CULTURABILITY STUDIES
7. CULTURABILITY STUDIES

7.1 MATERIALS AND METHODS

Experiments were designed basically to study the suitability of Chocolate Mahseer for fish farming under different aquaculture systems in the cooler climatic conditions in the North-Eastern Hill region of the country. The systems of aquaculture studied involved (a) the modern methods of composite fish farming or polyculture of carps based on principles of optimum utilization of available ecological niches in a pond and (b) Running water aquaculture based on the principles of maximizing unit area production through supply of artificial feed. Considering the poor productivity of the ponds and poor growth of the Indian Major Carps under cooler temperature regime, it was felt necessary to standardize the polyculture of Carps with reference to the species components under different temperature regimes and accordingly experimental trials of polyculture involving seven Carp species (i.e. Silver Carp, Grass Carp, Common Carp, Chocolate Mahseer, Catla, Rohu and Mrigal) were carried out under three different temperature regimes of water in the N.E. Hill Region. Such farming practice on the line of composite fish culture is directed towards utilization of stagnant water ponds in the hills.

However scope for horizontal expansion of aquaculture in the hills is limited owing to limited conventional aquaculture
resource in the hills and owing to acute pressure on agricultural land precluding possibilities of large scale construction of conventional ponds in the valleys.

The avenue open for Aquaculture development in hills involve use of gully lands and truncated valleys for construction of running water ponds by tapping the vast flowing water resource available in the hills on account of heavy precipitation. Though such ponds are poor from productivity point of view yet, offer immense scope of vertical expansion of aquaculture through high unit area production involving high stocking rate of fish and use of improved quality of artificial feed. The second part of the studies were conducted to develop a running water aquaculture technology using Chocolate Mahseer as the candidate species.

Keeping the above objectives in view, the following experiments were designed

a. Confined Water Aquaculture System

I. Suitability of seven carp species for polyculture under varying water temperature regimes in the hills.

II. Compatibility of Chocolate Mahseer with exotic carps.

III. Effect of stocking rate on growth of Chocolate Mahseer under monoculture.
b. Running Water Aquaculture System

IV. Effect of stocking rate on growth of Chocolate Mahseer under monoculture.

V. Effect of feed and feeding rate on growth & production of Chocolate Mahseer.

Experimental Design

The Randomised Block Design was followed for conducting statistical analysis. One way analysis of variance (ANOVA) was made for all the variables under each experiment. Duncan's Multiple range test using least significant difference (LSD) at 5% and 1% level of significance was done. Normally for drawing valid inferences, degree of freedom for error for all the experiments excepting Experiment II (which is not statistically laid) should have been 12. However on account of paucity of ponds, the required replication (Five replication) could not be made in case of Experiment I, V and VI. The number of replication in these experiments were four only, which resulted in 9 degrees of freedom for error. The results in case of experiment no. II was not statistically analysed and has been considered for observation only.
Confined Water Aquaculture System

Experiment I:

Suitability of Seven species of Carp for Polyculture under Varying Water Temperature Regimes

Ponds at three different elevations (at 800m, 950m and 1400m above MSL respectively) were selected in East Khasi Hill district of Meghalaya, India, differing in their average annual water temperature by approximately 5°C. The three experimental stations enjoyed average water temperatures of approximating 20°C, 15°C and 10°C respectively. The ponds were all perennial in nature and received continuous supply of subsoil water (Plate 15 & 16). The average photosynthetic production and average fish production potentials of the ponds at the three locations were more or less at par. The production potentials are as under:

<table>
<thead>
<tr>
<th>Location/annual average water temperature</th>
<th>Photo synthetic Production (Cal/m²/yr. x 10⁶)</th>
<th>Fish Prod.Potential (kg/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location I (10°C)</td>
<td>4.394885</td>
<td>439.5</td>
</tr>
<tr>
<td>Location II (15°C)</td>
<td>4.531785</td>
<td>453.2</td>
</tr>
<tr>
<td>Location III (20°C)</td>
<td>4.628255</td>
<td>462.8</td>
</tr>
</tbody>
</table>

At each location a set of four ponds were stocked. Thus for each treatment, there were four replicates. Each pond was
Plate 15: Experimental ponds at the ICAR Research Complex farm

Plate 16: Experimental ponds at the ICAR Research Complex farm
having a water spread area of 400 m² and average depth of 1.5 metre. These ponds were uniformly treated as far as pond management practices are concerned. The various input levels and management practices involved in raising the fish species (Plate 17) for 12 months duration are as under:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Liming</td>
<td>2000 kg/ha/yr.</td>
</tr>
<tr>
<td>2. Manuring</td>
<td>50,000 kg/ha/yr.</td>
</tr>
<tr>
<td>3. Fertilization</td>
<td></td>
</tr>
<tr>
<td>(i) Ammonium Sulphate</td>
<td>350 kg/ha/yr.</td>
</tr>
<tr>
<td>(ii) Triple Super Phosphate</td>
<td>500 kg/ha/yr.</td>
</tr>
<tr>
<td>(iii) Muriate of Potash</td>
<td>80 kg/ha/yr.</td>
</tr>
<tr>
<td>4. Stocking (With fingerlings of 20-25 gm)</td>
<td></td>
</tr>
<tr>
<td>(i) Silver Carp (Hypophthalmichthys molitrix)</td>
<td>@ 1000 nos/ha</td>
</tr>
<tr>
<td>(ii) Grass Carp (Ctenopharyngodon idella)</td>
<td>@ 1000 nos/ha</td>
</tr>
<tr>
<td>(iii) Common Carp (Cyprinus carpio)</td>
<td>@ 1000 nos/ha</td>
</tr>
<tr>
<td>(iv) Chocolate Mahseer (Acrossocheilus hexagonolepis)</td>
<td>@ 1000 nos/ha</td>
</tr>
<tr>
<td>(v) Rohu (Labeo rohita)</td>
<td>@ 1000 nos/ha</td>
</tr>
<tr>
<td>(vi) Catla (Catla catla)</td>
<td>@ 1000 nos/ha</td>
</tr>
<tr>
<td>(vii) Mrigal (Cirrhinus mrigala)</td>
<td>@ 1000 nos/ha</td>
</tr>
<tr>
<td>5. Feeding</td>
<td></td>
</tr>
<tr>
<td>(i) Artificial feed/day</td>
<td></td>
</tr>
<tr>
<td>(Rice bran : Mustard Oil Cake :1:1)</td>
<td>@ 2% of fish biomass</td>
</tr>
<tr>
<td>(ii) Green leaves of squash (cucurbit) - Two days in a week</td>
<td>@ 40% of biomass of Grass Carp and Mahseer instock</td>
</tr>
<tr>
<td>6. Duration of culture</td>
<td>12 Months</td>
</tr>
</tbody>
</table>
Plate 17: Different Carp species used for Polyculture
The ponds were prepared by first liming @ 1000 kg/ha, followed by manuring @ 30,000 kg/ha and then fertilizing with 1/10 part of the prescribed fertilizer requirement. The remaining lime, manure and fertilizers were added in equal monthly doses in the post stocking phase. Stocking was done as prescribed. Daily feeding with artificial feed was done @ 2% of body wt. of fish stock (Plate 18 & 19). Green leaves of squash were given @ 40% of the biomass of grass carp and Chocolate Mahseer on two days a week for six months (depending on its availability).

Observations recorded on the above study include the following:

1. Monthly growth of the seven fish species were recorded (Plate 20 & 21).
2. Water quality parameters were studied at weekly interval.
3. At the end of the culture period, observations were recorded on the survival, average weight, growth (weight gain), gross yield, and net yield of each species from each pond (Plate 22) for all the three locations.

For water quality analysis, samples were collected weekly in early morning hours from 10 cm below the surface with polythene bottles and analysis were initiated within two hours of collection. Concentration of dissolved oxygen were measured in the field with a polarographic D.O. meter and the
Plate 18: Feed preparation for polyculture trials

Plate 19: Feeding carps in a polyculture pond
Plate 20: Harvesting of carps from a stagnant water pond

Plate 21: A fish haul from a polyculture pond
Plate 22: Multispecies Carp harvest from a polyculture tank
The above experiment was conducted during the first year of the study.

7.1.1.2 Experiment II:

Compatibility of Chocolate Mahseer with Exotic Carps

During the second year of the study an experimental trial was laid to study the compatibility of the Chocolate Mahseer vis-a-vis three exotic carps viz. Silver Carp, Grass Carp and Common Carp. The experiment was laid at the Barapani farm at 950m MSL, enjoying average annual temperature of 15°C. There were six levels of treatment including two sets of controls.

The treatments of the experimental design are as under:

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Treatment Combinations</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Silver Carp, Grass Carp, Common Carp, and Chocolate Mahseer</td>
<td>Equal</td>
</tr>
<tr>
<td>2.</td>
<td>Silver Carp, Grass Carp, and Common Carp (Control)</td>
<td>Equal</td>
</tr>
<tr>
<td>3.</td>
<td>Silver Carp and Chocolate Mahseer</td>
<td>Equal</td>
</tr>
<tr>
<td>4.</td>
<td>Grass Carp and Chocolate Mahseer</td>
<td>Equal</td>
</tr>
<tr>
<td>5.</td>
<td>Common Carp and Chocolate Mahseer</td>
<td>Equal</td>
</tr>
<tr>
<td>6.</td>
<td>Chocolate Mahseer (Control)</td>
<td>Equal</td>
</tr>
</tbody>
</table>
For each treatment there were four replicates. Thus there were 24 ponds which were of 40 sq.meter water spread area each and average depth of 1.5 metre. The overall stocking rate followed for each pond was 6000 nos per hectare. The prestocking and post stocking management followed were the same as in Experiment No.I. The Duration of culture was twelve months.

The observations recorded were as follows.
1. Growth (Average weight gain) and Average weight of each species were recorded at the end of each month.
2. Water quality parameters were recorded at weekly interval in the same manner as in Experiment No.I.

7.1.1.3 Experiment III:

Effect of Stocking Rate on Growth of Chocolate Mahseer under Monoculture

During the second year of the study, field trial was conducted on the effect of stocking rate of Chocolate Mahseer on its growth under confined water pond culture system. Three rates of stocking were followed:

(i) @ 0.5 no/m²
(ii) @ 0.75 no/m²
(iii) @ 1.0 no/m²

There were five replicates for each level of treatment. The
ponds were of 40 sq. meter water spread area each with av. depth of 1.5 meter. The pre-stocking and post-stocking management followed are the same as in case of experiment No.I & II. The duration of culture was 12 months.

The observations recorded are as under:

1. Monthly growth and average weight of the fish species.
2. Water quality parameters were recorded at weekly intervals.
3. At the end of the culture period, observations were made on average weight, growth, survival, gross production and net production.

7.1.2 Running Water Aquaculture System

7.1.2.1 Experiment IV:

Effect of Stocking Rate on Growth of Chocolate Mahseer under Running Water Monoculture System

Studies were conducted during the second year on the effect of stocking rate on growth of Chocolate Mahseer under running water condition. Specially designed rectangular ponds with continuous supply of water were constructed (Plate 23 & 24). A daily water exchange to the extent of 50% pond volume were effected. The ponds were located at the Barapani farm. Fifteen ponds were used for the purpose. Three different stocking rates (Plate 25) were tried as follows:
Plate 23: Water intake structure for running water pond culture

Plate 24: Cemented raceway for rearing brood stock
There were five replicates and each pond were of 40 sq. metre water spread area with average depth of 1.5 metre.

The pre-stocking management involved liming of 2000 kg/ha. However the Ponds were not fertilized.

Artificial feeding and feeding green fodder was done as in the case of earlier experiments. The fishes were reared for 12 months.

The observations recorded are as under:
1. Monthly growth and average weight of the species.
2. Water quality parameters were recorded at weekly intervals.
3. At the end of the culture period, harvesting was done (Plate 26) and observations were made on average weight, growth, survival, gross production and net production.

7.1.2.2 Experiment V:

Effect of Artificial Feeding on Growth of Chocolate Mahseer under Running Water System

During the third year of the study field trials were conducted on the effect of artificial feeding on the growth of Chocolate Mahseer under running water pond condition.
Plate 25: Stocking of Chocolate Mahseer fingerlings

Plate 26: Pond grown Chocolate Mahseer
Running water ponds as earlier described were used (Plate 27). Water spread area of the ponds were 40 sq. meter each. Three sets of ponds with four replicates each were prepared for stocking. Uniform stocking rate of 3 Nos. per sq. metre was followed. Three different levels of feeding with artificial pelleted feed with F.C.R. of 4:1 was followed. The proximate composition of the ingredients and the feed are as under:

The proximate composition of Carp feed ingredients used for preparing feed

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Ingredients</th>
<th>Crude Protein %</th>
<th>Crude Fat %</th>
<th>Crude Fiber %</th>
<th>Nitrogen Free extract %</th>
<th>Ash %</th>
<th>Moisture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rice Bran</td>
<td>7.8</td>
<td>6.1</td>
<td>14.4</td>
<td>43.4</td>
<td>20.5</td>
<td>7.8</td>
</tr>
<tr>
<td>2</td>
<td>Groundnut Cake</td>
<td>28.6</td>
<td>13.8</td>
<td>7.5</td>
<td>28.9</td>
<td>13.4</td>
<td>7.8</td>
</tr>
<tr>
<td>3</td>
<td>Soyabean meal</td>
<td>46.0</td>
<td>0.9</td>
<td>7.3</td>
<td>35.2</td>
<td>0.6</td>
<td>10.0</td>
</tr>
<tr>
<td>4</td>
<td>Tapioca Flour</td>
<td>1.8</td>
<td>1.3</td>
<td>1.8</td>
<td>86.9</td>
<td>0.2</td>
<td>8.0</td>
</tr>
<tr>
<td>5</td>
<td>Fish meal</td>
<td>37.2</td>
<td>2.7</td>
<td>22.7</td>
<td>16.1</td>
<td>6.7</td>
<td>14.6</td>
</tr>
</tbody>
</table>

The proximate composition of Carp feed manufactured using above ingredients for feeding trials

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Composition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Crude Protein</td>
<td>23.58</td>
</tr>
<tr>
<td>2</td>
<td>Crude Fat</td>
<td>6.64</td>
</tr>
<tr>
<td>3</td>
<td>Crude Fibre</td>
<td>11.25</td>
</tr>
<tr>
<td>4</td>
<td>Nitrogen free extract</td>
<td>38.075</td>
</tr>
<tr>
<td>5</td>
<td>Ash</td>
<td>11.285</td>
</tr>
<tr>
<td>6</td>
<td>Moisture</td>
<td>9.17</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>100.0</td>
</tr>
</tbody>
</table>
The three different levels of daily feeding were practised.
1. @ 2% of the biomass of fish in stock.
2. @ 4% of the biomass of fish in stock.
3. @ 6% of the biomass of fish in stock.

The pre-stocking management involved only liming. The ponds were not fertilized.

The trial was conducted for a period of six months (April to October).

The following observations were recorded.
1. Monthly growth and average weight of the stocked fish.
2. Water quality at weekly interval.
3. At the end of the culture period, the stock was harvested (Plate 28) and observations were made on average weight, growth, survival, gross production and net production.

7.1.2.3 Experiment VI

Effect of Feeding with Green Fodder on growth of Chocolate Mahseer

A trial on the effect of Green fodder on the growth of Chocolate Mahseer was laid during the third year of the study in running water pond system. Twelve numbers of running water ponds of 40 sq. meter W.S.A. each were used for laying the trial. The ponds were divided into three sets with four replicates. All ponds were stocked uniformly @ 3 nos per sq. metre of water spread area. The ponds were prepared by
Plate 27: Chocolate Mahseer in running water ponds

Plate 28: Harvested Chocolate Mahseer from running water pond
PLATE 27.
PLATE 28.
liming @ 2000 kg/ha Fertilization and manuring were not resorted to. The Green fodder used involved green leaves of squash plant (a cucurbit grown on the pond embankments). The green fodder was very well accepted by the fish. The luxuriant growth of the creeping plant enabled its on-farm production. Since the availability of squash leaves lasted for six months (April to October), the duration of the trial was restricted to the same period. Three different rates of daily feeding were tried as under:

1. @ 20% of the fish biomass in stock.
2. @ 40% of the fish biomass in stock.
3. @ 60% of the fish biomass in stock.

The following observations were recorded.

1. Monthly growth and average weight of the stocked fish.
2. Water quality at weekly interval
3. At the end of the culture period, observations were made on the average weight, growth, survival, gross production and net production.
7.2 RESULTS

7.2.1 Confined Water Aquaculture System

7.2.1.1 Experiment I:

Suitability of seven carp species for Polyculture under varying Water Temperature Regimes

One way analysis of variance (ANOVA) following completely randomized block design were made for the five variables observed for each species of fish separately. Duncan's Multiple range test using least significant difference (LSD) at 5% and 1% level of significance, was used.

The results of ANOVA have been presented in tables (30 to 34). The results of ANOVA are discussed here variable wise for all the seven species.

Variable I - Survival

Common Carp

No effect of the treatment (temperature) on the variable (survival) was observed (Table 30). The response was significant at 5% level of significance between treatment 1 (T = 10°C) and treatment 2 (T = 15°C). The differences between all the treatment levels were non-significant at 1% level of significance. Thus the survival of the species was not found to be grossly affected by the variations in temperature (Fig.36).
Fig. 36: Effect of Temperature on survival of seven species of carps
Table 30: Effect of temperature on survival of seven species of Carps

ANOVA Experiment No.1

Variable : Survival; Treatment; Temperature

<table>
<thead>
<tr>
<th>Rank</th>
<th>CC</th>
<th>CM</th>
<th>C</th>
<th>SC</th>
<th>M</th>
<th>R</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>M</td>
<td>SR(SR)SR(1%)</td>
<td>T</td>
<td>M</td>
<td>SR(SR)SR(1%)</td>
<td>T</td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td>90.625</td>
<td>a</td>
<td>a</td>
<td>1</td>
<td>87.5</td>
<td>a</td>
</tr>
<tr>
<td>II</td>
<td>3</td>
<td>84.375</td>
<td>ab</td>
<td>a</td>
<td>2</td>
<td>81.25</td>
<td>b</td>
</tr>
<tr>
<td>III</td>
<td>2</td>
<td>80.625</td>
<td>b</td>
<td>a</td>
<td>3</td>
<td>78.75</td>
<td>b</td>
</tr>
</tbody>
</table>

NB:-
1. The means followed by same letters do not differ significantly
2. Please refer Table in Annexures 1 to 7 for LSD (5% & 1%)
3. "T" stands for treatment levels. "M" for Mean for treatment and "SR" for significant range
4. CC : Common Carp; CM : Chocolate Mahseer; C : Catla; GC : Grass Carp; M : Mrigal; R : Rohu; SC : Silver Carp
Chocolate Mahseer

A decreasing trend in survival with increasing level of treatment (water temperature) was observed (Fig.36). The difference between treatment 1 & 3 was significant at both 5% and 1% level of significance. However, the difference between treatment 2 & 3 was not significant at 5% level of significance. The difference between treatments 1 & 2 and 2 & 3 were not significant at 1% level of significance (Table 30).

Catla

An increasing trend in the survival of the species with increase in the level of treatment (water temperature) was noticed (Fig.36). The differences between treatment 1 and 3 was significant at both 5% and 1% level of significance. The difference between treatment 1 & 2 was not significant at 5% level of significance. The difference between treatments 1 & 2 and 2 & 3 were also not significant at 1% level of significance (Table 30).

Grass Carp

The effect of the treatment (water temperature) on the variable (survival) was found to be non-significant at both 5% and 1% level of significance (Table 30) excepting for treatment 1 & 2 at 5% level.
An increasing trend in the survival of the species with increasing level of treatment (water temperature) was observed (Fig. 36) and the same was significant at 1% level of significance. The difference between the treatments at all levels were significant at 5% and 1% levels of significances (Table 30).

Increasing trend in survival of the species with increasing water temperature was witnessed (Fig. 36). The difference between all the levels of treatment were significant at 5% level of significance. However the difference between treatments 1 & 2 and 2 & 3 were not significant at 1% level (Table 30) of significance.

The effect of treatments (water temperature) on the variable (survival) was found to be non-significant at both 5% and 1% level of significance (Table 30).

Both the variables (weight gain and Average weight) showed an increasing response with increase in treatment levels (water temperature) for all the seven species and the responses were significant at 1% level of significances (Fig. 37). The
Fig. 37: Effect of Temperature on Average weight of seven species of carps

![Graph showing the effect of temperature on average weight of seven species of carps at different temperatures (T1, T2, T3). The graph compares the average weight in grams for each temperature, with different species represented by distinct patterns. The species include SC, GC, CC, CM, C, R, and M.]
Table 31: Effect of temperature on Height Gain of seven species of Carps

ANOVA Experiment No. 1: Variable: Height Gain; Treatment; Temperature

<table>
<thead>
<tr>
<th>Rank</th>
<th>CC</th>
<th>CM</th>
<th>C</th>
<th>GC</th>
<th>M</th>
<th>R</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
<td>T M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
<td>T M</td>
</tr>
<tr>
<td>I</td>
<td>3 772</td>
<td>a a</td>
<td>3 552.75</td>
<td>a a</td>
<td>3 700</td>
<td>a a</td>
<td>3 279.75</td>
</tr>
<tr>
<td>II</td>
<td>2 650.75</td>
<td>b b</td>
<td>2 402.5</td>
<td>b b</td>
<td>2 450</td>
<td>b b</td>
<td>2 552.5</td>
</tr>
<tr>
<td>III</td>
<td>1 559.0</td>
<td>c c</td>
<td>1 319.5</td>
<td>c c</td>
<td>1 260</td>
<td>c c</td>
<td>1 450</td>
</tr>
</tbody>
</table>

The means followed by same letters do not differ significantly.

1. Please refer Table in Annexures 15 to 21 for LSD (5% & 1%)
2. *T* stands for treatment levels, *H* for Mean for treatment and *SR* for significant range.
3. CC: Common Carp; CM: Chocolate Mahseer; C: Catla; GC: Grass Carp; M: Hrigal; R: Rohu; SC: Silver Carp.

Table 32: Effect of temperature on Average Height of seven species of Carps

ANOVA Experiment No. 1: Variable: Average Height; Treatment; Temperature

<table>
<thead>
<tr>
<th>Rank</th>
<th>CC</th>
<th>CM</th>
<th>C</th>
<th>GC</th>
<th>M</th>
<th>R</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
<td>T M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
<td>T M</td>
</tr>
<tr>
<td>I</td>
<td>3 797</td>
<td>a a</td>
<td>3 559</td>
<td>a a</td>
<td>3 722</td>
<td>a a</td>
<td>3 304.75</td>
</tr>
<tr>
<td>II</td>
<td>2 650.75</td>
<td>b b</td>
<td>2 422.5</td>
<td>b b</td>
<td>2 450</td>
<td>b b</td>
<td>2 577.5</td>
</tr>
<tr>
<td>III</td>
<td>1 579</td>
<td>c c</td>
<td>1 339.5</td>
<td>c c</td>
<td>1 280</td>
<td>c c</td>
<td>1 475</td>
</tr>
</tbody>
</table>

NB:- 1. The means followed by same letters do not differ significantly.
2. Please refer Table in Annexures 15 to 21 for LSD (5% & 1%).
3. *T* stands for treatment levels, *H* for Mean for treatment and *SR* for significant range.
4. CC: Common Carp; CM: Chocolate Mahseer; C: Catla; GC: Grass Carp; M: Hrigal; R: Rohu; SC: Silver Carp.
### Table S3: Effect of temperature on Gross Yield of seven species of Carps

**ANOVA Experiment No. 1**: Variable: Gross Yield; Treatment: Temperature

<table>
<thead>
<tr>
<th>Rank</th>
<th>CC</th>
<th>CM</th>
<th>C</th>
<th>GC</th>
<th>M</th>
<th>R</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
<td>T</td>
<td>M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>672.36</td>
<td>3</td>
<td>660.87</td>
<td>a</td>
<td>a</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>624.75</td>
<td>b</td>
<td>2</td>
<td>539.35</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>524.59</td>
<td>b</td>
<td>1</td>
<td>257.06</td>
<td>c</td>
<td>c</td>
</tr>
</tbody>
</table>

The means followed by same letters do not differ significantly.

Please refer Table 29 to 35 for LSD (5% & 1%).

T stands for treatment levels. "H" for Mean for treatment and "SR" for significant range.

CC: Common Carp; CM: Chocolate Mahseer; C: Catla; GC: Grass Carp; M: Mrigal; R: Rohu; SC: Silver Carp.

### Table S4: Effect of temperature on Net Yield of seven species of Carps

**ANOVA Experiment No. 1**: Variable: Net Yield; Treatment: Temperature

<table>
<thead>
<tr>
<th>Rank</th>
<th>CC</th>
<th>CM</th>
<th>C</th>
<th>GC</th>
<th>M</th>
<th>R</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
<td>T</td>
<td>M</td>
<td>SR(5%)</td>
<td>SR(1%)</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>647.36</td>
<td>3</td>
<td>415.13</td>
<td>a</td>
<td>a</td>
<td>3</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>504.75</td>
<td>b</td>
<td>2</td>
<td>323.35</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>504.59</td>
<td>b</td>
<td>1</td>
<td>257.02</td>
<td>c</td>
<td>c</td>
</tr>
</tbody>
</table>

The means followed by same letters do not differ significantly.

Please refer Table 29 to 35 for LSD (5% & 1%).

T stands for treatment levels. "H" for Mean for treatment and "SR" for significant range.

CC: Common Carp; CM: Chocolate Mahseer; C: Catla; GC: Grass Carp; M: Mrigal; R: Rohu; SC: Silver Carp.

NB:-
1. The means followed by same letters do not differ significantly.
2. Please refer Table in Annexures 29 to 35 for LSD (5% & 1%).
3. "T" stands for treatment levels. "M" for Mean for treatment and "SR" for significant range.
4. CC: Common Carp; CM: Chocolate Mahseer; C: Catla; GC: Grass Carp; M: Mrigal; R: Rohu; SC: Silver Carp.
difference between all the treatment levels for all the seven species were significant at both 5% and 1% level of significance respectively (Table 31 & 32).

Variable IV (Gross yield) & Variable V (Net yield)

Common Carp & Silver Carp

Both the species showed increasing response of Gross yield and Net yield to increasing treatment level (water temperature). The responses between treatment 1 & 3 and that between 2 & 3 for both the variables and for both the species were significant at 1% level of significance (Fig.38). The difference between treatment 1 & 2 were not significant at both 5% and 1% level of significance respectively for both the species (Table 33 & 34).

Chocolate Mahseer, Catla, Mrigal, Rohu

All the four species showed a positive response of the variables (gross yield & net yield) to the increasing treatment levels (water temperature) and the same were significant at 1% level of significance. The differences between all levels of treatments for all the four species were significant at both 5% and 1% level (Table 33 & 34) of significance.

Grass Carp

The species showed an increasing response in Gross yield and
Fig. 38: Effect of Temperature on Gross yield of seven species of carps

Yield in Kg/ha

T1 (10 oC)  T2 (15 oC)  T3 (20 oC)
TEMPERATURE

Yield in Kg/ha
Net yield to increase in water temperature regime like all other species and were significant at 5% level of significance. The difference between all the three levels of treatments were significant at 5% level of significance. However the difference between treatment 1 & 2 was not significant at 1% level (Table 33 & 34) of significance.

Water Quality Parameters

Water quality parameters were recorded for all the ponds at all the three locations. The average water quality at each locations were worked out and their variations recorded. The observations are recorded in Table 35.

As it may appear from the water quality records, there was no major difference in any of the water quality parameters prevailing at the three locations. The observations indicate that the ponds are in general of low pH and low alkalinity because of moderately acidic muds. As expected in such situations, the phenolphthalein alkalinity was nil. Free CO₂ was moderate not contributing much to the acidic condition of the water. The total hardness indicate that these are soft water ponds with slightly less hardness than required for fish culture (20 mg/l). However since hardness is linked with alkalinity, hence the lower hardness values are expected in these low alkalinity ponds.

Dissolved oxygen concentrations were moderate and confirms to the requirements of fish culture.
However concentrations of dissolved phosphate and Nitrate were quite low and may be attributed to non-availability of the nutrients owing to low total alkalinity.

**Table : 35 Average Water Quality parameters of the experimental ponds (Exp.I) located at the three temperature zones in Khasi Hills, Meghalaya**

<table>
<thead>
<tr>
<th>Sr Parameters</th>
<th>Variations at the different temperature Regimes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone I ($10^\circ$C)</td>
</tr>
<tr>
<td>1. Water pH</td>
<td>6.0 - 6.5</td>
</tr>
<tr>
<td>2. Mud pH</td>
<td>5.0 - 5.5</td>
</tr>
<tr>
<td>3. Dissolved Oxygen (mg/l)</td>
<td>7.6 - 10.2</td>
</tr>
<tr>
<td>4. Total Alkalinity (mg/l)</td>
<td>6.8 - 12.0</td>
</tr>
<tr>
<td>5. Phenolphthaline alkalinity (mg/l)</td>
<td>0</td>
</tr>
<tr>
<td>6. Free CO$_2$ (mg/l)</td>
<td>5.7</td>
</tr>
<tr>
<td>7. Hardness (mg/l)</td>
<td>4.0 - 9.0</td>
</tr>
<tr>
<td>8. Nitrate (mg/l)</td>
<td>0.025 - 0.041</td>
</tr>
<tr>
<td>9. Phosphate (mg/l)</td>
<td>0.031 - 0.052</td>
</tr>
<tr>
<td>10. Dissolved Organic matter (mg/l)</td>
<td>8.9 - 17.1</td>
</tr>
<tr>
<td>11. Pariculate Organic matter (mg/l)</td>
<td>18.11 - 39.2</td>
</tr>
</tbody>
</table>
### 7.2.1.2 Experiment II

**Compatibility of Chocolate Mahseer with Exotic Carps**

The results of the experiment on Compatibility of Chocolate Mahseer with exotic carps is presented here (Table 36).

<table>
<thead>
<tr>
<th>Combinations</th>
<th>Mean weight-gain of fish species (gms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Silver Carp</td>
</tr>
<tr>
<td>1. SC, GC, CC &amp; CM</td>
<td>605.025</td>
</tr>
<tr>
<td>2. SC, GC &amp; CC</td>
<td>608.0875</td>
</tr>
<tr>
<td>3. SC &amp; CM</td>
<td>608.4625</td>
</tr>
<tr>
<td>4. GC &amp; CM</td>
<td>-</td>
</tr>
<tr>
<td>5. CC &amp; CM</td>
<td>-</td>
</tr>
<tr>
<td>6. CM</td>
<td>-</td>
</tr>
</tbody>
</table>

**NB:** SC = Silver Carp; GC = Grass Carp, CC = Common Carp, CM = Chocolate Mahseer;

The following observations are made based on the above results.

1. Chocolate Mahseer when grown alone, or grown along with silver carp or common carp, showed maximum mean weight gain (i.e. 425.22 gm to 427.9875).

2. Growth of common carp and silver carp when grown along
with Chocolate Mahseer, did not show any change in their mean weight gain as compared to the control, wherein Chocolate Mahseer was not grown with the exotic carps. Thus it may be inferred that there is no negative interaction between Chocolate Mahseer and the above exotic carps.

3. Growth of Chocolate Mahseer as well as Grass carp showed a decline when grown together as compared to treatments wherein (i) grass carps were grown along with other exotic carps and (ii) Chocolate Mahseers were grown either alone or with exotic carps, other than Grass carp. This may be due to the preference for herbivorous diet of both Chocolate Mahseer and Grass carp.

Water quality parameters of experiment II

The water quality parameters of the six set of ponds Table 37 did not show any significant differences and therefore represented identical conditions. Thus it may be concluded that the observed growth of the species were not influenced by any differences in water quality conditions.
Table 37: Water quality parameters of experimental ponds (Exp.II) with different species composition

<table>
<thead>
<tr>
<th>Parameters</th>
<th>SC:GC, CC, CM</th>
<th>SC,GC, CC, CM</th>
<th>SC,CM</th>
<th>GC,CM</th>
<th>CC,CM</th>
<th>CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. pH</td>
<td>6.8</td>
<td>6.7</td>
<td>6.5</td>
<td>6.6</td>
<td>6.5</td>
<td>6.4</td>
</tr>
<tr>
<td>2. Dissolved O$_2$(mg/l)</td>
<td>10.8</td>
<td>12.0</td>
<td>11.9</td>
<td>10.9</td>
<td>12.0</td>
<td>11.6</td>
</tr>
<tr>
<td>3. Free CO$_2$(mg/l)</td>
<td>5.2</td>
<td>5.5</td>
<td>6.0</td>
<td>5.8</td>
<td>6.4</td>
<td>5.4</td>
</tr>
<tr>
<td>4. Total alkalinity (mg/l)</td>
<td>10.1</td>
<td>11.5</td>
<td>11.0</td>
<td>9.8</td>
<td>10.5</td>
<td>9.8</td>
</tr>
<tr>
<td>5. Phenolphthaleine alkalinity (mg/l)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6. Nitrate Nitrogen (mg/l)</td>
<td>0.186</td>
<td>0.118</td>
<td>0.148</td>
<td>0.168</td>
<td>0.181</td>
<td>0.156</td>
</tr>
<tr>
<td>7. Phosphate (mg/l)</td>
<td>0.095</td>
<td>0.092</td>
<td>0.083</td>
<td>0.095</td>
<td>0.089</td>
<td>0.109</td>
</tr>
<tr>
<td>8. Dissolved Organic matter (mg/l)</td>
<td>14.2</td>
<td>16.4</td>
<td>13.8</td>
<td>16.5</td>
<td>16.3</td>
<td>14.9</td>
</tr>
</tbody>
</table>

NB: SC = Silver Carp; GC = Grass Carp; CC = Common Carp; CM = Chocolate Mahseer.

7.2.1.3 Experiment III:

Effect of Stocking Rate on Growth of Chocolate Mahseer under Confined Water Monoculture System

Variable 1 (Average Weight) and Variable 2 (Weight gain)

Decrease in both variables were observed with the increase in
Table 38: Effect of Stocking rate on growth of chocolate mahseer under confined water system

ANOVA Experiment No. III  
Treatment: Stocking rate

Variables: Av. Weight (V1); Av. Weight Gain (V2); Survival (V3); Gross Yield (V4); Net Yield (V5)

<table>
<thead>
<tr>
<th>Rank</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>M</td>
<td>SR (5%)</td>
<td>SR (1%)</td>
<td>T</td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td>427</td>
<td>a</td>
<td>a</td>
<td>1</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>422.6</td>
<td>a</td>
<td>a</td>
<td>2</td>
</tr>
<tr>
<td>III</td>
<td>3</td>
<td>371.6</td>
<td>b</td>
<td>b</td>
<td>3</td>
</tr>
</tbody>
</table>

NB:–  
1. The means followed by same letters do not differ significantly
2. Please refer Table in Annexures 36 to 40 for LSD (5% & 1%)
3. "T" stands for treatment levels. "M" for Mean for treatment and "SR" for significant range
stocking rate (Table 38). The difference between the treatments 1 & 3 and 2 & 3 were significant at both 5% and 1% levels for both the variables. However, no significant variation was observed between treatment 1 & 2 for both the variables at both levels of significance respectively. Thus it appears that the average weight (v1) and weight gain (v2) of the species have a significant negative interaction with the stocking rate beyond the treatment 2 (the medium rate of stocking).

Variable 3 (Survival)

A fall in survival rate was observed with increase in stocking rate. The difference between the treatments 1 & 3 and 2 & 3 were significant at both 5% and 1% levels. However, the difference was not significant between treatment no.1 (lowest stocking) and treatment no.2 (medium stocking rate) at both 5% and 1% levels of significance. Thus it appears that the survival of the species has a significant negative interaction with stocking rate beyond the medium rate of stocking.

Variable 4 (Gross yield) & Variable 5 (Net yield)

The above variables showed highest response for the medium stocking and lowest response for the lowest stocking rate. These responses were significant at 1% levels of significance. The difference between treatment 2 & 3 was
found not to be significant at both 5% and 1% levels of significance. However the difference between treatment 1 & 2 and 1 & 3 were significant at both levels. Thus it can be inferred that Gross yield and Net yield of the species starts declining beyond the medium rate of stocking though the fall is not significant.

Water quality parameters of experiment III

Variations of water quality parameters of the fifteen ponds were recorded and the average values of the three sets of ponds with three different stocking rates were compared (Table 39).

A decrease in dissolved oxygen concentration was observed at the highest stocking rate. The results indicated a mild increase in concentration of dissolved nitrate with increasing stocking rate. Appreciable increase in dissolved organic matter and COD was noticed with increase in the rate of stocking. No significant change was observed in the concentration of filterable orthophosphates. The fall in survival, growth and yield beyond the medium level of stocking could be related to the declining water quality parameters.
Table 39: Water quality analysis of experiment III

<table>
<thead>
<tr>
<th>Water Quality Variables (mg/l)</th>
<th>Low Stocking (T1)</th>
<th>Medium Stocking (T2)</th>
<th>High Stocking (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td>8.93</td>
<td>8.97</td>
<td>7.73</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.0265</td>
<td>0.0302</td>
<td>0.0351</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.0308</td>
<td>0.0301</td>
<td>0.0300</td>
</tr>
<tr>
<td>Dissolved Organic matter</td>
<td>7.083</td>
<td>12.416</td>
<td>16.15</td>
</tr>
<tr>
<td>C.O.D.</td>
<td>16.166</td>
<td>26.0</td>
<td>37.5</td>
</tr>
</tbody>
</table>

7.2.2 Running Water Aquaculture System

7.2.2.1 Experiment IV

Effect of Stocking Rate on Growth of Chocolate Mahseer under Running Water Monoculture System

Variable 1 (Average weight) and Variable 2 (Weight gain)

Both the variables showed a decreasing trend with increasing stocking rate and were significant at 1% level of significance (Table 40). The difference between the treatment levels were significant for both the variables at both levels of significance. Thus it can be concluded that there is a negative co-relation between growth and stocking rate which was more pronounced between the treatments 2 & 3.

Variable 3 (Survival)

Survival of the species was observed to be negatively related to stocking rate and was significant at 1% level. Thus a
Table 40: Effect of Stocking rate on growth of chocolate mahseer under running water system

ANOVA Experiment No. IV  
Treatment: Stocking rate

Variables: Av. Weight (V1); Av. Weight Gain (V2); Survival (V3); Gross Yield (V4); Net Yield (V5)

<table>
<thead>
<tr>
<th>Rank</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TM</td>
<td>SR</td>
<td>SR</td>
<td>TM</td>
<td>SR</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>349.6</td>
<td>a</td>
<td>a</td>
<td>1</td>
<td>327.6</td>
</tr>
<tr>
<td>II</td>
<td>368</td>
<td>b</td>
<td>b</td>
<td>2</td>
<td>316</td>
</tr>
<tr>
<td>III</td>
<td>304.6</td>
<td>c</td>
<td>c</td>
<td>3</td>
<td>282.6</td>
</tr>
</tbody>
</table>

NB:  
1. The means followed by same letters do not differ significantly  
2. Please refer Table in Annexures 41 to 45 for LSD (5% & 1%)  
3. "T" stands for treatment levels, "M" for Mean for treatment and "SR" for significant range
decreasing survival was observed with increasing stocking rate. The differences between the treatment levels were significant at both levels of significance. The difference was more pronounced between the treatments 2 & 3.

Variable 4 (Gross yield) & Variable 5 (Net yield)

Both the above variables were found to be positively related to the increasing levels of treatment. Thus increasing yields were observed with increase in stocking rate and the trend was significant at 1% level of significance. The differences between the treatments were significant for both variables. However the differences were more pronounced between the lowest and the medium rate of stocking, than that between medium and highest level.

Water quality parameters of Experiment IV

The water quality parameters of the fifteen ponds were recorded and the average values of the three sets of ponds with three different stocking rates were compared. However no significant difference in the water quality was observed Table 41. The nature of the water management may be attributed to the uniform water quality characteristic of the ponds.
Table 41: Water quality parameters of experiment IV

<table>
<thead>
<tr>
<th>Water Quality Variables (mg/l)</th>
<th>Low Stocking (T1)</th>
<th>Medium Stocking (T2)</th>
<th>High Stocking (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td>10.8</td>
<td>11.0</td>
<td>10.6</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.065</td>
<td>0.068</td>
<td>0.072</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.045</td>
<td>0.055</td>
<td>0.056</td>
</tr>
<tr>
<td>Dissolved Organic matter</td>
<td>8.9</td>
<td>9.8</td>
<td>9.4</td>
</tr>
<tr>
<td>C.O.D.</td>
<td>13.16</td>
<td>16.16</td>
<td>15.26</td>
</tr>
</tbody>
</table>

7.2.2.2 Experiment V:

Effect of Artificial Feed on Growth of Chocolate Mahseer in Running Water System

Variable 1 (Average weight)

Average weight of the fish increased with increasing level of feeding. The difference between treatment 1 & 2 and 1 & 3 were significant at both levels of significance. However the difference in treatment 2 & 3 was not significant (Table 42). Considering the average weight difference between medium level and the high level of treatment to be non-significant, it may not be desirable to go for artificial feeding beyond the medium level treatment (i.e. @4% body weight) to prevent wastage and consequent high food conversion ratio.
Table 42: Effect of artificial feed on growth of chocolate mahseer under running water system

ANOVA Experiment No. V  Treatment: Feeding rate

Variables: Av. Weight (V1); Gross Yield (V2); Net Yield (V3)

<table>
<thead>
<tr>
<th>Rank</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>M</td>
<td>SR (5%)</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>324.5</td>
<td>a</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>320.75</td>
<td>a</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>299.75</td>
<td>b</td>
</tr>
</tbody>
</table>

NB:—
1. The means followed by same letters do not differ significantly
2. Please refer Table in Annexures 46 to 48 for LSD (5% & 1%)
3. "T" stands for treatment levels. "M" for Mean for treatment and "SR" for significant range
Variable 2 (Gross yield) & Variable 3 (Net yield)

Gross production and net production of the species showed increase in production with increasing feeding, however beyond the medium rate of feeding, the production recorded a fall and the trend was significant at 1% level. The difference in production between treatment level 2 & 3 for both the variables were not significant at both 5% and 1% levels.

Water quality parameters of experiment V

Variation in the water quality parameters of the twelve ponds were recorded and the average values of the three sets of ponds following three different feeding rates were compared.

Table 43: Water quality analysis of experiment V

<table>
<thead>
<tr>
<th>Water Quality Variables (mg/l)</th>
<th>Low Feeding (T1)</th>
<th>Medium Feeding (T2)</th>
<th>High Feeding (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td>10.8</td>
<td>9.9</td>
<td>9.0</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.039</td>
<td>0.054</td>
<td>0.064</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.0208</td>
<td>0.0301</td>
<td>0.036</td>
</tr>
<tr>
<td>Dissolved Organic matter</td>
<td>8.092</td>
<td>11.256</td>
<td>16.328</td>
</tr>
<tr>
<td>C.O.D.</td>
<td>12.66</td>
<td>16.78</td>
<td>28.34</td>
</tr>
</tbody>
</table>
Table 44: Effect of feeding Green Fodder on growth of chocolate mahseer

ANOVA Experiment No. VI Treatment: Feeding rate

Variables: Av. Weight (V1); Gross Yield (V2); Net Yield (V3)

<table>
<thead>
<tr>
<th>Rank</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>M</td>
<td>SR (5%)</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
<td>382.25</td>
<td>a</td>
</tr>
<tr>
<td>II</td>
<td>2</td>
<td>376.25</td>
<td>b</td>
</tr>
<tr>
<td>III</td>
<td>1</td>
<td>320.75</td>
<td>c</td>
</tr>
</tbody>
</table>

NB:—
1. The means followed by same letters do not differ significantly
2. Please refer Table in Annexures 49 to 51 for LSD (5% & 1%)
3. "T" stands for treatment levels. "M" for Mean for treatment and "SR" for significant range
The following observations are recorded.

A marginal fall in dissolved oxygen concentration with increasing feeding rate was observed. The results indicated increase in concentration of dissolved nitrate with increasing feeding rate. Similarly appreciable increase in dissolved organic matter and C.O.D. was observed with the increase in the rate of feeding.

7.2.2.3 Experiment VI:

Effect of Feeding with Green Fodder on Growth of Chocolate Mahseer

Variable 1 (Average Weight)

The average weight showed an increasing trend with increase in feeding rate. The difference between treatments were significant at 5% level. However the same was not significant between the medium rate and the high rate of feeding at 1% level of significance. Considering the findings it may be inferred that there is a significant increase in average weight with increase in feeding rate from low rate of feeding to the medium rate. However same can not be concluded about the increase from medium level to high level (Table 44).

Variable 2 (Gross yield) & Variable 3 (Net yield)

Gross yield and Net yield showed an increase with increasing
feeding rate. However, the increase in production between the medium rate and the high rate of feeding were not significant at both levels of significance. The increase in growth between the low rate of feeding and other two levels of feeding were highly significant. Thus from the point of production, feeding beyond the medium rate may not yield significant increase in production.

Water quality parameters of experiment VI

Variations in the water quality parameters of the twelve ponds were recorded and the average values of the three sets of ponds following three rates of feeding were compared Table 45. However no significant change of water quality was observed between the three groups.

<table>
<thead>
<tr>
<th>Water Quality Variables (mg/l)</th>
<th>Low Stocking (T1)</th>
<th>Medium Stocking (T2)</th>
<th>High Stocking (T3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td>11.6</td>
<td>11.2</td>
<td>11.4</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.032</td>
<td>0.048</td>
<td>0.050</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.021</td>
<td>0.030</td>
<td>0.028</td>
</tr>
<tr>
<td>Dissolved Organic matter</td>
<td>7.092</td>
<td>7.534</td>
<td>8.091</td>
</tr>
<tr>
<td>C.O.D.</td>
<td>14.66</td>
<td>16.78</td>
<td>18.89</td>
</tr>
</tbody>
</table>
7.3. DISCUSSION

In order to increase and save the chocolate mahseer population, it is necessary to culture them on a large scale in streams, lakes and reservoirs of the hilly region in North-Eastern India. The National Commission on Agriculture (1976) in its report on 'Fisheries' mentioned that there has been a general decline in the mahseer fishery due to indiscriminate fishing of brood stock and juvenile and by the adverse effects of river valley projects. Karamchandani et al. (1967), Pathani (1977, 1992), Singh and Badola (1978), Nautiyal (1984, 1989 & 1990), Dubey (1986), Kulkarni (1986), Nautiyal and Singh (1989), Jhingran (1991), Bhagat (1992) and Ogale (1992) have similarly suggested so many factors for the decline of mahseer. Moreover, the species is now declared as one of threatened cold water fishes of North Eastern India (Sinha, 1994). Hence measures should be taken for the preservation and multiplication of the mahseer fish in its natural habitat. The possibilities of Chocolate Mahseer culture in the mountainous terrain in North-Eastern India should be explored. One such possible alternative is the seeding of lakes and reservoirs with chocolate mahseer. Sir Henry Ramsay in 1858, the then British Commissioner of hill districts collected the live specimen of mahseer from river Kosi and transplanted them into lake Nainital and other lakes of the region. The fish adapted themselves successfully in lacustrine environment and flourished (Joshi and Saxena,
The main causes of depletion of mahseer fisheries are: Wanton destruction of the brood fish and juveniles by using dynamite or hand grenades, poisoning of streams and deterioration in the ecological conditions of the spawning and rearing grounds, damming of streams, pollution of streams, lakes and reservoirs, shifting of breeding grounds and lack of sufficient natural food in the water bodies.

It is necessary to adopt some measures for the conservation of the chocolate mahseer such as prohibition of mass killing of fry, fingerlings, juveniles and spawners, declaration of closed season, sanctuaries and implementation of mesh regulation.

Moreover, detailed survey of mahseer resources, ecological and biological investigations, establishment of seed farms, artificial propagation of seed, standardization of culture technology related to stocking, feeding, pond management etc. are very important for the success of aquaculture and conservation of chocolate mahseer.

Tripathi (1978) and Joshi (1982) attempted breeding of *T. putitora* by stripping on a small scale at Bhimtal. Joshi and Malkani (1986) carried out investigation on the artificial breeding of golden mahseer. Sehgal (1991) also succeeded on artificial propagation of *Tor putitora*. He
followed the dry method of stripping for fertilization of eggs. Sehgal and Malik (1991) devised a flow through system for seed production of *Tor putitora*, Kulkarni and Ogale (1978), and Kulkarni (1980) succeeded in artificial propagation of *Tor khudree* at Tatas Hydro-electric Company's Fish Farm, Lonavala in Maharashtra (Plate 29 & 30). It has opened up the possibility of its culture either alone or alongwith other compatible species of cultivable carps (Samoon, 1994). A revolutionary boost in production has been achieved by Indian Council of Agricultural Research in case of Indian major carps and other exotic species culture (Sinha, 1978a and 1978b). But, the culture of chocolate mahseer in particular has not received due attention even today. Hence the present studies were designed to study the followings:

(a) assessment of chocolate mahseer as a candidate species for aquaculture in the cooler climatic conditions as regard its suitability as an associate species under polyculture system (in confined water pond management) and as an exclusive species for monoculture (in running water pond management).

(b) standardization of various management practices associated with the above aquaculture practices.

7.3.1. Polyculture of carps under confined water management

The first experiment as already stated was conducted to study
Plate 29: Stripping a male fish

Plate 30: Fry of Mahseer
the suitability of seven carp species for polyculture under varying water temperature regime.

In conducting the present culture trial effort was made in the 1st experiment to keep some of the limiting factors constant. As for example, the daily rate of feeding and the size of fingerlings were made uniform in the culture ponds. Incidentally, the solar radiation and light energy were more or less uniform in all the ponds. The rate of fertilization and manuring were followed to maintain uniformity in natural production. Broadly speaking, the result (Fig.37) depicts the role of temperature in controlling growth of the various fish species in the composite fish culture.

Among the various environmental factors, temperature, light, oxygen and salinity are known to be important abiotic factors. While ratio, size of the stocking materials and competition between species are the most important biotic factors. These factors have different regulatory role to play in the growth process of fishes (Fry, 1971). In the formulation of a growth model for salmonids, Stauffer (1973) classified three factors like ration, size and temperature as the most important independent controlling factors.

Within the span of abiotic and biotic factors affecting growth, temperature was identified as the important controlling factor in the present experiment. The supply of food, oxygen, light or size restrictions could act as
limiting factors (Brett & Higgs, 1970). Hence, adequate care was taken to keep these limiting factors constant in experiment No.I, where the only variable was temperature.

In the 1st experiment, the effect of change of water temperature on the survival of grass carp, silver carp were not significant and that of common carp was not very clear. Thus the survival of these three species were not grossly affected by the observed variations in the temperature. But, in case of chocolate mahseer, the survival was inversely related to water temperature. Thus, greater survival was observed at cooler temperature.

Similar effect of temperature was encountered in rearing juvenile walleyes in experimental ecosystems by Wrenn & Forsythe (Kendall, 1978).

Results of the experiment on production and yield of juvenile Walleyes in simulated temperature regimes indicates that survival of the species decreases with increasing temperature. The temperature of 34°C was found to be lethal for the fish. In the present study, the chocolate mahseer were not subjected to higher temperature regimes which would prove lethal.

The Walleyes are more commonly associated with Northern lakes and streams and cooler upland reservoirs of USA. They are excluded from southern waters due to higher summer temperatures.
Plate 31: A typical Hill stream harbouring Mahseers

Plate 32: Angling for Mahseers
The distribution of chocolate mahseer in India is also associated with the cooler Himalayan river systems or upland reservoirs (Plate 31 & 32). However, the temperature regime preferred by the species is in between that of truly cold water species and the warm water species.

In case of the Indian major carps i.e. rohu, catla and mrigal, an opposite relationship was observed wherein, the survival rate increased with increasing water temperature indicating their preference for warmer water regimes.

In the present investigation, all the seven species of carps showed an increasing trend in growth and yield parameters with the increase in water temperature. However, increase in growth and body weight were more pronounced in the Indian major carps and silver carp as compared to the other species.

Also, these species of carps showed an increasing trend in yield parameters with the increase in water temperature. However, the yields were more pronounced in the Indian Major carps as compared to the other species (Fig.38). Thus it may appear that the growth and yield characters of the Indian major carps are more susceptible and hence less suited to cooler temperatures than the exotic species and the chocolate mahseer.

In order to determine choice of species for various temperature regimes, the impact of temperature on stocking
efficiency of the species was studied. The stocking efficiency is the ratio of the total fish yield to stocked biomass. The yield being a derived parameter based on survival and growth, it summarises the net effect of temperature on the species. Hence stocking efficiency which takes into account this net effect of temperature on growth as well as its ratio with the stocked biomass is a better yardstick for selection of the species. The minimum criteria for selection of a fish species was considered to be a stocking efficiency ratio of '10' (DeSilva, 1988). The mean stocking efficiency of the various species under different temperature regimes are shown in Table 46.

The selection of species based on the above criteria of stocking efficiency for the different temperature regimes are presented in Fig. 39. As is evident from the figure, Silver Carp, Grass Carp, Common Carp & Chocolate mahseer are suitable for polyculture in temperature zone I (Av. annual water temp. of 10°C). Similarly the species suited for Zone II (Av. annual water temp. of 15°C) are Silver Carp, Grass Carp, Common Carp, Chocolate Mahseer and Catla. The species suited for the Zone III (Av. annual water temperature of 20°C) would include all except Mrigal.

In the 2nd experiment viz., 'compatability of chocolate mahseer with exotic carp', it appears that the chocolate mahseer is a species which is compatible with the plankton
Fig. 39: Effect of temperature on stocking efficiency of seven species of carp.

- T1 (10°C)
- T2 (15°C)
- T3 (20°C)

Stocking efficiency for different species at various temperatures.
feeders as well as with the detritifeeders. As an omnivore, chocolate mahseer interacts somewhat negatively with the grass carp where macrovegetation in question is squash leaf. However, it can not be concluded from the above study whether the chocolate mahseer would compete with the grass carp as regard other macro-vegetations known to be widely accepted by this group of fish. Desai (1970) and Kulkarni (1971) reported the presence of large volume of macrovegetation in the gut of other group of mahseers. Saha et al. (1956) had advocated biological control of submerged aquatic vegetation in pond fisheries by culture of 'Katli', Barbus hexagonolepis,

Use of stems and leaves of squash (Cucurbita maschata, C. maxima and C. melopepo) is in practice as a green fodder for polyculture of carps in China (NACA, 1989). It is an annual plant belonging to the Cucurbitaceae family and is native of the tropics. It is a high yielding, juicy fodder rich in nutrients, viz., Carotene, Vitamin C, and glucose. Its stems and leaves can be processed into stalk sugar fodder after drying. The optimum temperature for the germination of squash seeds is reported to be 25-30°C. It grows profusely between March to October. The tender leaf and stems were offered to the fishes in the present experiment. The plant can be grown on the pond embankments and can meet the on-farm requirement of fish food.

The large quantity of macrovegetation found in the gut
content studies, reported under fish biology studies and also by Dasgupta (1982) lend support to the possible use of green feed in pond culture of chocolate mahseer.

Green fodders contain mostly water and cellulose. However, they also contain nutrients, i.e., fat, protein and carbohydrate, and are rich in vitamins (NACA, 1989). Green fodders are the principal feed for Grass Carp and Wuchang fish and serves as supplemental feed for other cultivated fish (NACA, 1989). Green fodders include aquatic plants and terrestrial plants and are mainly used for grass carp and breams and, sometimes, for common carp, crucian carp, and tilapia. The main aquatic plants used are Wolffia, Lemna, Vallisineria, Potamogeton, Hydrilla, Eichornia, and Pistia. The main terrestrial plants used are Echinochloa, Crusgalli, Pennisetum alopecuroides, Lolium perenne, Sorghum sundanes of the grass family, Lactuca tenticulata of the composite family; and various leaves and vines from melon and vegetable crops (NACA, 1989). Pumpkin vine and squash vine are also used as plant feeds. The FCR of pumpkin vine is reported to be 35 (NACA, 1989).

In the 3rd experiment, viz., 'The effect of stocking density on growth of chocolate mahseer' under confined water system, the dependent variables (gross yield and net yield) show maximum response for the medium level of treatment (stocking rate) and lowest response for the lowest level of treatment.
whereas the independent variables (i.e. Av. weight, weight gain and survival) show an inverse relationship with the treatment levels (Fig. 40). The medium stocking rate supports the maximum production without sacrificing average weight of the produce. Similar observations were made by Li Sifa (1988) while studying the effect of stocking density on average weight and yield of Silver Carp and Bighead. Relationship between stocking density and size of fish has been worked out in respect of Black Carp, Bighead, Wuchang bream, Grass carp, Silver carp (NACA, 1989).

Stocking density also known as stocking rate, refers to the quantity of fry or fingerlings per unit of water area. It is usually expressed as the number of weight of fish per hectare. In intensive fish-farming systems, the stocking density is expressed as the number or weight of fish per unit area or water volume (NACA, 1989).

The stocking density must be reasonable because it is inversely proportional to the quality of marketable fish under the same pond conditions and culturing measures. Excessive stocking densities produce fish below marketable size; therefore, fish yields are not improved. If the stocking density is too low, the per unit area production is also low, although the fish grow faster and reach larger sizes. A reasonable stocking density can ensure the desirable size and quality of fish products (NACA, 1989).
Fig. 40: Effect of stocking rate on growth characteristics of Chocolate mahseer under confined water (SR1 = 0.5/sqm; SR2 = 0.75/sqm; SR3 = 1.0/sqm)
Pond conditions, seed supply, species availability, fish sizes, feeds and operating techniques should all be taken into consideration in determining the stocking density (NACA, 1989).

If the fish grow well, the food-conversion rate is not higher than the average, no serious surfacing occurs during the culture period, and all species reach the marketable size at the end of production, the stocking density can be considered optimum (NACA, 1989).

Apart from feeds and water space, water quality (D.O. in particular) is the major factor affecting stocking density. The D.O. in pond water is closely related to the growth and survival of the fish. Oxygen demand varies with species, age, size of fish and water temperature. For Chinese carp, D.O. should be above 3 mg/l. The optimum D.O. is around 5.5 mg/l. The respiratory rate of cyprinids increases when the D.O. is below 2 mg/l. If it continues to drop, the fish will break the surface gasping for air. Asphyxiation occurs from 0.1 to 0.8 mg/l, depending on the species (NACA, 1989).

In the present experiment the D.O. concentration showed a fall at the high stocking rate (7.73 mg/l). However, the level was not low enough to cause any immediate concern, although the D.O. requirement of Mahseer is higher than that of the other carps grown along with it.
It is clear that the D.O. is closely related to the respiration, ingestion, growth, and survival of fish. In static fish ponds, the D.O. is mainly dependant on the photosynthesis of phytoplankton and the diffusion of the air against the water surface, the former being more important than the later. During the day, the upper layer of water usually becomes saturated with oxygen when photosynthesis is high. Nevertheless, the oxygen easily escapes from the water into the air (NACA, 1989).

In a fish pond, the respiration of the fish is not the leading factor in oxygen consumption, accounting for only 5-15 per cent of the total consumption. The oxygen consumption of natural food organisms (e.g., Zooplankton) accounts for less than 4.5 per cent; benthos, 0.2 per cent; the oxidation decomposition of manure applied and pond silt, about 8 per cent; and the decomposition of artificial food and fish feces about 32 per cent. Microbacteria (including phytoplankton) consumes about 50 per cent of the dissolved oxygen (NACA, 1989).

The water quality studies indicate a deterioration in the water quality with increasing stocking rate. The fall in the production at the highest stocking rate could be due to adverse impact on water quality. The deterioration of water quality on account of accumulation of high level of metabolites have been reported to have adverse impact on
growth of fish species (Pillay, 1993). Considering the above findings, it may be possible to develop three different polyculture systems for the different temperature regimes in the north eastern hill areas. The details of the proposed package of practices have been dealt with in the concluding part.

7.3.2. Monoculture of chocolate mahseer under running water management

The 4th experiment viz., 'Effect of stocking rate on growth of chocolate mahseer' under running water system, shows positive co-relation between treatment levels i.e. stocking rate and dependent variables (i.e. Gross yield and net yield) and negative co-relation with independent variables (i.e. Av. weight, weight gain and survival). It is observed that difference in the yield parameters between the lowest stocking and the other two rates of stocking are considerable, whereas the difference between the medium and the highest rate is much less. Similarly, the average weight and weight gain was highest at the lowest stocking rate and lowest at the highest stocking rate. However, the difference in growth parameters between the lowest stocking and medium stocking rate is much less compared to that between the medium and the highest stocking rate. Thus the medium stocking rate is the most useful having advantage of relative growth as well as high yield(Fig. 41).
Survival | Gross production (tons/ha) | Average weight (gms)

Fig. 41: Effect of stocking rate on growth characteristics of Chocolate mahseer under running water (SR1 = 1/sqm; SR2 = 3/sqm; SR3 = 5/sqm)

Fig. 41: Effect of stocking rate on growth characteristics of Chocolate mahseer under running water (SR1 = 1/sqm; SR2 = 3/sqm; SR3 = 5/sqm)
The stocking density must be reasonable because it is inversely proportional to the quality of marketable fish under the same pond condition, culture measures. Excessive stocking densities produce fish below marketable size; therefore, fish yields are not improved. If the stocking density is too low, the per unit area production is also low, although fish grow faster and reach larger sizes (NACA, 1989).

There was no appreciable change in water quality parameters as a result of higher stocking and feeding, which may be attributed to the daily water exchange of the ponds.

The 5th experiment viz., 'Effect of artificial feed on growth of chocolate mahseer', indicates that the average weight of the fish increased with increased feeding but the difference in response of Av. weight to feeding rate was not significant between the highest and the medium level of treatment. From the production point of view, the highest level of production was achieved at the medium level of treatment and hence the medium rate of feeding may be desirable from the point of view of production as well as growth(1). The result of the water quality studies indicate increasing concentration of dissolved nitrate, dissolved organic matter and C.O.D. with increasing feeding rate(Fig.42).

Thus decline in water quality parameters could be the reason
for fall in production at the highest level of feeding. Similar observations were recorded by Tucker et al. (1979) in channel catfish ponds. Though none of the water quality parameters assumed the critical concentrations, yet accumulation of feeding materials was apparent by the concentration of dissolved organic matter and chemical oxygen demand which might have resulted into setting in of stress conditions.

According to Brett (1979) and Jobling (1983), the feeding rate is not the only factor responsible for a better growth but the stress, choice of food, quality and quantity of food, temperature and other favourable environmental conditions also contribute to affect growth.

In the 6th experiment viz., 'Effect of feeding Green fodder on growth of chocolate mahseer', the variables viz. average weight, the gross production and the net production although showed increase with the treatment levels, the difference in treatment levels 3 and 2 were not significant and the fall in production at the medium level of feeding as compared to the high level of feeding was marginal. The above observation when considered along with the facts that there is virtually no additional yield beyond the medium rate of feeding, would suggest that the medium rate of feeding is optimum for growth and yield. As regard the water quality, no significant changes were observed between the treatment levels. This may
Fig. 42: Effect of artificial feed on average weight and gross production of chocolate mahseer (FR1 = 2%; FR2 = 4%; FR3 = 6%)
Fig. 43: Effect of green fodder on average weight and gross production of chocolate mahseer (FR1 = 20%; FR2 = 40%; FR3 = 60%)
be attributed to the easy removal of uneaten fodder and partial replenishment of water on daily basis. The green food in question is tender squash leaf, which grows profusely during the months of April to October. It is possible to grow the cucurbit on the pond embankments as well as on bamboo stakes. It may be possible to meet the entire on-farm requirement from squash cultivation on the pond margins.

Considering the above findings, it may be possible to develop an intensive running water culture system of chocolate mahseer in the N.E. Hills. Considering the seasonal availability of running water (6-8 months) in the hills and availability of green fodder (7-8 months), the duration of culture may be 6 months. The production potentials as assessed from the experiment is 7500-9000 kg/ha. The details of the proposed package of practice is dealt with in the concluding part.
ADDENDUM

Two important findings of the first part of the study pertaining to age and growth and food and feeding were made use of in the culturability trials. This can be substantiated from the followings.

i) The duration of culture of Chocolate mahseer was based on its growth as assessed from observations on age and growth studies in a limited period of seven days in the initial year of study.

ii) The preliminary information generated out of food and feeding study were abundantly utilized in the culture fishery experimental study in the 2nd part. It is confirmed from the aquaculture trials on food and feedings that use of green fodder like squash leaves, a cucurbit give higher yields.

iii) Squash vegetation was grown on the banks of the ponds in order to meet the requirement of macrovegetation during the culture period.

iv) Considering the feeding habit of Chocolate mahseer, a comparative study of two macrovegetation feeding carps, viz. chocolate Mahseer and exotic grass carp was conducted and it showed a negative interaction suggesting competition.
v) The duration of monoculture of chocolate Mahseer under running water condition had been linked with the duration of availability of green fodder in the adjacent area of the hilly region of Meghalaya.

(Sabir Kumar Ghosh)
15.11.1996.

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CONCLUSION

I. Suitability of carp species for polyculture under various water temperature regime

Considering the stocking efficiency of the various carp species the following inferences have been drawn regarding suitability of carp species for polyculture under different water temperature regimes.

1. Temperature zone I (Average annual temperature of 10°C). The suitable species with stocking efficiency exceeding '10' are: Silver Carp, Chocolate Mahseer, Grass Carp and Common Carp.

2. Temperature Zone II (Average annual temperature of 15°C). The suitable species with stocking efficiency exceeding '10' are: Silver Carp, Chocolate Mahseer, Grass Carp, Common Carp and Catla.

3. Temperature Zone III (Average annual temperature of 20°C). The suitable species with stocking efficiency exceeding '10' are: Silver Carp, Chocolate Mahseer, Grass Carp, Common Carp, Catla, and Rohu.

II. Compatibility of Chocolate Mahseer with Exotic Carp

From the results of the experiment in this connection the following conclusions can be drawn.

1. The Chocolate Mahseer is compatible with plankton feeders and detriti feeders.
2. Though the speci-s is an omnivore, it is likely to compete with grass carp as regard macro-vegetations concerned. When grown with grass carp, sufficient green fodder should be provided.

III. Effect of stocking rate on growth of Chocolate Mahseer under confined water system

The medium rate of stocking of fingerlings @ 7500 nos per hectare proved to be optimum from the point of view of growth, production and water quality for production of Chocolate Mahseer under confined water condition.

IV. Effect of stocking rate on growth of Chocolate Mahseer under running water system

The medium rate of stocking of fingerlings @ 30,000 nos per hectare proved to be optimum from the point of view of growth, survival, production and economics.

V. Effect of artificial feed on growth of Chocolate Mahseer in running water system

The medium rate of feeding i.e. @ 4% of the body weight of fish stock per day was found to be optimum from the point of view of growth, production, economics and water quality.

VI. Effect of feeding Green fodder on growth of Chocolate Mahseer

Daily Feeding with green fodder (Squash leaf) @ 40% of the body weight of the fish in stock was found optimum from the
point of view of growth, production and economics.

VII. Considering the experimental findings the following conclusions can be drawn regarding aquaculture technology for the hills.

I. Viable carp polyculture technology can be developed for the various water temperature regimes in the hills with the choice of carp species already suggested and production potentials indicated as under:

<table>
<thead>
<tr>
<th>Temperature Regimes (Av. annual temperature)</th>
<th>Species Combination</th>
<th>Approximate Fish Production potentials (kg/ha/yr)</th>
<th>Aquaculture Production Potentials (Kg/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10°C</td>
<td>Common Carp, Silver Carp, Chocolate Mahseer Grass Carp</td>
<td>440</td>
<td>2186</td>
</tr>
<tr>
<td>15°C</td>
<td>Common Carp, Silver Carp, Chocolate Mahseer Grass Carp &amp; Catla</td>
<td>450</td>
<td>2518</td>
</tr>
<tr>
<td>20°C</td>
<td>Silver Carp, Chocolate Mahseer, Grass Carp, Common Carp, Catla &amp; Rohu</td>
<td>460</td>
<td>3638</td>
</tr>
</tbody>
</table>

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The Management practice involved are as follows:

1. Type of Pond: Dugout, Dugout-cum-embankment type
2. Water Exchange: Nil
3. Liming: 2000 kg/ha/yr
4. Manuring: 50,000 kg/ha/yr
5. Fertilization
   (i) Ammonium Sulphate: 350 kg/ha/yr
   (ii) Triple super Phosphate: 500 kg/ha/yr
   (iii) Muriate of Potash: 80 kg/ha/yr
6. Stocking (Fingerlings of 20-25 gm weight): 7500 nos/ha
7. Stocking ratio: Equal ratio; the ratio between grass carp and chocolate mahseer may be adjusted after taking into account the relative demand and availability of green fodder
8. Feeding
   (i) Artificial feed (daily feeding with Rice bran and Mustard Oil cake in equal ratio): @ 2% of fish biomass
   (ii) Green Fodder (Leaves of squash or other cucurbits two days in a week): @ 40% of biomass of grass carp and chocolate mahseer
9. Duration of culture: 12 months

II. Viable running water aquaculture practice based on Chocolate Mahseer can be developed in the hills with the following considerations:
1. Water exchange : 50% daily  
2. Liming : 2000 kg/ha  
3. Stocking rate : 3 nos/m²  
4. Feed  
   (i) Artificial feed : @ 4% of biomass of fish in  
   (FCR 4:1) stock per day  
   or  
   (ii) Green Fodder : @ 40% of the biomass of fish  
   in stock per day  
5. Duration of culture : 6 months  
6. Production potential: 7500 - 9000 kg/ha