae, shrimp meals, and silkworm moths) were compared to that of the diet with synthetic proteins (synthetic amino acids) on survival and growth of the free swimming fries, fries, and fingerlings of rainbow trout. Further, impact of the physico-chemical parameters of the raceway water on survival and growth of the free swimming fries, fries, and fingerlings of rainbow trout were investigated. Furthermore, age of the broods, and size of the broods, eggs, sac-fries, and free swimming fries of rainbow trout on survival and growth of the free swimming fries, fries, and fingerlings were studied. Finally, what level of impact did physico-chemical parameters; age of the broods and size of the broods, eggs, sac fries and free swimming fries; and artificial feed could put on survival and growth of the free swimming fries, fries and fingerlings of rainbow trout was also mentioned.

Three feed formulations, two with substitute animal proteins of silkworm pupae (Treatment-1) as the first diet and silkworm moths (Treatment-2) as the second diet and the one with alternative to animal proteins of synthetic amino acids having lysine and methionine (Treatment-3) as the third diet were evaluated against the feed with shrimp meals (Treatment-4) as the fourth diet acting as control on survival and growth of the free swimming fries, fries,

and fingerlings of rainbow trout through total feed intake and total protein intake including all feed efficiency indicators of feed efficiency, protein efficiency ratio, absolute growth rate, specific growth rate, relative growth rate, condition factor, feed conversion ratio, and protein productive value, along with highest growth period and cost analyses. All the four diets (three formulated and one control) were fed to the free swimming fries, fries, and fingerlings for 150 days (5 months) each in two consecutive years (the first year from December 7, 2010 to May 6, 2011 and the second year from December 21, 2011 to May 19, 2012).

A significant difference ($P < 0.01$) on survival and growth of free swimming fries, fries and fingerlings of rainbow trout due to physico-chemical parameters in each year was noticed. The physico-chemical parameters were significant ($P < 0.01$) in each year. However, physico-chemical parameters each of the first year (December 2010 to May 2011) were not significantly different ($P > 0.05$) from that of the second year (December 2011 to May 2012).

There was significant difference ($P < 0.01$) on survival and growth of free swimming fries, fries and fingerlings of rainbow trout due to age of the broods and size of the broods, eggs, sac fries and free swimming fries in each year. The age of the broods and size of the broods, eggs, sac fries and free swimming fries were significant ($P < 0.01$) in each year. Again, age of the broods and size of the broods, eggs, sac fries and free swimming fries of rainbow trout each of the first year (December 2010 to May 2011) were significantly different ($P < 0.01$) from that of the second year (December 2011 to May 2012). The fertilization percentage of the eggs in each year was significant ($P < 0.01$). However, fertilization percentage of the first year (November 2010) was insignificantly different ($P > 0.05$) from that of the second year (November 2011).

The survival and growth due to total feed intake and total protein intake including all feed efficiency indicators of all the four diets in each year were found significantly different ($P < 0.01$). Again, total feed intake and total protein intake of all the four diets each of the first

year (December 2010 to May 2011) were significantly different ($P < 0.01$) from that of the second year (December 2010 to May 2011) however, all the feed efficiency indicators each of the first year (December 2010 to May 2011) were insignificant ($P > 0.05$) from that of the second year (December 2010 to May 2011).

The survival with shrimp meals diet fed stages revealed superiority over other feed formulations, silkworm pupae diet lesser survival, silkworm moths diet less survival, and synthetic amino acids diet least survival. Here, survivability increased with increased days and months in all the four diets. So, there was day-wise and month-wise significant difference ($P < 0.01$) on survival due to silkworm pupae, silkworm moths, synthetic amino acids and shrimp meals diets.

There was significant difference ($P < 0.01$) of all the diets on survival of free swimming fries, fries, and fingerlings through total feed intake and total protein intake The survival due to shrimp meals diet was insignificant ($P > 0.05$) with that of silkworm pupae diet however, survival due to shrimp meals diet was significant ($P < 0.01$) with that of silkworm moths and synthetic amino acids diets. Further, survival due to silkworm moths diet was significant ($P < 0.01$) with that of synthetic amino acids diet. In this way, shrimp meals and silkworm pupae diets were significantly different ($P < 0.01$) from that of silkworm moths and synthetic amino acids diets.

The growth due to silkworm pupae diet fed stages exhibited superiority amongst all the diets and synthetic amino acids diet lowest whereas shrimp meals diet and silkworm moths diet were in between. Results confirmed that free swimming fries, fries, and fingerlings grew exponentially with the three feed formulations containing silkworm pupae, silkworm moths, and shrimp meals. The periodic growth of above mentioned stages was somewhat stagnant with the feed comprised of synthetic amino acids. Here, growth increased with increased days

and months in all the four diets. So, there was day-wise and month-wise significant difference ($P < 0.01$) on growth due to silkworm pupae, silkworm moths, synthetic amino acids and shrimp meals diets.

There was significant difference ($P < 0.01$) of all the diets on the growth of free swimming fries, fries, and fingerlings through total feed intake and total protein intake including all feed efficiency indicators along with highest growth period and cost analyses. The total feed intake, total protein intake, feed efficiency, protein efficiency ratio, absolute growth rate, specific growth rate, and relative growth rate exhibited highest with silkworm pupae diet, higher with shrimp meals diet, low with silkworm moths diet, and lowest with synthetic amino acids diet. However, condition factor was highest due to silkworm pupae diet, higher due to shrimp meals diet, low due to synthetic amino acids diet, and lowest due to silkworm moths diet. Unlike other feed indicators, feed conversion ratio showed highest conversion rate with synthetic amino acids diet, higher with silkworm moths diet, low with shrimp meals diet, and lowest with silkworm pupae diet. The protein productive value of synthetic amino acids diet was highest, shrimp meals diet higher, silkworm moths diet low, and silkworm pupae diet lowest value resembling the crude protein percent of the diets.

The growth due to silkworm pupae diet was significant ($P < 0.01$) with that of shrimp meals diet, silkworm moths diet and synthetic amino acids diet. Further, the growth due to shrimp meals diet was significant ($P < 0.01$) with that of silkworm moths diet and synthetic amino acids diet. Again, silkworm moths diet was significant ($P < 0.01$) with that of synthetic amino acids diet.

The survival and growth of free swimming fries, fries, and fingerlings of rainbow trout might be due to suitable physico-chemical parameters of the raceways; mainly due to age of the broods, and size of the broods, eggs, sac fries, and free swimming fries of the rainbow trout; and exclusively due to formulated and control artificial feeds.

The diets containing natural and animal proteins of silkworm pupae, shrimp meals, and silkworm moths were superior on survival and growth to synthetic proteins of synthetic amino acids.

The highest growth period was observed during April to May and lowest during December to January whereas it was medium during March to April in all the feeds comprised of silkworm pupae, silkworm moths, synthetic amino acids, and shrimp meals. Comparing the feed cost and production cost both of rainbow trout, cost analyses revealed that silkworm moths diet was cheapest with low production cost, silkworm pupae diet cheaper with lowest, synthetic amino acids diet costly with highest, and shrimp meals diet highly costly with higher production cost.

The silkworm pupae diet proved cost effective being cheaper without compromising survival and growth thus decreasing the production cost of rainbow trout which was lowest; silkworm moths diet cost effective being cheapest with low production cost but survival and growth was very low; synthetic amino acids diet was less costly with least survival and lowest growth thus with highest production cost; and shrimp meals diet highly costly with highest survival and higher growth thus with higher production cost.

CONCLUSIONS

- The survival and growth of free swimming fries, fries, and fingerlings of rainbow trout during exogenous feeding might be due to suitable physico-chemical parameters of the raceway water; mainly due to age of the broods and size of broods, eggs, sac-fries, and free swimming fries of rainbow trout; and exclusively due to artificial feed of three formulated and one control diets.
- The diets containing natural and animal proteins of silkworm pupae, shrimp meals and silkworm moths are superior on survival and growth to synthetic proteins of synthetic amino acids.
- The silkworm pupae diet which is cheaper with lowest production cost in terms of total feed intake, total protein intake, feed efficiency, protein efficiency ratio, and feed conversion ratio amongst three feed formulations and one control diet in each year has proven best. Therefore, natural, cost effective, non-conventional, easily available, and animal protein of silkworm pupae diet could be used as better substitute to completely replaced shrimp meals diet without compromising survival and growth.
- There is a need for understanding the variability in supply and composition of various ingredients and evaluation of the potential to increase the ingredients in rainbow trout feed. Similarly, the capacity to evaluate nutritional requirements and the best way to utilize available ingredients for rainbow trout feed should be enhanced. So, it has been concluded that there is a perceived need to improve nutritional research capacity in many areas and the initiation of feed and feeding network, with a focused program of training and information exchange.
- The findings of physico-chemical parameters, breeding, and artificial feed of rainbow trout culture will be applicable in the areas with same physiography and climate. Therefore, technology transfer of such findings of rainbow trout culture can be done in India and Bhutan with same physiography and climate to help promote small scale farmers.