SUMMARY

All inland water bodies provide abode and shelter to mosquitoes, which are the vector parasite of disease, such as malaria, filaria and meningitis etc. The incidence of the mosquito born diseases indicates that existing chemical methods of vector control are insufficient. The use of D.D.T. and other chemicals are effective against the temporary breeding places of mosquitoes, such as small pieces of stagnant water areas, drainages, pit holes etc. These chemicals do not produce any effect in preventing the breeding of mosquitoes in permanent pieces of water areas in the inland water of rural areas and extensive marshes along the coastal districts. Even in the cities and towns drinking water reservoirs, wells, garden tanks, swimming pools etc. can not be spoiled by poisonous chemicals. The use of insecticides as agents for control of insects and other pests gained momentum around the mid twentieth century, but by the seventies their ill effects on human system became apparent.

The biological control, comparatively of remoter origin, is now recognised as a potent tool for the check on insect population without any harmful effect on the human system. Predacity on mosquitoes by larvivorous predators is one of the most economic, effective and lasting antimosquito measures.
The main larvivorous fishes which are regarded as efficient in mosquito control are *Gambusia affinis*, *Tilapia mossambica*, and *Poecilia reticulata* are the exotic fishes and the indigenous mosquito fishes are *Apolocheilus panchax*, *A. lineatus*, *A. blochii*, *Macropodus cupanus*, *Oryzias malastigma*, *Puntius ticto*, *Ambasis ranga*, *Habroda daniconius*, *Danio malabaricus*, *Eomus barbatus*, *E. danrica*, *Chela bacala* and the fry and fingerlings of *Channa punctatus*, *Orypinus carpio* and *Notopterus notopterus*.

Bay (1973) stated that the indiscriminate release of exotic fishes into the aquatic environment can lead to their monopolization of certain habitat and threaten the survival of organisms other than mosquito larvae. Menon and Rajgopalan (1977) reported that the small scale field trial in wells by using *Gambusia affinis*, *Poecilia reticulata*, *Apolocheilus blochii* and *Oryzias melastigma* showed that the indigenous fishes *Apolocheilus blochii* and *Oryzias malastigma* were more efficient than *Gambusia affinis* in controlling mosquito breeding, as they survived better and showed higher toleration for pollution, salinity and temperature. Regarding the possibilities of indigenous fishes for use in mosquito control, an intensive survey was made in aquatic habitats and studies were made on their larvicidal efficiency. It has been observed that the malaria is much prevalent in the rural area. In order to control the spread of the disease, it is suggested that the fish culture of indigenous larvivorous fishes be introduced in the inland waters of the rural area for controlling the mosquito population.
It was with this background that the present investigations were undertaken to study biology and ecology of larvivorous fishes. For this purpose, four larvivorous fishes *Habroda daniconius*, *Danio malabaricus*, *Ambassis ranga* and *Channa punctatus* have been selected for biological and ecological study in the water of Sagar lake.

Sagar lake is perennial water body situated in the heart of Sagar city at an altitude of 517 meters above MSL, at the latitude of 23°50'N and longitude of 78°45'E. The present area of the lake is about 82 hectares. The lake is eutrophic and the littoral zone of the lake is heavily infested with macrovegetation. The lake is surrounded by a number of ghats and by human settlements.

For the present investigation two stations were selected and both are littoral zones. The physico-chemical and biological parameters of the lake water were studied on monthly basis. For this purpose, water samples were collected and analysed fortnightly. At the same time, zooplanktons and larvivorous fishes were collected and preserved in 5% formaline for the study of food and feeding habits and reproductive cycle of these fishes.

The following physico-chemical parameters were taken into account to study the monthly and seasonal variation of the lake:

1. Air temperature
2. Water temperature
3. Secchi transparency
4. pH
5. Specific conductivity
6. Total dissolved solids (T.D.S.)
7. Carbonate alkalinity
8. Bicarbonate alkalinity
9. Total carbon-dioxide
10. Chloride
11. Calcium hardness
12. Total hardness
13. Dissolved Oxygen (D.O.)

The salient features of the present investigation can be enumerated as follows:

1. The climate of Sagar is generally pleasant and salubrious, and can be divided into three seasons viz – winter season from November to February, Summer season from March to June and Rainy season from July to October. Temperature and rainfall during November 1981 to October 1982 were recorded as minimum temperature ranged between 12.4°C and 25.3°C, maximum temperature ranged between 23.2°C and 38.1°C. The maximum rainfall 1065 mms was recorded in the month of August and minimum 0.5 mms in March.

2. During the present study the air temperature ranged from 23.5°C to 37.0°C, minimum was recorded in January and maximum in May.
3. Water temperature fluctuated between the minimum of 17.5°C in January and maximum of 29.0°C in April. Temperature shows direct effect on the seasonal variation of aquatic inhibitors. The rate of biochemical and biological reactions enhanced at the high temperature.

4. The secchi transparency varied from 15 cm to 54 cm. Minimum and maximum value was recorded in June and September respectively. Secchi transparency is inversely correlated with water temperature, pH and chloride.

5. Sagar lake is alkaline in nature. During the present investigation pH ranged from 7.5 in February to 9.4 in April. Seasonally the higher pH value was recorded during summer than in rainy and winter season. pH shows positive relation with water temperature and carbonate alkalinity, and negative relation with secchi transparency and bicarbonate alkalinity.

6. Specific conductivity showed monthly variation, its maximum value was noted in July as 630 micro mhos/cm and minimum of 224 micro mhos/cm in November. Seasonally highest value of specific conductivity was obtained in summer and lowest in winter season. Specific conductivity is positively related with water temperature, total dissolved solids and chloride and negatively related with dissolved oxygen.
7. Total dissolved solids varied from minimum of 116.2 mg/l to maximum of 403.2 mg/l in the month of September and July respectively.

8. Carbonate alkalinity varied from 12 mg/l to 48 mg/l. Minimum value was obtained in the month of October and maximum in April.

9. During the present observation bicarbonate alkalinity showed wide range of fluctuation varying from 44 mg/l to 138 mg/l. The highest value was recorded in July and lowest in November.

10. Seasonally highest value of bicarbonate was noted during rainy season and lowest in winter, whereas maximum value of carbonate alkalinity was found during winter and minimum in rainy season.

11. Free carbon dioxide was absent throughout the study period. It may, perhaps, be owing to its complete consumption by autotrophs.

12. Total carbon dioxide varied from the minimum of 52.80 mg/l in the month of November and maximum of 135.52 mg/l in July.

13. Carbonate alkalinity, bicarbonate alkalinity and total carbon dioxide shows inter-relationship. Bicarbonate alkalinity and total carbon dioxide are found to have positive relation, whereas carbonate alkalinity and bicarbonate alkalinity are inversely related with each other.
14. Chloride contents ranged from 24 mg/l to 53 mg/l. Its minimum value was observed in September and maximum in May. Seasonally highest chloride concentration was noted during summer and lowest in rainy season. Chloride content shows positive relation with temperature, conductivity, total hardness and total dissolved solids.

15. The value of calcium hardness fluctuated from 23.2 mg/l to 46.5 mg/l. The minimum value was recorded in the month of April and maximum in January. Seasonally the highest value of calcium hardness was observed during the winter season and its lowest value was noted in summer season.

16. Total hardness varied from the minimum of 98 mg/l in November to maximum of 146 mg/l in June. Highest value of total hardness was observed in summer and lowest in winter season. Total hardness shows positive relation with chloride and negative relation with dissolved oxygen.

17. Dissolved oxygen was widely fluctuated from the minimum of 4.4 mg/l in the month of May to maximum of 14.2 mg/l in the month of January. Present observation indicated that in summer the value of dissolved oxygen remained low and in winter it was higher. Higher value of dissolved oxygen during winter was due to more solubility of oxygen at low temperature. Dissolved oxygen shows negative relationship with water temperature, specific conductivity and chloride and positive relationship with percentage oxygen saturation and secchi transparency.
18. The percentage of oxygen saturation varied from 50.34% to 147.52%. The minimum value was recorded in May and maximum in December.

19. The zooplankton component was mainly comprised of four major groups:

   a. Protozoa.
   b. Rotifera.
   c. Cladocera.
   d. Copepoda.

   The total zooplankton density ranged from 300 organisms l$^{-1}$ to 3065 organisms l$^{-1}$. The maximum number of zooplanktons were observed in the month of July and minimum in March. Seasonally highest density of zooplankton was recorded in rainy season and lowest in summer season. Zooplankton was mainly represented by 4 species of protozoa, 26 species of rotifera, 7 species of cladocera, 2 species of copepoda and nauplii larvae.

20. The contribution of protozoa in total zooplankton population was very less and represented only by Arcella, Difflugia and Centropyxis.

21. Rotifers dominated over all the zooplankton groups and were represented by maximum number of species and genera. Two peaks of rotifers were observed first in July and second in February. Certain forms of rotifers like
Brachionus, Keratella and Anureopsis were observed throughout the year, which may be considered as indicator of eutrophication.

22. The cladoceran population was mainly dominated by Daphnia, Moina and Bosmina. The group cladocera showed two peaks, one in July and other in November.

23. The group copepoda was represented by Cyclops and Nauplii larvae. Diaptomus were rarely seen. The contribution of copepods in total zooplankton was always second to the rotifers. The main peak of copepods was noted in July.

24. Zooplankton shows positive relationship with secchi transparency and dissolved oxygen and negative relationship with water temperature and pH. Zooplanktons do not show any distinct relation with chloride.

The biological studies are subjected to investigate the habit and habitat, food and feeding habits and reproductive cycle of the larvivorous fishes. These are given below:

1. Larvivorous fishes Rasbora daniconius, Danio malabaricus, Ambasis ranga and young once of Channa punctatus are small, hardy warm water, surface or column feeders. These fishes are mostly found to live in the shallow water of littoral zone of the lake having abundant growth of macrophytes. Adults of Channa punctatus are bottom feeder and predatory in habit.
2. These larvivorous fishes mostly preferred animal food matter in their diet, such as zooplankton, crustaceans, insects and their larvae, fish eggs and larvae and chironomid larvae. Plant matter as their food was observed in rare instance.

3. Percentage of main food items of *Rasbora daniconius* was observed as zooplankton ranging from 21.7% in March to 64.4% in July. Insects and their larvae 28.0% in June to 43.0% in April, Crustaceans 2.8% in April to 13.4% in November. In addition to this, phytoplankton was found in very less proportion in the gut contents of the fish.

4. Food items of *Danio malabaricus* were observed similar to those of the *Rasbora daniconius*. Zooplankton ranged from 22.7% in March to 55.7% in July, insects and their larvae 25.2% in August to 40.3% in February, crustaceans 4.8% in May to 20.1% in August. Phytoplankton was rarely observed and constituted insignificant percentage in the diet of *Danio malabaricus*.

5. In *Ambassis ranga*, insects and their larvae formed the main food item varying from 40.1% in August to 60.2% in April. The next preferred food item was crustaceans ranging from 16.3% in April to 31.3% in August and zooplankton varied from 3.0% in April to 21.6% in July. Fish eggs and larvae, chironomid larvae and miscellaneous food items were also found but in very less proportion.
6. The percentage of main food items of *Channa punctatus* encountered as insects and their larvae which ranged from 25.3% to 46.8%, minimum in September and maximum in May. Crustaceans varied from 17.7% in December to 35.4% in September, zooplankton ranged from minimum of 3% in March to maximum of 29.3% in June. In addition to this food items, fish, fish eggs and larvae were also observed in rare instance varying from 0.2% in March to 9.4% in September. Chironomid larvae and miscellaneous food items were also encountered in the diet of *Channa punctatus*.

7. In *Rasbora daniconius* and *Danio malabaricus* two distinct peak periods of intensive feeding were observed first from February to May and second from mid September to November.

8. In *Ambassis ranga*, peak periods of active feeding were recorded in the month of November-December and from April to June.

9. During the present investigation, *Channa punctatus* showed either active or moderate feeding condition throughout the year, poor feeding was generally recorded in mature fishes during the spawning period i.e. from May to October.

10. The quality and quantity of food consumed, was influenced by physical factors like temperature and rainfall and biological factors like gonad maturity and spawning. Gut contents of larvivorous fishes showed almost a close similarity with the food items available in the environment.
11. Present investigations indicate that the larvivorous fishes feed actively during the post-spawning i.e. after the spawning and in pre-spawning period. The intensive feeding during the post-spawning period may be trying to recovery of the fish weight lost due to the spawning and in pre-spawning period it may be required for the building up of gonads to reach the final stage of maturity. The poor feeding during the spawning period was due to the peak maturity of gonads and spawning, during that time enlarge ovary exerts pressure on the alimentary canal, thereby preventing the passage of food through alimentary canal.

12. Poor and moderate feeding in winter season was recorded due to the lowering of water temperature. At low temperature fishes became less active for hunting its pray.

13. On the basis of general appearance of gonads, their colour, shape, size and gonad volume during different months of the year, the reproductive cycle of larvivorous fishes *Rasbora daniconius*, *Danio malabaricus*, *Ambassis ranga* and *Channa punctatus* have been divided into the following periods:

*Rasbora daniconius*:

- Post-spawning period - October to December
- Pre-spawning period - January to March
- Spawning period - April to September
Danio malabaricus:
Post-spawning period - September to December
Pre-spawning period - January to March
Spawning period - April to August

Ambassis ranga:
Post-spawning period - October to November
Pre-spawning period - December to January
First spawning period - February to March
Preparatory period - April to June
Second spawning period - July to September

Channa punctatus:
Post-spawning period - November to February
Pre-spawning period - March to mid April
First spawning period - Mid April to May
Preparatory period - June to mid July
Second spawning period - Mid July to October

14. The reproductive cycle of the fishes under present study has also statistically assessed on the basis of size distribution and relative number of ova present in the ovary during different months of the year. Such a study is found to be helpful in understanding the seasonal changes of the gonads.
15. In all larvivorous fishes, maturity of gonads advanced successively from April to September and was influenced by some environmental factors like temperature, rainfall, secchi transparency, pH, dissolved oxygen and total alkalinity.

16. Increasing of water temperature accelerated the maturity of gonads. pH decreased with the advanced maturity stages. Increased value of secchi transparency accelerated the spawning phase of maturity from June to September. Dissolved oxygen widely fluctuated with the gonad maturation. Total alkalinity increased with the increasing of maturation of gonads from June to July.

17. There is no sexual dimorphism in *Rasbora daniconius*, *Danio malabaricus* and *Ambasis ranga*. In male *Channa punctatus* the distinguishing mark is the presence of black pin head dots against the bloches in the corresponding part of the females.

18. These larvivorous fishes attain maturity within a year like the other minor carps.

19. *Rasbora daniconius* and *Danio malabaricus* spawn once a year, whereas *Ambasis ranga* and *Channa punctatus* spawn twice a year. Spawning of *R. daniconius* and *D. malabaricus* occurred from late June to September. In *A. ranga*, first spawning took place from February to March, whereas second spawning occurred from July to mid September.
In *G. punctatus* first spawning occurred from mid April to May, whereas second spawning commenced from mid July and extends till October.

20. These larvivorous fishes normally breed during heavy rainfall, in shallow confined water having abundant macrovegetation. *Rasbora daniconius* and *Danio malabaricus* generally spawn at the first flood of monsoon, whereas *Ambasis ranga* and *Channa punctatus* spawn in subsequent floods.

21. The physico-chemical factors influencing the natural spawning of these fishes were the reduction in water temperature, increasing of dissolved oxygen and secchi transparency, lowering of pH, total alkalinity and chloride.

22. The physico-chemical condition of lake water at the spawning of these fishes were recorded as water temperature 23.5°C - 26.8°C, pH 7.6-8.0, secchi transparency 20.5 cm - 42.3 cm. and dissolved oxygen 6.4 mg l⁻¹ - 8.2 mg l⁻¹.

23. Fertilized eggs of *Rasbora daniconius*, *Danio malabaricus* and *Ambasis ranga* are rounded, demersal and transparent yellowish in colour, with diameter of 1.0 mm, 0.96 mm and 0.78 mm respectively. The eggs are adhesive attached to the leaves of submerged aquatic plants. The fertilized eggs of *Channa punctatus* are rounded, buoyant, free, non-adhesive and transparent, straw yellow in colour, with diameter of 1.2 mm.
24. The newly hatched larvae are sticking to the submerged leaves and roots of aquatic plants. Fry feed on planktonic crustaceans and rotifers. The fingerlings of *G. punctatus* feed on mosquito larvae and pupae whereas *M. daniconius*, *D. malabaricus* and *A. ranga* are larvivorous in their adult stage.
### LEGEND

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>PHYSICO-CHEMICAL PARAMETERS</th>
<th>UNIT</th>
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<tbody>
<tr>
<td>1.</td>
<td>AIR TEMPERATURE</td>
<td>°C</td>
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<tr>
<td>2.</td>
<td>WATER TEMPERATURE</td>
<td>°C</td>
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<tr>
<td>3.</td>
<td>SECCHI TRANSPARENCY</td>
<td>Cm</td>
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<tr>
<td>4.</td>
<td>HYDROGEN ION CONCENTRATION (pH)</td>
<td>UNIT</td>
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<tr>
<td>5.</td>
<td>CONDUCTIVITY</td>
<td>micro mhos/cm</td>
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<tr>
<td>6.</td>
<td>TOTAL DISSOLVED SOLIDS</td>
<td>mg/l</td>
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<tr>
<td>7.</td>
<td>CARBONATE ALKALINITY</td>
<td>mg/l</td>
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<td>8.</td>
<td>BICARBONATE ALKALINITY</td>
<td>mg/l</td>
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<td>9.</td>
<td>TOTAL CARBONDIOXIDE</td>
<td>mg/l</td>
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<tr>
<td>10.</td>
<td>CHLORIDE</td>
<td>mg/l</td>
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<td>11.</td>
<td>CALCIUM HARDNESS</td>
<td>mg/l</td>
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<td>12.</td>
<td>TOTAL HARDNESS</td>
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<td>13.</td>
<td>DISSOLVED OXYGEN</td>
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<td>14.</td>
<td>PERCENTAGE OXYGEN SATURATION</td>
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<table>
<thead>
<tr>
<th>S.NO.</th>
<th>ZOOPLANKTON (organisms l⁻¹)</th>
<th>COMMON SCALE FOR STATION A AND B IN ALL SEASONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>TOTAL ZOOPLANKTON</td>
<td>1 cm = 750</td>
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<tr>
<td>2.</td>
<td>PROTOZOA</td>
<td>1 cm = 20</td>
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<tr>
<td>3.</td>
<td>ROTIFERA</td>
<td>1 cm = 380</td>
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<td>4.</td>
<td>CLADOCERA</td>
<td>1 cm = 42</td>
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<tr>
<td>5.</td>
<td>COPEPODA</td>
<td>1 cm = 320</td>
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</tbody>
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**LEGEND**

**FISH**

A - **Rasbora daniconius**
B - **Danio Malabaricus**
C - **Ambasis Ranga**
D - **Channa punctatus**

**MONTHS**

N - November
D - December
J - January
F - February
M - March
A - April
M - May
J - June
J - July
A - August
S - September
O - October

**SCALE**

Common scale for fish A, B, C and D

1 cm = 50% (Rating)
FIG:BV-3: BIRD'S EYE VIEW OF MONTHLY VARIATION IN THE CONDITION OF FEED IN RASBORA DANICONIUS, DANIO MALABARICUS, AMBASIS RANGA AND CHANNA PUNCTATUS.
### LEGEND

<table>
<thead>
<tr>
<th></th>
<th>FISH</th>
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<tbody>
<tr>
<td>A</td>
<td><strong>RASBORA DANICONIUS</strong></td>
</tr>
<tr>
<td>B</td>
<td><strong>DANIO MALABARICUS</strong></td>
</tr>
<tr>
<td>C</td>
<td><strong>AMBASIS RANGA</strong></td>
</tr>
<tr>
<td>D</td>
<td><strong>CHANNA PUNCTATUS</strong></td>
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### FOOD ITEMS

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>I</td>
<td><strong>PHYTOPLANKTONS</strong></td>
</tr>
<tr>
<td>II</td>
<td><strong>ZOOPLANKTONS</strong></td>
</tr>
<tr>
<td>III</td>
<td><strong>OTHER CRUSTACEANS</strong></td>
</tr>
<tr>
<td>IV</td>
<td><strong>INSECTS AND THEIR LARVAE</strong></td>
</tr>
<tr>
<td>V</td>
<td><strong>FISH, FISH EGGS AND LARVAE</strong></td>
</tr>
<tr>
<td>VI</td>
<td><strong>CHIRONOMID LARVAE</strong></td>
</tr>
<tr>
<td>VII</td>
<td><strong>HIGHER AQUATIC PLANTS</strong></td>
</tr>
<tr>
<td>VIII</td>
<td><strong>MISCELLANEOUS</strong></td>
</tr>
</tbody>
</table>

### SCALE

Common scale for fish A, B, C and D:

1% of each food item = 3°36'.
FIG: BIRD'S EYE VIEW OF PERCENTAGE COMPOSITION OF DIFFERENT FOOD ITEMS (ANNUAL MEAN) OF RASBORA DANICONIUS, DANIO MALABARICUS, AMBASIS RANGA AND CHANNA PUNCTATUS.