CHAPTER NINE

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ON FISH SYSTEMATICS

Of the 48 species reported in the present study, 18 species and 6 sub-species form a new record from the drainages of Sikkim. And significantly, 4 species namely *Glyptothorax basnetti*, *G. bhutiai*, *G. deyi*, *Clupisoma bhandarii* and two sub-species namely *Glyptothorax sinense sikkimensis* & *Laguvia ribeiroi jorethangensis* are found new to science.

Variations in certain meristic characters are evident in some ichthyospecies from those reported by earlier workers and are discussed hereunder.

*Acrossocheilus hexagonolepis*: D.i.9 (versus D.iv.9 by Jayaram, 1981); *Glyptothorax conirostrae*: A.i.9 (versus A.i.i.9 - 10 by Day, 1878 and Jayaram, 1981); *G. gracilis*: A.9 - 12 (versus A.14 by Jayaram, 1979).

Morphometrically some ichthyospecies of Sikkim drainages also differ from those reported earlier from other drainages of the country. In this context the notable species are: *C. latius latius* - DF; *S. semiplotus* - maxillary barbels; *L. dero* - position of eyes; *G. annandalei* - HL, HB, IOD and DL; *G. goryla goryla* - HL, IOD, distance from vent to anal in that between anterior origin of pelvic and anal fin; *G. goryla stenorhynchus* - BD, distance from vent to anal in that between anterior origin of pelvic and anal fin; *G. lamia* - HD, distance from vent to anal in that between anterior origin of pelvic and anal, CPDL; *G. mullya* - BD, distance from vent to anal in that between anterior origins of pelvic and anal fin; *N. beavani* - Snout length, PFL; *N. carletoni* - VF, VFL, CFL; *N. corica* - PF, AF; *N. devdevi* - DF and CF with two black spots; *N. kangjupkhulensis* - Rostral barbel; *N. multifasciatus* - PFL, CFL; *N. scaturigina* - DF, VF, PFL and CFL; *N. sikmaiensis* - DF, VFL, CF; *N. spilopterus* - Barbels; *P. pangasius* - nature of head; *G. conirostrae* - Maxillary barbel, DF height, BD; *E. hodgardi* - CPD and ADFL.

Further the present investigation noteworthy extends the maximum TL of ten species from earlier size limit reported. They are *B. bendelisis chedra*, 160 mm (- 155 mm, Talwar & Jhingran,
1991); C. latius latius, 210 mm (- 150 mm, Datta Munshi & Srivastava, 1988; - 124 mm, T & J. 1991); G. goryla goryla, 230 mm (- 200 mm, DM & S, 1988; - 140 mm, T & J, 1991); G. goryla stenorrhynchus, 240 mm (- 150 mm, T & J , 1991); A. pangia, 69 mm (- 65 mm, T & J, 1991); G. sinense manipurensis, 257 mm (- 94.5 mm, Jayaram, 1979; - 126 mm, T & J, 1991); G. gracilis, 164 mm (- 127 mm, T & J , 1991), G. conirostrae, 220 mm (- 140 mm, T & J. 1991); E. hodgarti, 120 mm (- 57.5 mm, Jayaram, 1979; - 65 mm T & J, 1991); and P. sulcatus, 196 mm (- 180 mm, Jayaram, 1979).

Amongst the species reported from Sikkim, it has been observed that some workers used wrong nomenclature while identifying the species. An elucidation to this context along with the valid species has been reported hereunder in tabular form:

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Nomenclature used</th>
<th>Valid species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilak (1972)</td>
<td>Schizothorax plagiostomus</td>
<td>Schizopyge progastus (McClelland)</td>
</tr>
<tr>
<td>Bhutia &amp; Acharya (1987)</td>
<td>Schizothorax progastus</td>
<td>Schizopyge progastus (McClelland)</td>
</tr>
<tr>
<td>Tilak (1972)</td>
<td>N. inglishi</td>
<td>N. multifasciatus Day</td>
</tr>
</tbody>
</table>

Besides, the presence of Tor mosal (Hamilton) in the drainages of Sikkim reported by Tilak (1972) is doubtful. The apprehension gets reasons to avow due to the fact that the species, a South Indian form is not known to occur in any of the drainages of North East India (Dey & Das, 1989) nor it could be found in any of Sikkim drainages by the present investigator. Further, the occurrences of Glyptothorax striatus, Glyptosternum maculatum, Puntius spinulosus, P. clavatus, Labeo dyocheilus, Barilius barna by Tilak (1972) and of Glyptothorax pectinopterus, Barilius barna by Bhutia & Acharya (1987) could not be confirmed in the present extensive investigations raising scope of incredulity about the validity of such occurrences of ichthyospecies in Sikkim drainages. Further, N. de Terrai described by Tilak (1972) and Bhutia & Acharya (1987) has not been included in the list of species belonging to the genus Noemacheilus van Hasselt by Menon (1987) in his monographic work on cobitoidea.
On the species of the genus *Clupisoma* Swainson:

Bhutia & Acharya (1987) have wrongly identified the single species of genus *Clupisoma* Swainson as *C. montana* Hora. The present species is identified to be new to science and has been named as *C. bhandarii* (Plate XVIII-5 & XIX-3). The species can be readily distinguished from allied species on various characters especially on the keel, maxillary barbel, pelvic fin and anal fin rays characters. Accordingly, a key to identification prepared on these characteristics is purported hereunder among the species of the genus *Clupisoma* Swainson known so far.

**Key to the identification of the genus *Clupisoma* Swainson**

1. Abdominal edge rounded ............... 2
   Abdominal edge keeled throughout or partly ...... 3

2. Maxillary barbels not reaching beyond
   base of pectoral fin. Pectorals reaching
   pelvic fins. Anal fin with 41 - 43 rays ........... *C. montana* Hora
   Maxillary barbels extending up to or
   behind base of pelvic fin. Pectorals
   may or may not reach pelvics. Anal fin
   with 40 - 47 rays. ..................... *C. naziri* Mirza & Iqbal Awan

3. Abdominal edge keeled throughout.
   Maxillary barbels not reaching pelvics.
   Anal fin with 40 - 44 rays. ................ *C. prateri* Hora
   Abdominal edge keeled partly ........... 4

4. Abdominal edge keeled from vent to
   thorax. Pectorals not reaching pelvics.
   Maxillary barbels reaching anal fin
   base. Anal fin with 52 - 54 rays. ............. *C. bastari* Datta & Karmakar
   Abdominal edge keeled between pelvic
   and vent. Pectorals not reaching pelvics. ........ 5

5. Maxillary barbels reaching pelvic fin.
   Anal fin with 29 - 36 rays. ............. *C. garua* (Hamilton)
   Maxillary barbels crossing pectoral
   base but not reaching pelvic fin.
   Anal fin with 39 - 41 rays. ............ *C. bhandarii* sp.nov.
On the species of the genus *Laguvia* Hora:

There exists no report of genus *Laguvia* Hora by previous workers from Sikkim waters. Two sub-species of *L. ribeiroi* have been reported from Sikkim drainages for the first time by the present investigator namely *L. ribeiroi ribeiroi* Hora (Plate XVI-12) & *L. ribeiroi jorethangensis sub. sp. nov.* (Plate XVI-15 & XIX-5). Of the two, *L. ribeiroi jorethangensis* is new to science. These two sub-species can be readily distinguished from each other and allied species mainly on the dorsal spine and position of pelvic fin. A key to identification prepared on these characteristics is purported hereunder:

**Key to the identification of the genus *Laguvia* Hora**

1. Dorsal spine smooth. Origin of pelvic fin distinctly nearer base of caudal than tip of snout .... 2
   - Dorsal spine finely serrated along whole of anterior margin and also along upper one third of posterior margin. ........... 4

2. Body depth 4.5 - 5.0 in standard length.
   - Inter- orbital width 3.2 t 3.5, snout length 2.0 to 2.2 in head length.
   - Body with two bands, posterior band below entire width of adipose dorsal ...... *L. shawi* (Hora)

   Body depth 3.3 to 3.4 in standard length.
   - Inter- orbital width 2.5 to 2.85, snout length 1.66 to 1.82 in head length.
   - Body with two bands, posterior band base of adipose fin. ........... *L. asperus* (McClelland)

3. Origin of pelvic fin equidistant from tip of snout and caudal base or nearer tip of snout. ........... *L. ribeiroi ribeiroi* Hora
   - Origin of pelvic fin distinctly nearer caudal base than tip of snout. ........... *L. ribeiroi jorethangensis sub.sp nov.*
On the species of the genus *Glyptothorax* Blyth:

The previous workers reported three species of the genus *Glyptothorax* Blyth namely *G. striatus* (Tilak, 1972), *G. gracilis* (Tilak, 1972) and *G. pectinopterus* (Bhutia & Acharya, 1987). In the present study, altogether seven species have significantly been reported from the drainages of Sikkim namely *G. basnetti* sp. nov. (Plate XVII-4 & XIX-4), *G. bhutiai* sp. nov. (Plate XVII-8 & XIX-6), *G. conirostrae* (Plate XVII-6), *G. deyi* sp. nov. (Plate XVII-7 & XIX-2), *G. gracilis* (Plate XVII-3), *G. sinense manipurensis* (Plate XVII-1), *G. sinense sikkimensis sub. sp. nov.* (Plate XVII-5 & XIX-1) and *G. trilineatus* (Plate XVII-2). All the seven species with two sub-species can reasonably be distinguished from each other and allied species on various characters especially on adhesive apparatus, dorsal fin, body depth, pectoral fin and on barbel characteristics. Accordingly, a key to the identification prepared on these characters is purported hereunder:

**Key to the identification of the genus *Glyptothorax* Blyth**

1. Skin smooth, devoid of granulations or tuberculations.... 2
   Skin rough with granulations or tuberculations........ 10
2. Adhesive apparatus on thorax distinctly longer than broad ......... 3
3. Occipital process not reaching basal bone of dorsal fin... 4
4. Dorsal spine strong ........... 5
   Dorsal spine weak ........... 6
5. Adhesive apparatus on thorax without a central pit.
   Paired fins plaited ........... *G. sinense manipurensis* Menon
   Adhesive apparatus without a central pit.
   Paired fins not plaited. ........... 7
   Adhesive apparatus on thorax complete posteriorly enclosing a central pit. ........... 11
6. Dorsal spine serrated along inner margin.
   Paired fins not plaited. ........... *G. sinense sinense* (Regan)
   Dorsal spine smooth. Paired fins plaited ........... *G. sinense sikkimensis sub. sp. nov.*
7. Dorsal fin higher than body depth below it ...... 8
   Dorsal fin shorter than or equal to body depth below it.. 9
8. Body depth 5.0 - 5.5 in standard length.
   Pectoral fins longer than head ........... *G. gracilis* (Gunther)
   Body depth above 5.8 in standard length ........... *G. bhutiai* sp. nov.
9. Anal fin inserted opposite or before adipose origin.
Nasal barbels reaching anterior border of eye...........  G. trilineatus Blyth
Nasal barbels not reaching anterior of eye .............. 10
10. Body with one or two bands.  ...........  G. deyi sp.nov.
Head, sides and fins mottled with dark spots.........  G. telchitta (Hamilton)
11. Body depth 5.9 - 6.6 in standard length.
   Least height of caudal peduncle 2.5 times in its length... G. cavia (Hamilton)
   Body depth 4.5 - 5.6 in standard length. Least height
   of caudal peduncle 1.9 - 2.2 times in its length..........  G.basnetti sp. nov.

ON ECOLOGY AND FLUVIAL DYNAMICS

The Tista and the Rangit drainages of Sikkim are situated in the North of Tropic of Cancer
between 28°07'48'' and 27°04'46''N and 88° and 89° E and the region has a mixture of sub-
tropical, temperate and alpine climatic conditions (mean air temperature minimum - 4°C to
maximum 34°C).

The two major drainages in the higher gradients have a meandering course with feeble and
crystal clear water; the middle reach with very deep and narrow gorges with turbulent water flowing
through rocky to gravelly bottom; and in the lower gradients the rivers with relatively low velocity
pass through broader valleys demarcating the two adjacent hills before confluencing with each other
near Tista bazaar in Darjeeling Gorkha Hill Council region of West Bengal.

Although all the rivers under study are perennial, Ghattay khola, Roathak khola and Rishi
khola exhibit a dying state with feeble discharge (Figures 2 & 6) during the lean seasons (winter-
summer). The discharge rate of the Tista drainages at upper gradients is found to be influenced by
the water sources in the upper catchment. Since some of the rivers originating from high elevations
(3960 to 5300 m) are snow fed, the discharge rate of such rivers (e.g. Yumthang chhu) have been
recorded to be comparatively high during summer. But the common phenomenon exhibited by the
river systems is the highest discharge during the monsoon (2.01 to 404.64 m³s⁻¹) and lowest during
lean seasons (0.08 to 67.44 m³s⁻¹). Sharma (1983) has described Tista as a wild river and reported
that the flow of Tista was around 16,990 m³s⁻¹ in 1950's and it washed away Assam railway link
bridge at Sevoke during 1968 flood.
The rate of discharge at the confluence of river Rangit and Rangbhang khola reported by Bhutia & Acharya (1987) as 170.034 - 282.21 m³s⁻¹ is untenable as in the present study it has been recorded empirically to be 44.35 - 278.37 m³s⁻¹ at Nayabazar. Similarly, large variations have been observed in discharge rate reported by Venu et al (1990) for river Tista near Rangpo as 96.34 - 1400.37 m³s⁻¹ (vs. 67.44 - 404.64 m³s⁻¹ in the present study), Rani khola, 360 - 549 m³s⁻¹ (vs. 2.97 - 39.68 m³s⁻¹) and Rangpo khola, 17.65 - 70.6 m³s⁻¹ (vs. 15.24 - 106.68 m³s⁻¹).

In general, it is found that discharge rate of the river at a location is greatly influenced by the water velocity, the shape of river profile and its catchment area upstream.

The water velocity is highly influenced by the gradient of the river and the river's volume of discharge. It is observed to be higher during heavy flood in monsoon and lower during winter as a norm. River Tista at Tong exhibits the highest velocity (1.84 ms⁻¹) during monsoon and the lowest velocity of (0.2 ms⁻¹) by Ghattay khola during summer at Sirwani.

Basin patterns are found variable in the course of the river. It exhibits different types of bed made up of boulders, stones, pebbles, sand or even mud. Basin characteristics also vary considerably with altitude and fluvial trend.

Balaraman (1987) has wrongly mentioned the altitude of Thanggu as 4350 m (msl) which in fact is 3812 m (msl). Venu et al (1990) state the altitude of Sikkim Himalayas varying from 800 m to 5000 m. In fact, these ranges lie in between 310 m and 5300 m (up to Chho Lhamu) as critically studied in the present investigation. Further they have mentioned the origin of river Tista as Talung Kangshe Glacier which in fact, should be mentioned as Tista Khangse Glacier. Concomitantly, the origin of Rangpo khola is wrongly stated by them as Latui reserve forest instead of Menmoi chho, its actual source.

Some of the descriptions on the drainages of Sikkim put forward by Venu et al (1990) are also found erroneous. The depth of Menmoi chho varied from 21.3 m to 27.33 m as recorded in the present study (versus 7.5 m by Venu et al, 1990). The total length of rivers Tista and Rangit purported by Anon (1981) as 500 km has been corrected as 750 km in the study.
Tilak (1972) while reporting the small list of fishes from Sikkim does spell river/place name erroneously like Rangit as Ranjeet and Tadong as Tardhong. More curiously, chatra the collection place for Garra lamia and khola/Khoila river for G. goryla goryla & L. ribeirol as reported by him has no existence in Sikkim.

Complexity of stream habitat is correlated with the diversity of fish species. Stream depth, bottom type, water current are important factors responsible for the habitat diversity to a wide range of fish groups. From the present study, it is apparent that some fish groups are restricted to swift flowing water (true hill stream forms) while others to slow flowing ones. The correlation between habitat characteristics and presence or absence of fish species suggests that most fishes of small streams are habitat specialists which otherwise concurs the view of Garman and Karr (1978).

Based on fluvial dynamics and ecological conditions the river systems of Sikkim may reasonably be divided into (1) crystal clear zone through meandering course from 4200 to 5500 m (2) the middle aggressive zone from 500 to 3960 m characterized by turbulent water current throughout the year and (3) comparatively sluggish zone from 240 to 500 m.

The present investigation further reveals that some of the rivers remain more or less clear throughout the year with very high transparency of 62 cm and 85.17 cm as in river Rangit at Sikhip; Yumthang chhu, Bakcha chhu, Rin khola, Rangpo khola, and Rimbi khola. The remaining rivers are turbid during monsoon but clear during rest of the year. Of these rivers, Tista, Rani khola and Kalej khola are excessively turbid with silt and mud load during monsoon. This may be attributed to high rate of soil erosion along their banks (course) in upper reaches resulted due to excessive denudation of forests cover.

The present study reveals the air temperature of Rangit drainages ranging from 18.5°C - 34°C in Sikkim against 10°C to 25°C reported by Bhutia and Acharya (1987). Concomitantly, the air temperature of Sikkim is reported to vary from 0°C to 29°C (Dhiman et al., 1988 and -4°C to 31.1°C (Basnet, 1989). But the present observation portrays the range from -4°C to 34°C.

Water temperature is an important parameter, because it affects the rates of chemical and biological reactions, solubility of gases in water (particularly oxygen) and may induce stratified conditions (Rau, 1980). Temperature is a kind of seasonal yardstick and fish depends upon water
temperature as a signal for migration and spawning (Healy, 1976). The degree of insolation, substrate composition, transparency, rain water inflows and wind action have influence on the water temperature in the rivers. Admittedly, a direct relationship between the temperature of air and water as a general norm (Dey, 1981) is discernible in the drainages when water temperature follows air temperature fairly closely. The maximum water temperature is recorded to be 27°C in Rani khola during monsoon and minimum of -2°C in Yumthang chhu during winter. Comparatively higher water temperature (17 - 27°C) has been recorded at Rani khola, Jali khola and Seti khola. This exhibits the direct influence of transparency, gradient of the river basin, low water level and velocity and higher depth of sunlight penetration and influence of ambient temperature.

The range of water temperature of Rangit drainage reported by Bhutia & Acharya (1987) as 7 - 14 °C is significantly found to be 12 - 24 °C during present investigation. Great variations also found to exist in the present study from the range of water temperature reported by Venu et al (1990). River Tista near Singtam was reported as 16 - 21.5°C (vs. 15.5 - 25°C in the present study), Rani khola 17 - 22°C (vs. 18.5 - 27°C), Jali khola 16.5 - 22°C (vs. 17.75 - 26°C), Seti khola 16.5 - 22.5°C (vs. 17 - 25°C), Rangpo khola 16 - 24.5°C (vs. 15 - 21°C), river Rangit 17 - 25.5°C (vs. 14.7 - 21.5°C), Lachen chhu 15 - 16.5°C (vs. 9.3 - 13°C) and Lachung chhu 18 - 18.5°C (vs. 8.5 - 13.5°C).

The distribution of DO within the aquatic ecosystem is one of the main factors influencing the distribution of fish. Maximum fish species have been observed in rivers with DO ranging from 8.45 - 9.47 mg/l while the highest fish density in between 7.52 and 11.47 mg/l. The present study reveals that the rivers Tista and Yumthang have the highest mean DO values thereby exhibiting the direct correlation between the altitude and DO.

The data reported by Venu et al (1990) on DO level of the rivers significantly differ from the present investigation, viz, river Tista near Singtam 4 to 10.4 mg/l (vs. 4.14 to 14.88 mg/l in the present study), Lachen chhu 7.1 to 7.3 mg/l (vs. 8.82 to 13.16 mg/l) and Lachung chhu 8.4 to 9.1 mg/l (vs. 6.83 to 13.5 mg/l).

FCO₂ exhibits a different trend in the present study. River Rangit at lower Tashiding, Rimbi khola and Kalej khola of Rangit drainage are found to contain the highest FCO₂ during summer (30.2 to 60.6 mg/l); while majority of rivers of Tista drainage are found purporting
comparatively higher FCO₂ during the monsoon season (3.05 to 10.6 mg/l). And admittedly, FCO₂ is recorded in very small proportion during winter in most of the rivers of Sikkim.

The reports of Venu et al (1990) differ from that of present investigation on FCO₂ levels with river Tista near Singtam 1.5 - 4.95 mg/l (vs. 1.5 - 7.0 mg/l in the present study), Rani khola 1.8 - 6.98 mg/l (vs. 2.6 - 10.5 mg/l), Jali khola 5.8 - 6 mg/l (vs. 2.1 - 9.6 mg/l), Seti khola 2.1 - 5.4 mg/l (vs. 2.1 - 10.6 mg/l), river Rangit 1.2 - 4.5 mg/l (vs. 1.5 - 15.9 mg/l), Lachen chhu 0.86 mg/l (vs. 1.25 - 2.3 mg/l) and Lachung chhu 1.36 mg/l (vs. 1.9 - 3.05 mg/l).

pH portrays a moderate range of seasonal variation 6.0 - 7.4 in all the drainages. The increase in rate of influx of FCO₂ in the rivers during monsoon (Chakravorty et al, 1959; Subba Rao & Govind, 1964; Mathew, 1972; Laal, 1981) perhaps ensues low pH during that period. Consequently, an inverse relationship between pH and FCO₂ (Dey, 1981; Kumar, 1985) is avowed in the rivers studied.

TA considered as an indicator of productivity (Wallen, 1955) exhibits considerable seasonal fluctuation ranging from 1.9 (M) to 225 (S) indicating direct relationship amongst TA, DO and phytoplankton abundance. Alkalinity is mainly due to bicarbonate present in water (Reid, 1961). The fluctuation in alkalinity is mainly due to rainfall as observed by Michael (1969) and Jana (1973). The sudden influx of FCO₂ in high concentrations leached down to the soil alongwith rainfall lowers down TA to its minimal value during monsoon. Thus the concentrations of FCO₂ in water bears an inverse relationship with TA. Minimal TA level (absent in few rivers) during high flood reported by other fresh water bodies of India (Mookherjee & Bhattacharjee, 1949; Dutta et al, 1954; Chakraborty, et al, 1959; Subba Rao & Govind, 1964; Mathew, 1978) also happens to be normal phenomenon in the present drainages investigated.

The reports of Venu et al (1990) on the TA of Sikkim rivers are contradictory to the present findings - for example river Tista near Singtam is reported as 16.5 to 36.1 mg/l (vs. 17 to 52 mg/l in the present study), Rani khola 25 - 28.5 mg/l (vs. 1.9 - 102.5 mg/l), Jali khola 23.1 - 25.6 mg/l (vs. 16.7 - 88.5 mg/l), Seti khola 28 - 33.1 mg/l (vs. 4.5 - 62.5 mg/l), river Rangit 28.1 - 44.9 mg/l (vs. 25 - 81 mg/l), Lachen chhu 47.6 mg/l (vs. 25.5 - 100 mg/l) and Lachung chhu 40.8 mg/l (vs. 23 - 27 mg/l).
ON POTAMOPLANKTON

Plankton population, on which the whole aquatic life depends directly or indirectly, is governed by the interaction of a number of physical, chemical and biological conditions and tolerance of the organism to variation in one or more of these conditions (Reid, 1961). Concomitant to physical and chemical elements, the spatial and temporal distribution of plankton in Sikkim drainages is characterized by relatively poor concentration. Indeed, 43 genera of phytoplankton (out of 63 genera) and 17 genera of zooplankton which constitute the potamoplankton communities of the two river systems incidently form record from the present drainages. Besides, correlation between phytoplankton abundance and fluvial dynamics in the present drainages is recorded with relatively more polarization of phytoplankton during winter. That the rate of flow is dominant physical factor affecting planktonic life in a river (Dey, 1973) is discernable in the present study.

The phytoplankton domination, a familiar feature in N.E. freshwater bodies (Dey & Nath, 1982; Dey & Das, 1989) is found to play the key role in the net plankton yield of both the Tista (96.58 %) and the Rangit (95.90 %) drainages (Table 1). The net phytoplankton density of the drainages under study attain maximum level (12906 ul⁻¹) during winter followed by monsoon (12747 ul⁻¹) and summer (8400 ul⁻¹). The sparse phytoplankton flora of the present drainage is mostly composed of Binuclearia, Chlorella, Cladophora, Geminella, Sphaeroplea, Spirogyra, Ulothrix, Anabaena, Nostoc, Melosira, Pinnularia, Navicula and Tabellaria. The overall structure of phytoplankton groups in order of dominance is Chlorophyceae (34 genera) > Bacillariophyceae (19 genera) > Myxophyceae (4 genera) > Chrysophyceae (4 genera) > Xanthophyceae (1 genus) and Rhodophyceae (1 genus).

It is interesting to note that the diversity of phytoplankton genera was recorded to be maximum at higher gradients namely river Tista at Tong (33 genera), Yumthang chhu (29 genera) during winter months exhibiting habitat specificity. This is an indicative of relationship between the water velocity, DO, transparency and temperature. Some of the genera found to be restricted to the Tista drainages during the present study are Bulbochaete, Closterium, Coleochaete, Cosmarium, Ctenocladius, Gongrosira, Hydrodictyon, Oocarpum, Palmadictyon, Pearsoniella, Pediasastrum, Pithophora, Protodermia, Rhizoclonium, Tetradsorpa (Chlorophyceae); Monocilia (Xanthophyceae); Celloniella (Chrysophyceae), Fragilaria, Gomphonema (Bacillariophyceae). The single genus of Chrysophyceae found to be confined to Rangit drainage is Hydrurus.
Chlorophyceae represented by 34 genera occur all along the twin drainages throughout the year displaying highest abundance \((7054 \, \text{ul}^{-1})\) from monsoon to winter \((6347 \, \text{ul}^{-1})\) and the least in summer \((3737 \, \text{ul}^{-1})\). The genera which are responsible for the peak of Chlorophyceae are *Binuclearia, Chara, Chlorella, Cladophora, Dermatophyton, Geminella, Oedogonium, Pearsonella, Sphaeroplea, Spirogyra, Ulothrix* and *Zygnema*. Of the 16 rivers studied during present investigation, Ghattay khola & Bakcha chhu exhibit the highest density.

Bacillariophyceae which constitute the second dominant group is represented by 19 genera of which *Cymbella, Fragilaria, Frustulia, Gomphonema, Melosira, Pinnularia, Rhabdonema* and *Navicula* are the prime compositions.

Myxophyceae represented by 4 genera in the present drainages exhibits highest abundance during winter, followed by monsoon and summer.

Of the four Chrysophycean genera, *Celloniella, Phaeoplaca and Synura* are mostly confined to higher gradients of the Tista drainage while *Hydrurus* to the Rangit drainage. The contribution towards total phytoplankton production of the overall drainages made by Xanthophyceae and Rhodophyceae each consisting of only one genus is comparatively low.

Information on zooplankton in running water is sparse because flowing water is unfavourable for zooplankton. Zooplankton populations are, on the whole, very poor in the main channels of a river (Dey, 1973) as evident in the present studies, although numbers can build up in the reduced flow during the dry season. However, the predominance of rotifera, a common feature of Assam waters (Dey, 1973, 1981) is also apparent in the Sikkim drainages in respect of generic composition in the order, Rotifera (7 genera) > Protozoa (4 genera) > Copepoda (3 genera) > Cladocera (2 genera) > and Ostracoda (1 genus).

The total zooplankton population of the two drainages under the present study during 1987 and 1988 is observed to be 1304 \(\text{ul}^{-1}\) contributing to only 3.42 % and 4.10 % of the total plankton yield in the Tista and the Rangit drainages respectively. Unlike phytoplankton, zooplankton abundance is recorded to be highest during monsoon \((513 \, \text{ul}^{-1})\), followed by summer \((435 \, \text{ul}^{-1})\) and then by winter \((356 \, \text{ul}^{-1})\) indicating their preference for warmer water showing positive correlation with temperature. A similar trend is also reported by Das and Srivastava (1956), Moitra and...
Protozoa comprising of 4 genera is recorded to be the most dominant group amongst the zooplankton community with highest abundance (558 ul⁻¹) in the two river systems of Sikkim. \textit{Centropyxis sp.} and \textit{Astramoeba sp.} are the dominant genera recorded.

Rotifera represented by 7 genera is the second dominant group (467 ul⁻¹) with \textit{Asplanchna sp.} followed by \textit{Brachionus sp.} as the dominant genera. Ostracoda closely follow rotifera with abundance of 222 ul⁻¹ in the present drainages under study. Cladocera and Copepoda each with 2 and 3 genera contributes least with 26 ul⁻¹ and 31 ul⁻¹ respectively to the zooplankton yield.

Interaction between phytoplankton and zooplankton have been the subject of several workers cited by Seenayya et al., (1971). Higher density of zooplankton during the phytoplankton minima exhibiting an indirect correlation (Das & Srivastava, 1956) is not observed during the present investigation. On the contrary, a positive correlation (Pahwa & Mehrotra, 1966) between them is observed in all the rivers investigated.

\textbf{ON FISH GEOGRAPHY}

The fish fauna of the drainages of Sikkim accounted in the records of the present investigation are apt to focus new lights on the general distribution pattern as well as on the regional distribution too. Primary freshwater forms constitute 97.87 \% of the fish population of Sikkim with the remaining 2.12 \% contributed by the peripheral groups. Incidentally, similar trend of fish geography have been reported from Barak drainages of Assam (Nath & Dey, 1986) and North East State of Meghalaya (Sen & Dey, 1984).

For brevity and better understanding the distribution trend of the drainages of Sikkim may be divided into Zone I (ZI) consisting of river Tista, Yumthang chhu, Bakcha chhu and Rimbi khola above 1000 m msl; Zone II (ZII) comprising of river Tista, Seti khola, Jali khola, Rani khola, Rin khola, Dik chhu, Rangpo khola, river Rangit and Kalej khola above 500 m to 1000 m msl and Zone III (ZIII) consisting of river Tista, Ghattay khola, Rangpo khola, Rishi khola, Roathak khola, river Rangit and Rangbhang khola 500 m and below. The region-wise pattern of distribution (Table 103) of 47 ichthyospecies (excluding \textit{Salmo trutta fario}, the exotic form) collected indicates that Zone III
is richest in its ichthyofauna composition with 40 spp. (85.10 %) followed by Zone II with 35 spp. (74.46 %) and Zone III with only 9 spp. (19.14 %) while there are more overlapping species of 61.70 % (29 spp.) between ZII and ZIII and only 12.76 % (6 spp.) amongst the three zones. Concomitantly, only 10.63 % (5 spp.) are restricted to ZII and 19.14 % (9 spp.) to ZIII. And significantly only one river in ZI, three in ZII and two in ZIII do contain these restricted species with the endemicity structure in the order, Rimbi khola (2 spp.) in ZI, river Tista (1 sp.), Rani khola (1 sp.) in ZII and river Rangit (1 sp.) and Rangbhang khola (1 sp.) in ZIII.

*Schizopyge progastus* are confined to ZII and ZIII while *Schizorhorax richardsonii* has established its distribution to all the three zones up to 1340 m msl.

Present investigation also exhibits that out of the total ichthyospecies of the Sikkim drainages, their extra-Indian distribution structure (Table 105) is in the order, Nepal (48.93 %) > Burma (31.91 %) > Bangladesh (27.63 %) > Pakistan (25.53 %) > Sri Lanka (10.63 5) and Malaysia (8.51 %). Furthermore, the fish composition of the drainages contain more of north Indian element (25 spp.) with decrease in distribution to southern India (14 spp.).

Endemic species, as evident from the analysis, are found more localized in the Eastern Himalayas as compared to Western one. As many as 13 spp. are endemic to Eastern Himalayas.

*Garra mcclelandi* & *G. mullya* of southern India have been recorded from this region which infers that Sikkim Himalaya is a part of peninsular shield.

The ichthyodenizens of the present drainages may be broadly divided into four categories based on their structural body modification (Dey, 1973) to adjust variable ecological conditions. These are:

**Category I. True hill stream forms:** The group includes fishes having specialized body modification to withstand the adverse environmental nature of the rheophilic abode. Species of the genera *Garra*, *Balitora*, *Glyptothorax*, *Euchilloglanis* & *Pseudecheneis* belong to this category.

**Category II. Semi-torrential form:** Fishes with weak body form and minimal body modification belong to this group and include the species of the genera *Crossocheilus*, *Noemacheilus*, *Acanthophthalmus* & *Barilius*.

**Category III. Migratory forms:** Well built body formed fishes and having capabilities to overcome
unfavourable ecological conditions of the torrents are grouped under this category. This group includes species of the genera *Anguilla, Schizopyge, Schizothorax, Semiplotus, Acrossocheilus* and *Tor*.

**Category IV. Plain water forms:** The fishes without any significant migratory habit or with low degree of body modification to prefer plain water habitat are included in this group. All but the species of the genera mentioned above, recorded belong to this category.

From the general trend of the fish species of Sikkim, it is interesting to note that major percentage (74.46 %) of fishes are having overlapping distribution (Table 104). Occurrence of endemic species are more (19.14 %) in Rangit drainage than in Tista drainage (6.38 %). In Rangit drainage, endemic forms like *Balitora brucei, N. beavani, N. carletoni, L. ribeirol ribeirol, L. ribeirol jorethangensis, G. conirostrae, G. sinense sikkimensis and Channa orientalis* are present. Curiously enough these species are absent in the Tista drainages which shelters only two endemic species namely *N. spilopterus & Acanthophthalmus pangia*.

Of 35 overlapping species, only 14 of them are widely distributed between the twin drainages whereas 21 are having restricted occurrence. Of 14 widely distributed species, 13 are restricted to Eastern Himalayas (Table 105) only confirming the rimfire type of distribution (Dey, 1973) of the rheophilic fishes along the Himalayan belt.

**ON FISHERIES PROPENSITY AND TREND**

The present investigation reveals that altogether there are twenty eight fish species of commercial importance distributed in the drainages of Sikkim. Accordingly, these rivers in respect of presence of their commercial ichthyospecies are found in the order, river Rangit (25 spp.) > Rangpo khola (22 spp.) > Rangbhang khola (20 spp.) > river Tista (16 spp.) > Kalej khola & Roathak khola (14 spp.) > Rani khola & Ghattay khola (12 spp.) > Rishi khola (11 spp.), Dik chhu (9 spp.) > Seti khola (6 spp.) > Jali khola and Rin khola (5 spp.) > Rimbi khola (4 spp.) > Yumthang chhu and Bakcha chhu (1 sp.). Such qualitative differences may be attributed largely due to the fluvial dynamics, physico-chemical conditions, potamoplankton populations and elevations of the rivers (Dey, 1973).
It is to be noted that maximum number of fish species (25) has been reported from river Rangit at lower gradients having discharge rate 34.43 - 180.72 m$^3$s$^{-1}$, velocity 0.53 - 1.17 ms$^{-1}$, DO 8.45 - 9.47 mg l$^{-1}$, FCO$_2$ 1.5 - 15.9 mg l$^{-1}$, TA 25 - 81 mg l$^{-1}$, pH 6.7 - 7.3, Transparency 39 - 89.28 cm, water temperature 14.7 - 21.5°C and potamoplankton 2076 ul$^{-1}$ whereas minimum fish species have been recorded from Yumthang chhu and Bakcha chhu.

On the basis of the presence of commercial ichthyospecies, their abundance, discharge rate and shore-line; altogether ten principal rivers (PR) have been identified which are arranged in order of their importance as river Rangit > Rangpo khola > Rangbhang khola > River Tista > Rani khola > Dik chhu > Bakcha chhu > Rimbi khola > Roathak khola > Kalej khola.

*Schizothorax richardsonii* (Gray), the snow trout is the single most dominant species present throughout the drainages of Sikkim up to an elevation of 1340 m msl. The species thus exhibits its wide range of temperature tolerance from 9.25 - 27°C. The highest density of *Schizothorax richardsonii* (Gray) has been recorded in Bakcha chhu, Rimbi khola and Dik chhu. The mean values of fluvial dynamics and physico-chemical parameters of Bakcha chhu where *Schizothorax richardsonii* has been exclusively established are: discharge rate 24.24 m$^3$s$^{-1}$, velocity 1.24 ms$^{-1}$, DO 9.69 mg l$^{-1}$, FCO$_2$ 1.3 mg l$^{-1}$, TA 41.3 mg l$^{-1}$, pH 6.85, Transparency 47.60 cm and water temperature 14.46°C.

The overall catch composition of ten principal rivers display majority of Carps over Catfishes. The trend analysis is, river Rangit: Carps (14 spp.) > Catfish (11 spp.); Rangpo khola: Carps (13 spp.) > Catfish (7 spp.); Rangbhang khola: Carps (12 spp.) > Catfish (8 spp.); river Tista: Carps (11 spp.) > Catfish (4 spp.); Dik chhu: Carps (5 spp.) > Catfish (2 spp.) > Kalej khola: Carps (8 spp.) > Catfish (2 spp.); Rani khola: Carps (10 spp.) Catfish (2 spp.) > Roathak khola: Carps (9 spp.) > Catfish (1 sp.) > Rimbi khola: Carps (2 spp.) & Catfish (2 spp.) > Bakcha chhu: carps (1 sp.).

It is also significant to note that amongst the Carps the species of the genus *Garra* (Hamilton) top the list in abundance next to *Schizothorax richardsonii* followed by the other genera in the order *Schizothorax > Garra > Schizopyge > Crossocheilus > Acrossocheilus > Barilius > Glyptothorax > Tor > Bagarius > Semiplotus & Labeo.
The migratory propensity of *Anguilla bengalensis* (Gray) reveals that this interesting catadromous species is found to migrate along the bank of river Rangit up to 500 m msl, 35 km away from the confluence of Tista and Rangit. The species generally prefers deep pools in larger rivers and as such are rarely caught. *Acrossocheilus hexagonolepis* (McClelland) is commonly available fish with wide distribution range from 240 to 745 m (msl) occurring in both the drainages. *Tor putitora* (Hamilton) or the golden mahseer has been observed to migrate up and enter the drainages within 240 to 525 m msl. Alongwith *Tor putitora* (Hamilton) other plainwater forms like *Bagarius bagarius* (Hamilton), *Labeo dero* (Hamilton), *L. pangusia* (Hamilton), *Semiplotus semiplotus* (McClelland) and *Clupisoma bhandarii sp. nov.* exhibit similar trend of migration propensity into Sikkim drainages with the onset of summer and migrate down to warmer water in plains during winter.

The relative growth of different body parts in *Schizothorax richardsonii* (Gray) studied from the twin drainages of Sikkim exhibits allometric growth. Correlation coefficients show corresponding growth of one part of the body with the growth of the other. Pre-anal distance shows fastest relative growth followed by pre-pelvic distance > pre-dorsal distance in accordance with the particulars purported in Table 13 having the length of both barbels showing minimum relative growth trend. The analysis of change in ratio index of each measurable characters (Table 13) as the fish grows in length reveals a steady increase in the present species. And the result happens to be in good agreement with the findings of Misra (1967), Iftekhar and Dwivedi (1977) and Das (1989). The differences between the extreme values of the ratio indices are not statistically significant (P > 0.05). The calculated length of the older fish in the earlier years of life are systematically lower than those of younger fish at same age (Carlander, 1977) as revealed in the present investigation.

The weight of the fish considered as the function of its growth (Gulland, 1977) is well established in the species under study through length-weight relationship amongst the populations. And in the present analysis \( W = cL^n \) is a better fit (Ricker, 1975) to express relationship between \( L \) & \( N \) than the hypothetical cube law. The value of exponent \( "n" \) in the parabolic equation has been found to lie between 1.97 and 31.5 (Hile, 1936; Martin, 1949). The change in the body form with increasing age often cause the coefficient of regression of logarithm of \( W \) on log of \( L \) to deviate substantially from the slope value of 3.0 (cube law) which is the characteristic of isometric growth (Allen, 1938) in fishes.
In *Schizothorax richardsonii* (Gray), the L-W relationship shows the slope value deviating marginally from the cube law in both male and female population (Figures 14 to 19), a trend also recorded in other Indian teleosts (Jhingran, 1959b; Rao & Rao, 1972; Pandey et al., 1974; Thakur & Das, 1974; Pathak, 1975; Sen, 1982; Roy, 1986, 1987 & Das, 1989).

The goodness of fit of the equation derived in the present investigation has been analyzed from the sample coefficient of correlation, and the significance is tested through t-test. The result shows that a strong correlation (P < 0.001) does exist between log W and log L in the species investigated.

The L-W relationship of the present species exhibits seasonal variation (Ricker, 1975) as they do not retain the same shape or body contour throughout the year. Marginal allometry (Tesch, 1968) with the value of “n” nearer to 3.0 has been recorded during winter in males (2.833) and during summer in females (3.124) of *Schizothorax richardsonii* (Gray). Distinct deviation of the slope value from the cube law has been recorded in the males and females of this species during the other seasons of the year investigated. The present observation is in good agreement with the marginal allometry recorded in *Crossocheilus latius latius* (Dey, 1984) and *Acrossocheilus hexagonolepis* (Dey, 1987) from the rheophillic drainages of N.E. India. Natural tangent value of the angle formed by regression line is very much nearer to the slope value (Dutta, 1974), justifying the use of angles to express the relationship between the two variables (Length and Weight) in fishes in general.

The coefficient of condition, an index of well being of fish, exhibits independent trend in the present species. Low value of coefficient of condition has been attributed to poor feeding activity (Varghese, 1973) or cessation of feeding (Carlander, 1977) or onset of spawning (Karamchandani et al., 1967; Desai, 1970) in the fishes appears plausible in *Schizothorax richardsonii* (Gray). Indeed, estimation of coefficient of condition in fishes from total body weight but excluding the internal organs (Clark, 1928) as also advocated by Das (1989) in *Tor putitora* (Hamilton) and *Tor tor* (Hamilton) from the Brahmaputra drainages of Assam deserves serious consideration.

*Schizothorax richardsonii* (Gray) has been established as sexually dimorphic. The breeding habits and limitation of food space along with other abiotic factors of the water bodies in which the present species maintains itself perhaps necessitate the maintenance of an economic ratio of the
number of males to the females. Sex ratio in the population of *Schizothorax richardsonii* (Gray) dwelling in the river systems of Sikkim has been studied and Chi-square is used to evaluate the abundance of sexes. The dominance of female over male, a common trend in fishes (Corington, 1946; MacDonald, 1948; Das, 1989) however is not discernable in the present species, where male marginally dominates over female with the ratio of 1.12 : 1.0. The relatively higher incidence of male over female may be attributed to more agility of female over male to evade capture (Alm, 1959). Besides other probable factors, the larger number of male than female in the sexed fishes may perhaps also be attributed to the overlapping number of the unsexed individuals accounted.

Fecundity defined as the potential number of matured eggs (yolked ova) that could be spawned during a breeding season (Lowe, 1955; McFadden et al., 1965; Bagenal, 1968; Marichamy, 1971; Baglin, 1982; Das, 1989) is a basic determinant of productivity in fishes. In *Schizothorax richardsonii* (Gray) the fecundity is found to vary from 1167 to 3653 in females having TL of 232 to 297 mm. The number of ova per gram ovary weight and fish weight is found between 101 to 292 and 11 and 12 respectively. Admittedly, the fecundity of *S. richardsonii* (Gray) is quite low in comparison to *Schizothorax plagiostomus* Heckel reported by Raizada (1982) from the river Beas in the Kulu district of Himachal Pradesh.

Regression analysis depicts a positive correlation between F and TL, F and BW and F and OW in the species. Although r-values depict differential correlation of F with the variables studied in the order, TL ($r = +0.715 \pm 0.028$) > BW ($r = +0.468 \pm 0.124$) and OW ($r = +0.135 \pm 0.011$), t-test reveals the correlation highly significant only in respect of TL ($P<0.01$) purporting the reliability of TL as a parameter in estimating the fecundity of the females of *Schizothorax richardsonii* (Gray).

GDSI is a good indicator of spawning frequency in fishes. Wide fluctuation of GDSI in a year (Qassim et al. 1961; Joseph, 1980; Das, 1989) as discerned in *S. richardsonii* (Gray) may be attributed to maturity factor. Two spawning periods have been reported in *S. plagiostomus* Heckel by Raizada (1982). The first is from mid April to mid June with peak in May and the second from mid July to mid September with peak in early August. In the context of such observation, the spawning period of *S. richardsonii* (Gray) in the drainages of Sikkim is found to be confined to the monsoon periods extending from June to October.
There has been a gradual decline of the fish population in the twin drainages of Sikkim. As opined by some experienced and professional fishermen of the state, the size, weight and the abundance of the fish as they used to catch in earlier days have now become a matter of remembrance. The highest growth of some of the important fishes observed during the present investigation are of meagre proportion namely Schizothorax richardsonii 1 kg, A. hexagonolepis 1.5 kg, Tor putitora 13 kg, Glyptothorax basnetti 0.75 kg and L. dero 0.75 kg. The present investigation further reveals that Tor putitora, Semiplotus semiplotus, Anguilla bengalensis, Clupisoma bhandarii, Balitora brucei and Acanthophthalmus pangia among others are now threatened. Some of the species like Glyptosternum maculatum, Glyptothorax striatus, Glyptothorax pectinopterus, Puntius clavatus, P. spinolosis, Tor mosal, Labeo dyocheilus, Barilius barna, Brachydanio rerio & Ctenops nobilis reported by earlier workers could not be collected during the present extensive survey program. This indicates that either these valuable species are wrongly reported or have already started becoming extinct from the Sikkim drainages. The conservation of the existing fisheries, therefore, is of prime importance in order to maintain the sustained population of the natural stocks in the drainages. This decline of the population can be attributed to the impact of various factors, notably, (a) soil erosion induced deforestation, (b) hydroelectric project activities along the banks of rivers Tista and Rangit leading to soil erosion/siltation as well as to restriction in the migration of fish, (c) illegal fishing through dynamiting and poisoning, (d) water pollution by both small and large scale industries especially, distillery, tannery, paper factory, cosmetic factory and mining, (e) sewage and pesticide run-off from agricultural fields and (f) over-exploitation of fishing due to increased human pressure. All these impediments made the fishes exposed to difficulties in sustenance.

In order that a population of fish can exist, it is necessary that they are supported with the law of minimum. And in such manoeuvre the ecological requisites for a species also must be congenial. Otherwise even a change in an ecological parameter may jeopardize the entire network making the habitat unsuitable for successful maintenance of a particular ichthyospecies. It is, therefore, imperative that all conditions necessary for the habitat management of the species are made available. The following measures are, therefore considered pertinent in the effective conservation and management of the riverine ecosystem especially to develop and enhance fisheries productivity of the state.
1. Stream shore improvement by planting suitable trees/shrubs to provide enough vegetation cover/tree canopy. Abundant riverside vegetation will help contribute food supply to fishes in the form of insect falling and also supply of leaf litter will convert detritus in the streams and provide food source for aquatic invertebrates. Concomitantly, soil erosion can also be controlled by this measure and mass mortality of the fish population experienced during monsoon flood will be checked at reasonable proportion.

2. Diversion of stream course by construction of hydroelectric dams and weirs for irrigation purpose, results loss in volume of water in the natural course, changes the natural habitat, spawning and breeding grounds and cause obstruction to fish migration. Hydropower development and irrigation project schemes should address all these environmental adverses through judicious planning and properly designed structures like fish-ladders should be incorporated to provide free passage of migratory fishes.

3. Pollution control measures should be taken up and the affluent should be pre-treated and made to safe tolerance level before they are discharged into the river system.

4. Wanton killing of fishes by illegal and mass destructive methods like dynamiting and poisoning should be strictly prohibited by enforcing proper legislation, conservation policies and implementation of Fisheries Acts. It is of particular concern in the preparation and passage of such legislation relative to wildlife and fish resources to prevent the elimination of the species due to human activities, to ensure that their populations do not decline below self-perpetuating levels, and to preserve representations of all such natural species population for future generations. Water resource sharing policies with adjoining states especially to fisheries development may perhaps be another pragmatic proposition.

5. The water resources of the rivers Tista and Rangit should be harnessed at optimum limit for fishery development.

Artificial propagation techniques of some of the commercially important species like Schizothorax richardsonii, S. progastus, A. hexagonolepis, Tor putitora, L. dero, Clupisoma bhandarii, Semiplatus semiplatus and Anguilla bengalensis should be taken up to replenish declining population. And in this endeavour, certain rivers have been identified suitable for the breeding of respective fish species notably, (a) Bakcha chhu, Dik chhu and Rimbi khola for S. richardsonii, (b) River Tista at Singtam, Rani khola, Rangpo khola, Kanaka chhu, Dik chhu, river Rangit and Rangbhang khola for S. progastus, (c) River Tista, Rani khola, Rangpo khola, river Rangit, Rangbhang khola, Roathak khola and Kalej khola for A. hexagonolepis, (d) River Tista, Rangpo
khola, river Rangit, Rangbhang khola and Kalej khola for *T. putitora*, (e) River Tista, Rangpo khola, river Rangit and Rangbhang khola for *C. bhandarii* and (f) Rangpo khola, river Rangit and Rangbhang khola for *S. semiplotus*.

The twin drainages of Sikkim harbour one of the most popular game fish, *Tor putitora*. Besides, *S. richardsonii, S. progastus, A. hexagonolepis, Glyptothorax spp., B. bagarius, and C. bhandarii* are the common sport fish of the state. This small picturesque mountainous state has already started attracting tourists, both domestic and foreign. Once the identified fishes are allowed to flourish well in Sikkim rivers, it will bring the state on anglers’ map of the country and will soon draw the attention of sizeable concentration of tourists. This proposition in turn will help increase revenue earning prospect of the state and formation of a state anglers’ association will contribute a great deal in encouraging and organizing such activities.

In fine, it may be inferred that the empirical treatise purported in the present communications will help achieve a blue revolution in this Himalayan state of the country in no time if the results and recommendations are judiciously explored and executed with rigour and subtlety.