11. SUMMARY

1. Investigations on some aspects of environment induced modulations in the bimodal respiration, haematology, biochemistry and immunology of air-breathing bubble nest builder, *Trichogaster pectoralis* was undertaken adopting standard methods.

2. The fish is excellently adapted for living on land for brief period. Survival on land is limited by the humidity of the environment.

3. At 30 -35% RH the mean survival out of water is 2.82 hr (10.82 -18.50g). The regression equation computed for the fish weight vs survival time is:
   \[ Y = 28.68 - 1.835x \quad (r=0.45; \ P = \text{NS}) \]

4. At 70-75% RH, the mean survival rate is 4.36hr (11.40-18.50g). Computation of the regression equation yielded:
   \[ Y = 31.61 - 1.559x \quad (r=0.915; \ P > 0.05) \]

5. Prolonged terrestrial living was possible at higher humidity. 90-95% RH extended the survival of fish up to 6hr. The statistical calculation gave the regression equation:
   \[ Y = 28.61 - 1.297x \quad (r=0.915; \ P > 0.05) \]

6. The mean blood water thickness barrier recorded for the fish weight ranging 5.0 -14.7g was 2.44 μm. The fish weight vs blood water thickness barrier given the regression equation:
   \[ Y = 9.79 - 0.707x \quad (r=0.949; \ P < 0.01) \]

7. Temperature influences the asphyxiation in *Trichogaster*. Higher the temperature, lower is the asphyxiation time.

8. Temperature increases the ABF. At 20°C, the mean ABF/hr is 24. But at 40°C, the mean ABF/hr increased to 38.

9. Presence of labyrinthine organ is an asset to *Trichogaster*. The labyrinthine organ store O₂ rich water for respiration and terrestrial living. Amputation of the
labyrinthine organ increases the ABF/hr. Normal *Trichogaster* surfaces ABF/hr at 20 °C. Removal of both the labyrinthine organs increased the ABF to 35. Sham-operated *Trichogaster* increased the ABF to 32.

10. The fish adopts limited aquatic respiration. Fish with a mean weight of 16.27 g extracted 79.62 mlO₂ kg⁻¹ hr⁻¹ from water. The poor capacity of the gills are attributed to be due to the presence of reduced gill filaments.

11. Air-breathing is vital for the survival of *Trichogaster*. Labyrinthine organ and the associated structures are increasingly used at times of stress to consume more O₂ from air. The fish ranging in weight 11.40 – 20.81 g obtained 128.52 mlO₂ kg⁻¹ hr⁻¹ from air.

12. *Trichogaster* is a bimodally breathing obligatory air-breathing fish. Under laboratory conditions at 28°C, the fish extracted more quantity of O₂ from air (64%). The gills contributed only to the tune of about 36% only to the total O₂ uptake.

13. Low temperature (23°C) stress increased the role of labyrinthine organ in extracting more O₂ from the air (69%). Similarly, higher temperature stress (33°C) significantly increased the contribution (74%) of air-breathing organ to the total gas exchange.

14. Air-exposure increased the bimodal respiration. Prolonged (4 hr) air exposure stress increased the aquatic (+17.53%) and aerial (+14.4%) respiration.

15. 2 hr hypoxic exposure (2.5 mlO₂ L⁻¹) decreased the role of gills (-19.31%). Greater depression (-32.28%) was observed at 4 hr hypoxic treatment. Labyrinthine organ plays a very important role in extracting more O₂ from the air in the hypoxic stress.
16. Normoxic submergence (7.2 mlO₂ l⁻¹) stressed the gills and labyrinthine organ. An adaptive shift in the increased respiratory metabolism was recorded.

17. The steel factory effluent was rich in BOD and COD. The DO (3.0-3.5 mg/l) was low. Iron (10-15 mg/l) content was high.

18. 1,2 and 5% steel factory effluents were sublethal concentrations to *Trichogaster*. Prolonged survival was observed in these concentrations at all times of exposure.

19. Branchial respiration dropped in 1% SFEE. Chronic (15 d) exposure further depressed (-16.18%) the role of gills. Prolonged (30 d)1% SFEE further lowered (-17.99%) the role of gills. Concomitantly, air-breathing increased in the acute (+6.81%), 15 d chronic (+13.32%) and 30 d chronic (+17.11%) treatment.

20. Higher (2% SFEE) effluent exposure lowered the contributions of gills in the acute (-15.65%), 15 d chronic (-13.58%) and 30 d chronic (-15.13%) treatment. An increased participation of the air breathing organ was observed.

21. 5% SFEE depressed the role of gills in the 48 hr (-33.45%), 15 d (-17.45%) and 30 d (-28.83%) period. A greater contribution of labyrinthine organ was observed at all times of effluent stress.

22. Bimodal respiration was strongly rhythmic in *Trichogaster*. The fish displayed a single peak period of maximum total O₂ uptake at 0000 hr. The minimum O₂ consumption was recorded at 1800 hr. This rhythmic pattern was persistent for the fishes weighing 3.5 -27.3 g on all days.

23. Environmental pollution (1% SFEE) totally eliminated the peak period. Acute and prolonged treatment disrupted the respiratory rhythm. Environmental stress
stimulated a new peak period at 1200hr. Air-breathing continue to be the dominant mode for O₂ uptake.

24. 2% SFEE continue to interfere in the respiratory rhythm. The peak period was eliminated. Instead, new peaks at 0900 and 1800hr emerged after effluent stress.

25. Higher concentration (5%) of the effluent never restored the original peak period. 3 new peaks (at 1200, 1500 and 2100 hr) appeared. Labyrinthine organs continued to play an important role in the respiratory processes.

26. TEC, Hb, Ht, O₂ capacity and standard bicarbonates were higher in Trichogaster. The increased blood parameters reflect the adaptations to obligatory air-breathing habit and habitats with poor O₂ content.

27. The fish modulated the blood parameters to overcome the air-exposure stresses. Prolonged air exposure increased the TEC, Hb, Ht, O₂ capacity and standard bicarbonates. Air-exposure stress induced compensatory erythropoiesis to make up the respiratory deficiencies in order to maintain the constancy of the internal environment.

28. Hypoxic treatment increased the blood parameters.

29. Forcible normoxic submergence stimulated the TEC, Hb, Ht, O₂ capacity and standard bicarbonates.

30. Air exposure, submergence and hypoxic treatment triggered the increase of WBC and DLC. Leucocytosis was severe. Neutrophilia, lymphocytosis, monocytosis and granulocytosis was evident at all times of stress.

31. Effluent exposure (1,2 and 5%) induced adaptive shiftings in the TEC, Hb, Ht, O₂ capacity and standard bicarbonates in the acute and chronic treatments.
32. Steel factory effluent targeted DLC. Dose depended increases were recorded for WBC, lymphocytes, neutrophils, smudged cells, coarse granulocytes and unidentified cells at all times of exposure.

33. Air exposure, submergence and hypoxic stresses stimulated depletions of carbohydrates and glycogen content in the gills, labyrinthine organ, liver and dorsal muscle.

34. Significant accumulation of total FAA and total proteins were observed for air exposure, submergence and hypoxic stresses in the vital organs.

35. Respiratory organs (gill and ABO) and non-respiratory organs (dorsal muscle and liver) were increasingly anaerobic. This is evident from the lowering of the mitochondrial enzyme SDH and glycolytic enzyme LDH at all times of stress.

36. 1% effluent exposure rapidly induced glycogenolysis in the gill, ABO, liver and muscle.

37. Glycogenolysis, anaerobic oxidation and accumulation of FAA and proteins were observed at 2% effluent treatment.

38. The organs continue to be anaerobic at 5% exposure. FAA and proteins increased significantly to ward off pollutant stresses.

39. Physical stresses (air exposure, submergence and hypoxic) decreased the Na\(^+\)K\(^+\)ATPase and Mg\(^{2+}\)ATPase contents of gills and labyrinthine organ.

40. Alkaline phosphatase and acid phosphatase were increasingly secreted as a response to stressful conditions in the gills and labyrinthine organs.

41. Effluent exposure rapidly depleted Na\(^+\)K\(^+\)ATPase and Mg\(^{2+}\)ATPase contents of gills and labyrinthine organs.
42. Alkaline phosphatase and acid phosphatase were increasingly secreted to overcome the stresses of the effluent.

43. Statistically significant accumulations were recorded in lysozyme content of spleen, kidney, plasma and mucus during physical stresses.

44. Serum agglutination activity was significantly lowered at all times of physical stresses.

45. Hyperglycemic condition in the plasma was recorded for the physical stresses.

46. 5% SFEE accumulated the lysozyme content in the spleen, kidney, plasma and mucus.

47. SFEE decreased the serum agglutination activity significantly. Greater accumulation of plasma glucose indicated the involvement of stress triggered hormonal secretions.

In conclusion it can be stated that *Trichogaster pectoralis* is excellently adapted for obligatory air-breathing habit. The fish modulated the labyrinthine organ skillfully to overcome the stresses of the environment. Adaptive shifts in the bimodal respiration, haematology, biochemistry and immunology were recorded for various physical and pollutional stresses. The fish can be cultured even in waters with little oxygen content.