

**STUDIES ON SOME ASPECTS OF THE
BIOLOGY OF *LABEO PANGUSIA* AND *LABEO DERO*
FROM THE NORTH-EASTERN INDIA**

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Thesis submitted in fulfilment of the requirements of the Degree of
DOCTOR OF PHILOSOPHY

to



**THE NORTH-EASTERN HILL UNIVERSITY
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We certify that the thesis entitled "Studies on some aspects of the Biology of Labeo pangusia and Labeo dero from the North-Eastern India", submitted by Mr. SHYAMAPRASAD BISWAS for the Degree of DOCTOR OF PHILOSOPHY of the North-Eastern Hill University, Shillong (India), embodies the record of original investigations carried out under our joint supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of a Ph.D. degree. This work has not been submitted for any degree of any other University.


(DR. K. CHATTERJEE)


(DR. S.A.K. NASAR)

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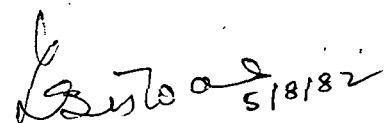
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C O N T E N T S

	<u>PAGE</u>
ACKNOWLEDGEMENTS	
LIST OF TABLES	i
LIST OF FIGURES	iii
INTRODUCTION	1
Review of Literature	10
Description of the Fishes	20
Taxonomic Status	20
Diagnostic Characters	21
Synonyms	23
Vernacular Names	28
Geographical Distribution	28
MATERIALS AND METHODS	30
RESULTS	45
Morphometric and Meristic Counts	45
Population Structure	55
Length-weight Relationships	57
Condition Factor	62
Food and Feeding Habits	63
Maturity and Spawning	83
Age and Growth	94
DISCUSSION	100
Morphometric and Meristic Counts	100
Population Structure	104
Length-weight Relationships	105
Condition Factor	108
Food and Feeding Habits	110
Maturity and Spawning	121
Age and Growth	134
SUMMARY AND CONCLUSIONS	140
LITERATURE CITED	148
APPENDIX	

LIST OF TABLES

<u>TABLE</u>	<u>TITLE</u>
1	Morphometric analysis of <u>Labeo pangusia</u> .
2	Morphometric analysis of <u>Labeo dero</u> .
3	Regression equations of variable morphometric characters of <u>Labeo pangusia</u> .
4	Regression equations of variable morphometric characters of <u>Labeo dero</u> .
5	Meristic counts of <u>Labeo pangusia</u> .
6	Meristic counts of <u>Labeo dero</u> .
7	Mean biometric indices in different length groups of <u>Labeo pangusia</u> .
8	Mean biometric indices in different length groups of <u>Labeo dero</u> .
9	Length-weight equations of <u>L. pangusia</u> and <u>L. dero</u> .
10	Monthly fluctuations in the condition factor: (A) <u>L. pangusia</u> , (B) <u>L. dero</u> .
11	Fluctuations in the condition factor of different length groups: (A) <u>L. pangusia</u> , (B) <u>L. dero</u> .
12	Index of preponderance of various food components in the guts of <u>Labeo pangusia</u> .
13	Seasonal variation of various broad groups of food items in <u>Labeo pangusia</u> .
14	Variations in the food composition of <u>Labeo pangusia</u> in different size groups.
15	Index of preponderance of various food components in the guts of <u>Labeo dero</u> .
16	Seasonal variation of various broad groups of food items in <u>Labeo dero</u> .
17	Variations in the food composition of <u>Labeo dero</u> in different size groups.
18	Average gastroscopic index (G.S.I.) in various months: (A) <u>L. pangusia</u> , (B) <u>L. dero</u> .
19	Gastroscopic index (G.S.I.) in various length groups: (A) <u>L. pangusia</u> , (B) <u>L. dero</u> .

- 20 Relative length of the gut (R.L.G.) in various length groups: (A) L. pangusia, (B) L. dero.
- 21 Ova diameter in different stages of maturation of Labeo pangusia.
- 22 Ova diameter in different stages of maturation of Labeo dero.
- 23 Average gonadosomatic ratio (maturity index) in various months: (A) L. pangusia, (B) L. dero.
- 24 Percentage of maturity at various length groups of Labeo pangusia.
- 25A Fecundity of Labeo pangusia from Simsang River.
- 25B Fecundity of L. pangusia from Lubha River.
- 25C Fecundity of L. pangusia from Madhura River.
- 26 Regression equation of fecundity with different parameters: (A) L. pangusia, (B) L. dero.
- 27 Percentage of maturity at various length groups of Labeo dero.
- 28A Fecundity of Labeo dero from Simsang River.
- 28B Fecundity of L. dero from Lubha River.
- 28C Fecundity of L. dero from Madhura River.
- 29 Mean calculated length at each annulus as determined by back calculation: (A) L. pangusia, (B) L. dero.
- 30 Average size and weight at the time of various annuli formation: (A) Labeo pangusia, (B) L. dero.
- 31 Annual growth increments of L. pangusia in length and weight.
- 32 Annual growth increments of L. dero in length and weight.
- 33 Regression co-efficient (b) of length-weight relationship of certain Labeo species.
- 34 Relative length of the gut (R.L.G.) and feeding habits of some Labeo species.
- 35 Absolute and relative fecundity of some Labeo species.

LIST OF FIGURES

<u>FIGURE</u>	<u>TITLE</u>
1	Map showing collection sites.
2	Diagrammatic representation of <u>L. pangusia</u> and <u>L. dero</u> .
3	Biometric indices of <u>Labeo pangusia</u> .
4	Biometric indices of <u>Labeo dero</u> .
5	Length-frequency distribution of (A) <u>L. pangusia</u> and (B) <u>L. dero</u> .
6	A & B. Sex-ratio in different months.
7	C & D. Sex-ratio in different length groups.
8	Parabolic curve (A, B & C) and log-log relationship (D, E & F) between length and weight in the juveniles of <u>Labeo pangusia</u> .
9	Parabolic curve (A, B & C) and log-log relationship (D, E & F) between length and weight in the males of <u>Labeo pangusia</u> .
10	Parabolic curve (A, B & C) and log-log relationship (D, E & F) between length and weight in the females of <u>Labeo pangusia</u> .
11	Log length-weight relationship in the juveniles of <u>Labeo dero</u> .
12	Log length-weight relationship in the adults of <u>Labeo dero</u> .
13	Condition factor in different months: (A) <u>L. pangusia</u> and (B) <u>L. dero</u> and in different length groups: (C) <u>L. pangusia</u> and (D) <u>L. dero</u> .
14	Percentage composition in different broad groups of food items for <u>Labeo pangusia</u> .
15	Percentage composition in different broad groups of food items for <u>Labeo dero</u> .
16	Seasonal variations in different broad groups of food items of <u>Labeo pangusia</u> .
17	Seasonal variations in different broad groups of food items of <u>Labeo dero</u> .
18	Variations in the broad groups of food items in the different length groups of <u>Labeo pangusia</u> .
19	Variations in the different broad groups of food items in different length groups of <u>Labeo dero</u> .

- 20 Gastrosomatic index in different months: (A) L. pangusia and (B) L. dero and in different length groups: (C) L. pangusia and (D) L. dero.
- 21 Relative length of the gut (R.L.G.) of (A) L. pangusia and (B) L. dero.
- 22 Size-frequency distribution of intra-ovarian oocytes of Labeo pangusia at different maturation stages.
- 23 Size-frequency distribution of intra-ovarian oocytes of Labeo dero at different maturation stages.
- 24 Seasonal variations in the gonadosomatic ratio of Labeo pangusia.
- 25 Seasonal variations in the gonadosomatic ratio of Labeo dero.
- 26 Graph showing length at M_{50} (50% maturity): (A) L. pangusia and (B) L. dero.
- 27 Relationship between fecundity and (A) length, (B) weight and (C) Ovary weight and log-log relationship between fecundity and (D) length, (E) weight and (F) Ovary weight of Labeo pangusia from Simsang river.
- 28 Relationship between fecundity and (A) length, (B) weight and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight and (F) ovary weight of Labeo pangusia from Lubha river.
- 29 Relationship between fecundity and (A) length, (B) weight and (C) ovary weight and log-log relationship between fecundity (D) length, (E) weight and (F) ovary weight of Labeo pangusia from Madhura river.
- 30 Relationship between fecundity and (A) length, (B) weight and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight and (F) ovary weight of Labeo dero from Simsang river.
- 31 Relationship between fecundity and (A) length, (B) weight and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight and (F) ovary weight of Labeo dero from Lubha river.

- 32 Relationship between fecundity and (A) length, (B) weight (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight and (F) ovary weight of Labeo dero from Madhura river.
- 333 Relationship between fecundity and age of L. pangusia (A, B & C) and L. dero (D, E & F).
- 34 Log-log relationship between scale radius and total length of L. pangusia (A, B & C) and L. dero (D, E & F).
- 35 Percentage of scales with marginal rings in (A) L. pangusia and (B) L. dero.
- 36 The growth curve of L. pangusia (A, B & C) and L. dero (D, E & F) showing absolute and relative growth.
- 37 Graph showing the maximum expected length (L_{∞}) of L. pangusia (A, B & C) and L. dero (D, E & F).
- 38 Weight attained at different ages by L. pangusia (A) and L. dero (B).

INTRODUCTION

INTRODUCTION

Fishes have great significance in the life of mankind, being an important natural source of protein and providing certain other useful products as well as economy of many nations, particularly in a developing country like ours. Freshwater fishes too, form a vital part of the diets of people throughout the tropics. The fact that the world catch of fish which was increasing until recently, has now started declining at an alarming rate, mainly due to over-exploitation and other factors. However, today almost all the inland water bodies are undergoing eutrophication, in other words, a step prior to pollution, particularly due to our burgeoning population, growing advancement in the cultural activities etc. This lays emphasis on the urgent need to develop these resources fully and to achieve this, we need to understand the factors governing fish production.

In a country like India, the intake of meat and milk is low, so fish has special importance as a supplement to ill-balanced diets. Today, protein deficiency is the world's most serious human malnutritional problem, and perhaps 30-40% of the world's population suffers from protein deficiency. It is estimated that about 8.5 million tonnes of fish is required annually to meet the present day demand of fish protein in the country against an annual production of only about 1.7 million tonnes (Nasar and Kaur, 1979).

In India, inland waters with potentialities of fish culture is approximately 7.5 million hectares or in other words 2.34% of the total area of the country. Many of our inland waters remain either unutilized or not properly utilized for fish culture for want of proper scientific knowledge. The aim of any good fishery management is always to obtain the maximum sustained yield of fish from a water body, this involves removal of fishes equivalent to the amount of fish produced each year. For developing fishery, it is necessary to understand their population dynamics -- how fast they grow and reproduce, the size and age at which they spawn; their mortality rates and its causes, on what they prey upon along with other biological processes.

Likewise, in the present day world, where the economy of a nation depends on judicious prospecting, conservation and exploitation of both removable and natural resources, the role of biological studies is manifestly of significant importance. Today, the field of biology is no longer an academic subject only as its concerns to everyone because all the world problems today are in one or another form related to food or energy crisis or pollution (Nasar, 1977).

Extensive researches on freshwater fishes in India, generally centres around the biology of only those species which are being used to stock dams and lakes rather than on natural fish communities. In India, generally the important

culturable fishes are the Indian major carps, such as Catla catla, Labeo rohita and Cirrhinus mrigala and the exotic carps viz., Cyprinus carpio, Ctenopharyngodon idellus and Hypophthalmichthys molitrix. The maximum production of fishes is needed to meet the present day demand of animal protein, hence we need to explore the natural resources properly and find out suitable cultural feasibility of indigenous fishes.

Among the commercially important freshwater fishes available in India, the genus Labeo is considered to be very important as it is preferred throughout the country. But except Labeo rohita and L. calbasu none of the other Labeo species are being cultured on commercial basis, though in some areas particularly in the hilly regions where L. rohita and L. calbasu are not frequently available and the people have to depend on other capture Labeo species which are decreasing in numbers gradually by indiscriminate fishing and over-exploitation. It is a well known fact that the knowledge on fish biology particularly on morphometry, length-weight relationship, conditional factor, reproduction, food and feeding habit etc. is of utmost importance not only to fill up the lacuna of our present day academic knowledge but also in the utility of the knowledge in increasing the technological efficiencies of the fishery entrepreneurs for evolving judicious pisciculture management.

Views on various aspects of fish population dynamics have been expressed in many countries but the problem was of

no general concern until the mid-nineteenth century. However, Ber (1854) was the founder of the modern progressive theory of productivity and of fish population dynamics. The theory of population dynamics is a division of the general theory of the development of life, which deals with the laws of reproduction, growth and the causes of death of living organism (Nikolsky, 1969). They are concerned with the continuous process of the replacement of generations in time, the birth of a generation, its growth and death. The details of the process are governed by specific adaptations and by the relationships of the years with the environment.

According to Regier (1974), with very notable exceptions, fish biologists have tended to specialize at one particular level of organisation, mostly of the organism, some at the population and fewer at the community level. The population dynamics of commercially valuable organisms is now primarily applied to the problem of providing their maximum yield. This entails a study of the productivity of the biosphere as a whole, which in turn involves the solution of various biological problems. The dialectical materialistic theory of development should be the basis of a progressive theoretical population dynamics for fish and other organisms, especially ideas such as the unity of an organisms with its environment, the reality of a species, the adaptive significance of all species features, discontinuous continuity (Stages) and so on.

/ It is well known that the unity of any organism and environment represents a system of adaptive relations between the organism and the biotic and abiotic parts of its environment. The dominant relations are not fixed but are dependent on all the other links in the system. They change during ontogenesis and may differ between populations of the same species. |

Morphological variations in fish as a result of adaptation to its new environment have been cited by various authors (Schmidt, 1921; Vladykov, 1934; Taning, 1944; Lindsay, 1954; Fage, 1958; Barlow, 1961). According to Grant and Spain (1977), the concepts of size and shape are fundamental to the analysis of variation in living organisms. LeCren (1951) had earlier pointed out that the knowledge of the length-weight relationship of a fish, is essential since various important biological aspects viz., general well being, appearance on first maturity, onset of spawning, etc., can also be assessed with the help of condition factor of this relationship. An important derivation of growth is what fish population analysts have termed "condition factor" or "Ponderal index" or more popularly known as the "K-factor". Apart from estimating the length-weight relationship of fish which makes it possible to convert length into weight and vice-versa, another approach has been to determine the coefficient of condition (K-factor) with the objective of expressing the condition of the fish in numerical terms i.e., degree of well-being, relative robustness, plumpness or fatness.

As recently pointed out by Kaur (1981) that for proper fishery management, a thorough knowledge of maturation cycle and depletion of gonads is of utmost importance as it is essential to understand and predict the annual changes that the population undergoes. From these studies a variety of inference could be drawn, such as the rates of regeneration of stocks and determination of ecological factors which led to synchronization of breeding activity. Similarly, information on such related aspects as fecundity, size at first maturity etc., are also pertinent and all these aspects should be taken into consideration for successful aquaculture programme. The knowledge of the number of eggs produced by fishes is of great value in aquaculture, as it would determine the amount of rearing facilities required and the extent to which various kinds of equipment will be needed. According to Corbin (1948 and 1952), the number of eggs produced by the fish must be known, if survival is to be estimated. The data pertaining to fecundity are also useful in determining the density dependent factor affecting population size (Simpson, 1951) and for separating different fish stocks from the same population (Farran, 1938). For several centuries the attention of laymen naturalists and fishery scientists has been drawn to the number of eggs in the roes of female fish. Fish fecundity has been studied not only as one aspect of natural history, but also in association with studies of population dynamics, racial characteristics, production and stock recruitment problem (Bagenal, 1978; Habib, 1979).

The constant demand for adequate nourishment is a selective agent that may greatly influence an organism's existence. This influence can be so persuasive that many ecologists feel it as a primary factor declining in organism's niche (Schoener, 1974). Investigations of the feeding ecology of a species can produce insight into how the organisms has evolved ecologically to meet the pressure (Grossman et al., 1980). Most studies on the food and feeding habits of fishes from varying habitat have shown that those species differ in time and space and at different stages of growth (Hardy, 1924; De Silva, 1973a), thereby emphasizing the need to the study of food and feeding habits of a species in more details. It is also considered important for the propagation of the species to gain more accurate knowledge on its feeding behaviour, since it can be utilized for exploiting natural fish food.

The age determination in fish is one of the most important aspects in the study of their population dynamics. It forms the basis for calculations leading to the knowledge of the growth, mortality, recruitment and other fundamental parameters of their populations. The great importance of the determination of age of fishes in the solution of biological problems of fisheries has led to the accumulation of a large amount of information in this field and there are many investigations which are interesting from a technical point of view (Nikolsky, 1963).

The growth of a fish results from the consumption of food, its assimilation, and the construction from it of the organism's body (Vasnetsov, 1953^{2b}). The growth process is specific for each species of fish, as for any other organism. Growth is a specific, adaptive property, ensured by the unity of the species and its environment (Nikolsky, 1963). A comparison of the rate of growth of different bodies of water may partly identify suitable or unsuitable environmental conditions and point the way for future action. Attempts at environmental improvement may be afforded by the effect of changes made on growth rate. Age and growth rate may also show suitability of stocking, used as a follow up measure.

The North-Eastern Hilly Regions of India are mostly inhabited by tribals and most of them are meat-eaters having inadequate source to fulfil the great protein deficiencies. Moreover, it is well known that the tribals of the hilly areas in Meghalaya (Khasis, Jaintias and Garos) have less land for agriculture, but 85% of the population subsists on agriculture. Apart from animal husbandry and mining of sillimanite, coal, etc., there are no industries in Meghalaya. There is, however, plenty of rainfall and sufficient water bodies to grow fish in this part of the country. Hence, introduction of fish farming in these highlands would certainly help to grow a new occupation which will raise the economic status of small farmers. There is, however, hardly any practical information available on the biology of the fishes that naturally grow in this region.

There is a paucity of information on the biology and ecology of the fishes indigenous to the highlands of the North-Eastern part of India and knowledge on these, is of utmost importance, not only from the academic point of view, but its utility in increasing the technological efficiencies of the fishery entrepreneurs for evolving judicious management measures in pisciculture. Hence, a virtual absence of scientific knowledge on these aspects, particularly of carps prompted to undertake the present investigation. It is, therefore, earnestly hoped that the information embodied in this dissertation, apart from its academic value, would have application and relevance to the socio-economic development of these areas of the country by evolving suitable pisciculture techniques.

The present study pertains to the specimens of Labeo pangusia and L. dero collected during the period from August 1978 to November 1980 from three river populations viz., (i) Simsang river (Garo Hills, Meghalaya), (ii) Lubha river (Jaintia Hills, Meghalaya) and (iii) Madhura river (Cachar, Assam). The results obtained during the present study are presented in this thesis entitled "Studies on some aspects of the biology of Labeo pangusia and Labeo dero from the North-Eastern India".

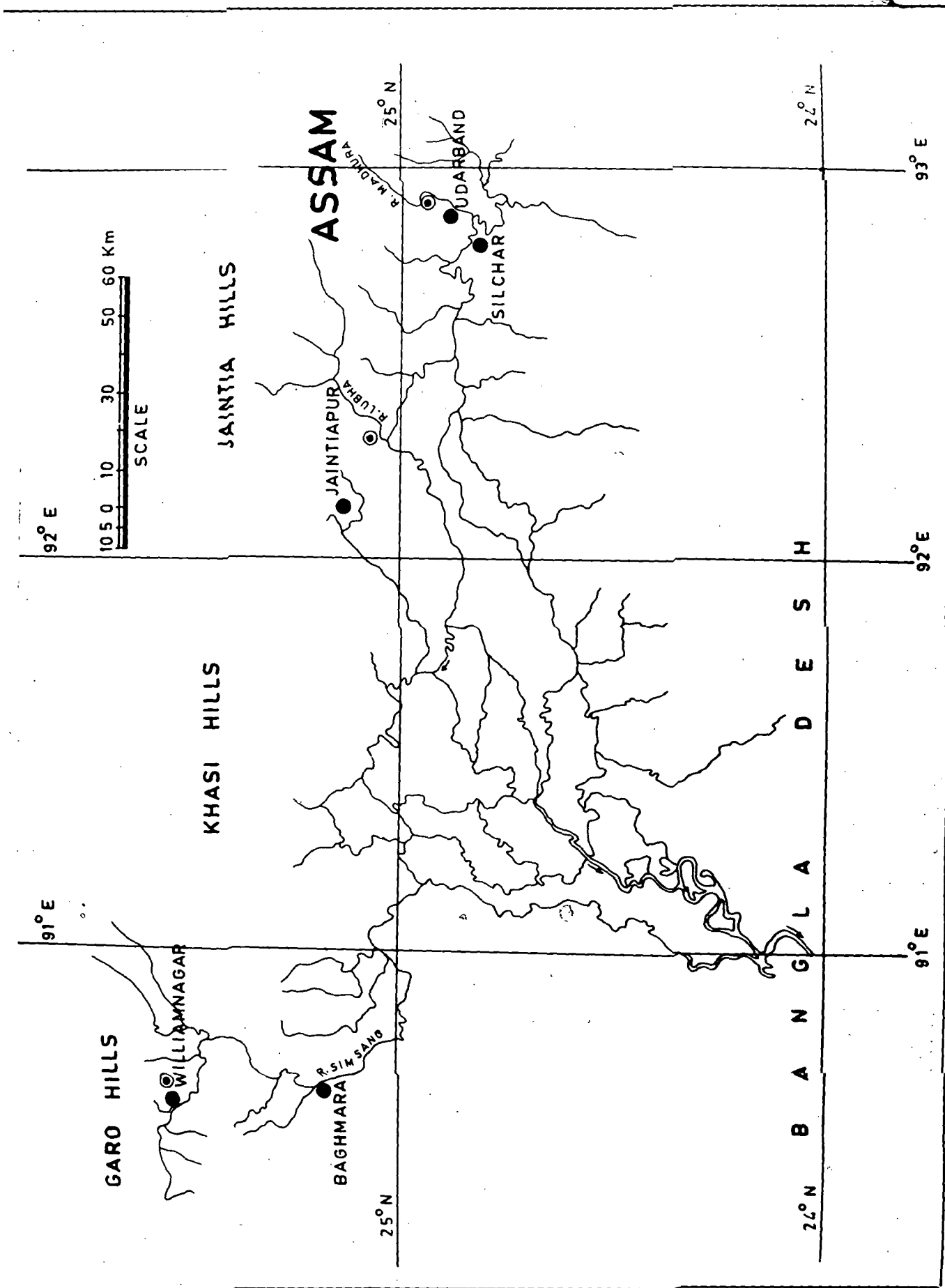


Fig. 1. Map showing the collection areas (●)

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Knowledge of the occurrence of fish in India dates back to three millennium B.C. (Hora, 1956). According to Nath (1966) fish remains with cut marks, indicative of their use as food, have been obtained from excavation at Mohenjodaro and Harappa of the Indus Valley civilization (2500 - 1500 B.C.). While Aristotle (384 - 327 B.C.) is said to be the founder of Ichthyology, King Somesvara, the son of king Vikramaditya VI, who composed the book "Manasoltara" in 1127 A.D., was responsible for the first record of the common sport fish of India grouping them into marine and freshwater riverine forms (Hora, 1951a). The first modern writer on Indian fishes, according to Day (1878) was Bloch, whose splendid work Auslaniche Fische was published in 1785. Later, Lácepède wrote Historie des Poissons (1798-1803). Russell (1803) described 200 species from Vizakhapatnam. Then appeared Hamilton's (1822) pioneer work "An account of the fishes found in the River Ganges and its branches", which contains a description of 269 species from the Ganges and its tributaries. Cuvier and Valenciennes' Historie Naturelle des Poissons, published in 1828-1849, provided more impetus to the study of Ichthyology than any other work till then. Other notable works on the taxonomy of fishes are those of McClelland (1839), Bleeker (1853), Blyth (1860), Günther (1859-1870).

There seems, however, no work of greater importance on Indian fishes than the epoch making contributions of Day's

"Fishes of India" (1878) and "Fauna of British India, Burma and Ceylon" (1889). In the present century, valuable contributions on fish systematics have been made by Hora (1936, 1944a, 1951b, 1955), which are being continued by many zealous workers notably Shaw and Shebbeare (1937), Misra (1959) and Menon (1951).

As far as systematics of the genus Labeo is concerned certain characters such as morphometric and meristic counts, key to the identification, distribution etc., have been studied by many workers, such as Hamilton (1822); Day (1878 and 1889); Hora (1921, 1936, 1947 and 1951b); Shaw and Shebbeare (1937); Menon (1951); Lal and Chatterjee (1962); Motwani et al. (1962); Sehgal et al. (1971); Sinha and Rajtilak (1972); Datta and Sen (1976); Biswas (1978) and Sen (1978).

A number of literature are available on different aspects of the biology of various Labeo species from different parts of India. A brief account of the earlier reports on various Labeo species have been summarized below.

Length-weight relationship of L. bata has been reported by Chatterjee et al. (1977). The same has been reported by Rao and Rao (1972) and Pathak (1975) for L. calbasu from Godavari river and Loni reservoir respectively. Karamchandani et al. (1967), Bhatnagar (1972) and Rao (1976) reported the length-weight relationship of L. fimbriatus from different populations while Chondar (1972), Parameswaran et al. (1974) and Chatterjee (1980) of L. gonius. The length-weight

relationship of L. rohita has been studied by Jhingran (1952), Motwani and Bose (1957), Pantulu et al. (1967), Khandker and Haque (1968) and Khan (1972).

The relative condition factor (Kn) of L. bata was studied by Chatterjee et al. (1976). The condition factor (K) of L. calbasu was reported by Rao and Rao (1972) and Pathak (1975). The ponderal index (K-factor) of L. fimbriatus from Narmada river was studied by Bhatnagar and Karamchandani (1970) and Bhatnagar (1972). The same has been studied in L. gonius by Parameswaran et al. (1974) and Chatterjee (1980). Khan (1972) worked on the general well-being of L. rohita from Aligarh.

Several reports are available on cultural aspects of Labeo (Hora, 1944b; Chacko, 1948; Ganapati and Chacko, 1950; Job et al. 1955, Alikunhi, 1957 and Hora and Pillay, 1962). Chacko et al. (1954) reported on the fisheries of L. kontius and L. rohita from Cauvery river. Jhingran and Chakraborty (1958) reported the annual landings of L. calbasu and L. rohita from Ganga river system. Motwani et al. (1962) described the fisheries of L. bata, L. calbasu, L. gonius, L. nandina, L. pangusia and L. rohita from Brahmaputra river system. Rajyalakshmi (1972) reported on the fisheries of L. calbasu, L. fimbriatus and L. rohita from Godavari river whereas Karamchandani and Pisolkar (1967) described the fisheries of L. boggut, L. calbasu and L. fimbriatus from Tapti river, Karamchandani et al. (1967) reported on the fisheries of L. bata, L. calbasu,

L. fimbriatus, L. gonius and L. pangusia from river Narmada.

A good deal of works have been done on the food and feeding habits of different Labeo species. Mookerjee and Ganguly (1952) studied the modification of facial structure of L. calbasu and L. rohita in relation to their feeding habits. Sarbahi (1939), Khanna (1961), Sehgal (1966) and Sinha (1976) worked on the morphology and histology of the alimentary canal of L. calbasu, while Kamal (1967) reported the food and alimentary canal of L. rohita. Mookerjee and Das (1945), Das and Srivastava (1979) studied the relative length of the gut of L. calbasu and L. rohita with changes from fingerling to adult stage. Mookerjee et al. (1946) reported the food of L. calbasu, L. gonius and L. rohita from Bengal. Das and Moitra published a series of papers (1955, 1956a, b, 1958 and 1963) on food and variation in the alimentary canal in relation to feeding habits of Indian freshwater fishes including L. bata, L. calbasu, L. gonius and L. rohita. The food and feeding habits of the juveniles of L. calbasu and L. rohita were studied by Alikunhi (1952 and 1958) while of adults by Mookerjee (1945a) and George (1963 and 1965). Hora and Pillay (1962) mentioned the food and feeding habits of L. bata, L. calbasu, L. fimbriatus, L. kontius and L. rohita along with other well known culturable species. Chacko (1951) reported the food composition of L. boggut whereas Karamchandani and Mishra (1978) described the food and feeding habits of the species from Kulgarhi reservoir (Madhya Pradesh). Pathak (1975) contributed to the knowledge on the feeding habit

of L. calbasu from Loni reservoir. The same has been studied by Chacko and Kuriyan (1948) for L. fimbriatus from Tungabhadra reservoir, by Bhatnagar and Karamchandani (1970) from the Narmada river and by David and Raja-Gopal (1975) also from Tungabhadra reservoir. Alikunhi (1952), Parameswaran et al. (1974) and Chatterjee et al. (1978) reported the food and feeding habits of L. gonius. The same in L. rohita have also been reported by Khan (1934), Hora (1944b), Chacko (1951), Misra (1953), Alikunhi (1957), Ranade and Kewalramani (1967), Khan (1972), Khan and Siddiqui (1973a), Khan and Jhingran (1975), Akhtar (1979) and Dewan et al. (1979).

Sexual dimorphism of L. boggut and L. rohita were studied by Misra (1950) and Chaudhury (1959) respectively. Sex-determination of L. rohita was studied by Mookerjee (1938) and Khan and Hussain (1945). Ahmad (1948) worked on identification of ova of L. rohita while Mazumdar (1957) on the impregnated eggs of L. calbasu.

Alikunhi (1956) studied the fecundity and larval development of L. bata. Hora and Pillay (1962) reported the breeding habit of L. bata whereas Bhatnagar (1964) reported the spawning frequency and fecundity of the species from Bhakra reservoir. Siddiqui et al. (1976a) also studied the reproductive biology of L. bata from Aligarh. Alikunhi et al. (1962) reported the fecundity and breeding of L. boga whereas David et al. (1979) reported the breeding of the species. Fecundity and breeding of L. boggut have been studied by Selvaraj et al.

(~~1971~~ and 1972) from Madhya Pradesh and David et al. (1979) from Tungabhadra reservoir.

As far as the reproductive biology of L. calbasu is concerned a good deal of literature are available, worth-mentioning among those are by Khan (1924 and 1945), Das and Das Gupta (1945), Qasim and Qayyum (1961), Hora and Pillay (1962), Sehgal (1971), Rao and Rao (1972), De (1973) and Pathak and Jhingran (1977). The maturity, fecundity and certain related aspects of L. fimbriatus from river Narmada, have been reported by Bhatnagar (1972), whereas David et al. (1979) reported the breeding of the species collected from Tungabhadra reservoir. The spawning biology of L. gonius has been studied by Ahmad (1944), Ray et al. (1969), Parameswaran et al. (1970 and 1974) and Siddiqui et al. (1976b).

The well-known culturable species of India, L. rohita has attracted many workers as far as studies on reproductive biology is concerned (Ghosh and Ghosh, 1922; Khan, 1924 and 1945; Das and Das Gupta, 1945; Khan, 1959; Dubey and Tuli, 1961; Qasim and Qayyum, 1961; Hora and Pillay, 1962; Alikunhi et al., 1964; Gopalakrishnan et al., 1966; Chaudhurn, 1967; Parameswaran et al., 1970; De, 1973; Varghese, 1973; Karamchandani and Pandit, 1975; Khan and Jhingran, 1975). The spawning habits of L. calbasu and L. rohita were studied by Khan (1924), Hora (1945), Mookerjee (1945b), Hussain (1945), Khan (1947), Ganapati and Chacko (1954), Khanna (1958) and Sinha et al. (1974).

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Studies on the life-history of cultivated species of Labeo were conducted by many investigators. Alikunhi (1956) reported this in L. bata, whereas Alikunhi et al. (1962) in L. boga and Selvaraj et al. (1972) in L. boggut. Mookerjee and Mazumder (1946) studied the life history of L. calbasu and again Alikunhi et al. (1949) of L. calbasu and L. fimbriatus. Mookerjee and Ganguly (1949) studied the life history of L. gonius. The life-history of L. kontius was reported by Alikunhi and Rao (1951) from South Indian waters. Mookerjee (1945c) and Chakrabarty and Murty (1972) reported the life-history of L. rohita.

Age and growth of different Labeo species were studied by many workers. Mitra (1942) reported the rate of growth of L. rohita from Orissa. Chacko and Krishnamurthy (1951) studied the age and growth of L. fimbriatus. Alikunhi and Rao (1951) studied the growth of L. kontius from South India. Menon et al. (1955) reported the age and growth of L. fimbriatus from Madras (Tamil Nadu) state. Das (1960) and Sukumaran (1969) studied the growth rate of L. rohita from culturable ponds. Rao (1965 and 1976) studied the age and growth of L. fimbriatus from Godavari river. Khandker and Haque (1970) reported the age of L. rohita from East Pakistan whereas Khan and Siddiqui (1973b) of the same species from Aligarh. Chatterjee et al. (1979) studied the age and growth of L. bata from river Kali (Uttar Pradesh) and Bhatnagar (1979) reported for L. fimbriatus from Narmada river.

However, few worthmentioning reports are also available on the exotic species of Labeo which are as follows :

Girgis (1952) worked on alimentary tract of L. horie. Jackson (1961) reported the spawning habit of L. altivelis and L. congoro from lake Kariba. Blache and Miton (1962) described the morphology of L. coubie and L. senegalensis from some seasonal rivers of West Africa. Kamel et al. (1963) worked on food and feeding habits of L. niloticus. Matthes (1963) gave a comparative account of the feeding mechanisms of L. horie, L. lineatus, L. niloticus and L. variegatus. Cadwalladr (1965) studied the breeding biology and ecology of L. victorianus from lake Victoria. The food and feeding habits of L. capensis were studied by Schoonbee (1969), while the morphometric and meristic characters of L. capensis and L. umbratus were studied by Jackson (1973). The same aspects have been described by Mulder (1973) in L. capensis and L. umbratus. Bloemhof (1974) worked on certain aspects of the biology of L. capensis. Baird (1976) studied the growth and reproduction of L. capensis. Baird and Fourie (1978) reported the length-mass relationship and condition of L. capensis from the Caledon river (South Africa), whereas the length-weight relationship and population structure of L. capensis and L. umbratus have been reported by Hattingh (1976). Mann (1971) gave a taxonomical note on L. cylindricus, whereas Ssentigo and Mann (1971) reported the distribution of the same species from African waters. Aspects on the distribution and fisheries of

L. lunatus and L. mesops were touched by Balon (1972) and Lowe-McConnell (1975) respectively. Okedi (1969, 1970 and 1971) reported breeding, fecundity, growth and feeding habits of L. niloticus from lake Victoria and Hashem (1972 and 1973) studied the age, growth, maturity and feeding habits of the species. Lauzanne (1972) reported the feeding habit of L. senegalensis from lake Chad while Blake and Blake (1978) studied the age and growth of the species.

The reports on the biology of L. pangusia and L. dero are very meagre. So far the following works appeared with regards to the biology of both the species.

Hora and Misra (1936) reported the sexual dimorphism whereas Bhatnagar (1964) reported the spawning frequency and fecundity of L. dero. Tandon and Arora (1969) reported the morphological features of the same species from Punjab. Recently, Dasgupta and Nasar (1980) described the food and feeding habit of L. dero from the river Pagladia (Assam), while Biswas and Nasar (1981) reported the changes in diet preference in relation to gut length of L. pangusia and L. dero from the river Madhura (Assam).

The foregoing review of literature reveals that though a fairly good reports on the biology of various Labeo species are available but there are several points with regard to the general biology of the genus particularly of L. pangusia and

L. dero requires elucidation. Moreover, the review further indicates that there is practically no information available on the biology of any of these species from the North-Eastern region of India.

Therefore, it has been felt desirable to conduct a detailed investigation on the biology of Labeo pangusia and L. dero from the North-Eastern region of the country.

DESCRIPTION OF THE FISHES

TAXONOMIC STATUS (After Berg, 1940)

Phylum : Vertebrata
Sub phylum : Craniata
Super class : Gnathostomata
Series : Pisces
Class : Teleostomi
Sub class : Actinopterygii
Order : Cypriniformes
Division : Cyprini
Sub order : Cyprinidei
Family : Cyprinidae
Sub Family : Cyprininae

Genus : Labeo Cuvier, 1817
Species : Labeo pangusia (Hamilton, 1822)
Labeo dero (Hamilton, 1822).

DIAGNOSTIC CHARACTERS

General morphological characters of the genus Labeo and distinguishing characters of Labeo pangusia and L. dero.

The genus Labeo has long, cylindrical bodies with large fins. The head is somewhat pointed, the snout bearing pairs of barbels. The mouth is round and appear to have lips, hence the name Labeo has been given (McInerny and Gerard, 1958).

Day (1878) outlined the following characters of the genus Labeo.

- (i) Body moderately elongated and abdomen is rounded.
- (ii) Mouth sometimes anterior but mostly inferior, transverse, and semi-oval.
- (iii) Lips thick, covering the jaws, continuous at the angle of the mouth, and one or both having an inner transverse fold.
- (iv) A soft and movable horny covering with a sharp margin of the inner side of one or both lips.
- (v) Snout rounded, generally projecting beyond the mouth, mostly covered with tubercles, and some times having a lateral lobe or projection.
- (vi) Barbels when present, four or two: if only one pair they are on the maxilla, the second being on the snout, or they may be absent.
- (vii) Pharyngeal teeth in three rows.
- (viii) Dorsal fin of moderate length or elongated, without any osseous ray and arising anterior to the

commencement of the ventral.

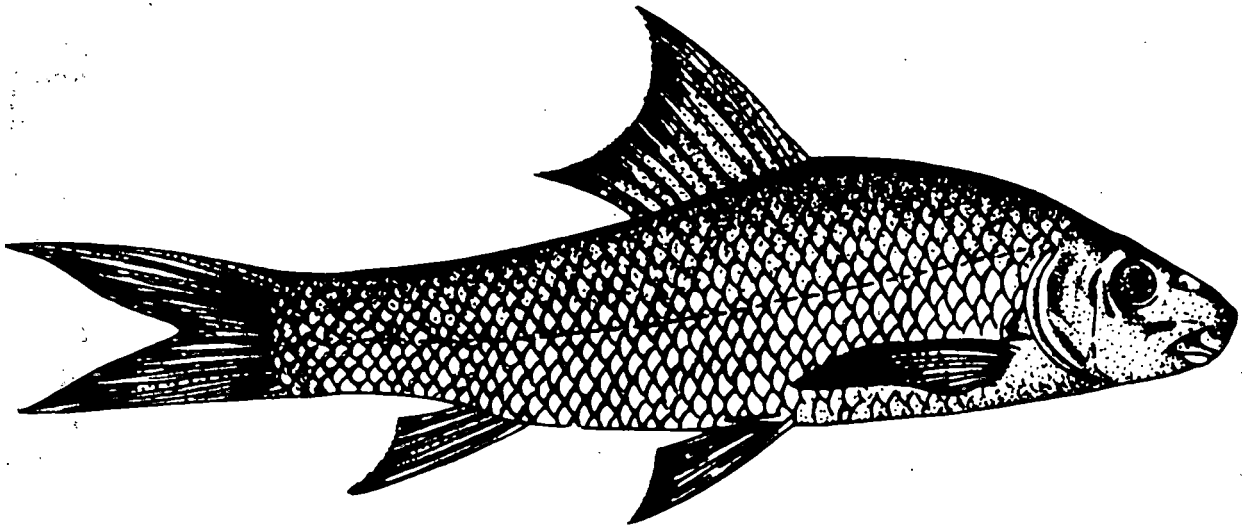
(ix) Scales of large, moderate, or small size.

(x) Lateral line running along the middle side of the tail.

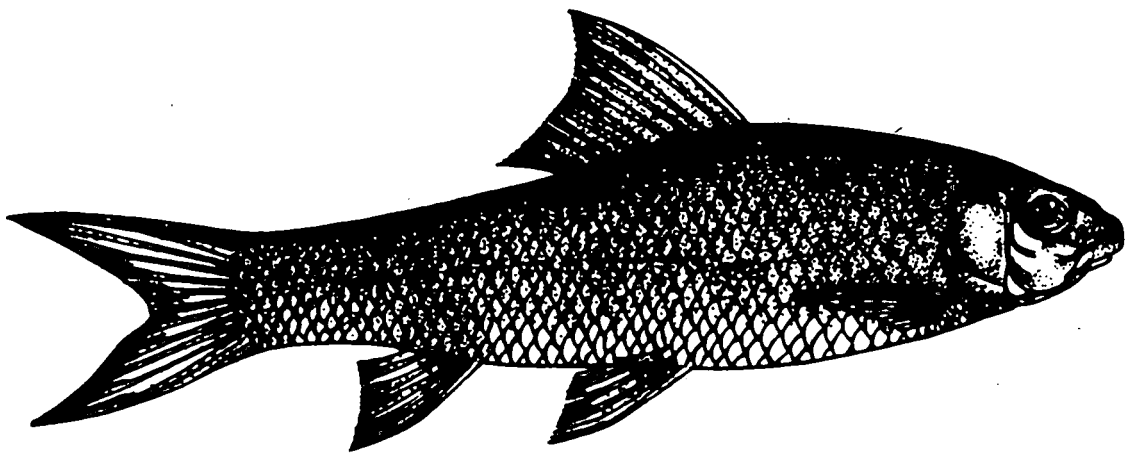
(xi) Gill-rackers usually short.

Labeo pangusia and L. dero are similar in several features and their respective ranges of distribution are more or less similar. Day (1878) and Hora (1936) differentiated the two species as follows :-

<u>Labeo pangusia</u>	<u>Labeo dero</u>
(i) Length of the head $5-5\frac{1}{2}$, height of the body $3\frac{3}{4}-4\frac{1}{2}$ in total length	(i) Length of the head $5\frac{1}{2}-6\frac{1}{4}$, height of the body $5-5\frac{1}{2}$ in in total length
(ii) Diameter of eye 6-9 in length of the head, $3\frac{1}{2}-5$ in interorbital width.	(ii) Diameter of eye $5-6\frac{1}{2}$ in length of the head, $2\frac{1}{2}-3$ in interorbital width.
(iii) 5 rows of scales below lateral line to base of ventral.	(iii) 6-7 rows of scales below lateral line to base of ventral.
(iv) The front part of the snout, dorsally, laterally and ventrally, is studded with pearl organs or spiny tubercles.	(iv) The spiny tubercles, when present, fewer in number and totally absent from the ventral surface of the head.



Labeo pangusia



Labeo dero

Fig. 2. Diagrammatic representation of L. pangusia and L. dero

- | | |
|--|---|
| (v) Snout without a groove and with distinct lateral lobes. | (v) Snout with a groove and without lateral lobes. |
| (vi) Mouth wide. | (vi) Mouth rather narrow. |
| (vii) The anterior dorsal rays of males remain normal in shape as the fish grow. | (vii) The anterior dorsal rays prolonged in case of mature males. |
| (viii) Pectoral reaches ventral and the latter base of anal. | (viii) Pectoral does not extend to ventral, nor the latter to anal. |

SYNONYMS

(a) Labeo pangusia (Hamilton, 1822)

- 1822 Cyprinus angra Hamilton, Fish. Ganges, pp. 331-391;
type locality : R. Brahmaputra.
- 1822 Cyprinus morala Hamilton, Fish. Ganges, pp. 331, 391,
pl. 18, fig. 91; type locality : Bengal.
- 1822 Cyprinus musiha Hamilton, Fish. Ganges, pp. 333, 392;
type locality : R. Ganges, Patna.
- 1822 Cyprinus pangusia Hamilton, Fish. Ganges, pp. 285, 386;
type locality : R. Kosi.
- 1830-32 Cyprinus angra Gray, Ill. Ind. Zool., 1, pl. 86, Fig. 1
(from Hamilton's MS. drawings).
- 1834 Cyprinus (Bangana) hamiltonii Gray, Ill. Ind. Zool., 2,
pl. 93, Fig. 1 (from Hamilton's MS drawings).

- 1839 Cyprinus (Labeo) dyocheilus McClelland, Asiat. Res., 19, pp. 268, 330, pl. 37, Fig. 1, Assam.
- 1839 Cyprinus pangusia McClelland, Asiat. Res. p. 279, pl. 42, Fig. 1 (from Hamilton's MS drawings).
- 1839 Gobio pangusia McClelland, Asiat. Res., 19, pp. 279, 362, pl. 42, Fig. 1 (from Hamilton's MS drawings).
- 1842 Gobio angra Valenciennes (in C. & V.), (not McClelland), Hist. Nat. Poiss., 16, p. 319.
- 1868 Labeo morala Gunther, Cat. Fish. Brit. Mus., 7, p. 56.
- 1868 Labeo pangusia Gunther, Cat. Fish. Brit. Mus., 7, p. 58.
- 1877 Labeo chycheilus Day, Fish. India, p. 540, pl. 131, Fig. 1.
- 1877 Labeo pangusia Day, Fish. India, p. 541, pl. 131, Fig. 1.
- 1878 Labeo angra Day, Fish. India, p. 541, pl. 128, Fig. 2.
- 1889 Labeo angra Day, Faun. Brit. Ind. Fish., 1, p. 267.
- 1889 Labeo dyocheilus Day, Faun. Brit. Ind. Fish., 1, p. 266.
- 1889 Labeo pangusia Day, Faun. Brit. Ind. Fish., 1, p. 266.
- 1912 Labeo kunki Chaudhuri, Rec. Indian Mus., 7, p. 438, Pl. 38, Fig. 3; type locality : Saran, Bihar.
- 1912 Labeo tezporensis Chaudhuri, Rec. Indian Mus., 7, p. 439; type locality : Belsiri river, Tezpur, Assam.

- 1921 Labeo angra Hora, Rec. Indian Mus., 22, p. 183; type locality : Manipur.
- 1921 Labeo pangusia Hora, Rec. Indian Mus., 22, p. 183; type locality : Manipur.
- 1936 Labeo dyocheilus Hora, Rec. Indian Mus., 38, p. 320; type locality : Naga Hills.
- 1937 Labeo dyocheilus Hora, Rec. Indian Mus., 39, p. 45; type locality : Nepal.
- 1937 Labeo dyocheilus Shaw and Shebbeare, J. Asiat. Soc. Beng., 3, p. 53, Fig. 50, type locality : N. Bengal.
- 1937 Labeo pangusia Shaw and Shebbeare, J. Asiat. Soc. Beng., 3, p. 53, pl. 2, Figs. 6, 53; type locality : N. Bengal
- 1949 Labeo angra Menon, Rec. Indian Mus., 47, p. 233, type locality : R. Kosi, Chhatra, E. Nepal.
- 1949 Labeo dyocheilus Menon, Rec. Indian Mus., 47, p. 233; type locality : R. Kosi, Chhatra bazar, E. Nepal.
- 1949 Labeo dyocheilus Menon, J. Bombay nat. Hist. Soc., 48(3), p. 539; type locality : R. Kosi (Khairna), Kumaon.
- 1954 Labeo angra Menon, Rec. Indian Mus., 52, p. 22; type locality : Nepal.
- 1954 Labeo pangusia Menon, Rec. Indian Mus., 52, p. 22; type locality : Manipur.
- 1960 Labeo dyocheilus De Witt, Stanford Ichth. Bull., 7(4), p. 76; type locality : Biratnagar and vicinity, Nepal.

1974 Labeo pangusia Menon, A check-list of fishes of the Himalayan and the Indo-Gangetic Plains, Special Publication No. 1, Inland Fisheries Society of India, Central Inland Fisheries Research Institute, Barrackpore, India.

(b) Labeo dero (Hamilton, 1822).

1822 Cyprinus dero Hamilton, Fish. Ganges, pp. 271, 331, 385, pl. 22, Fig. 78; type locality : R. Brahmaputra.

1839 Labeo richorhynchus McClelland, Asiat. Res., 19, pp. 279, 363, pl. 55, Fig. 1; type locality : northern part of Bengal.

1868 Labeo ricnorhynchus Gunther, Cat. Fish. Brit. Mus., 7, p. 57.

1869 Labeo ricnorhynchus Day, Proc. Zool. Soc. Lond., p. 373.

1872 Cirrhina sindensis Day, J. Asiat. Soc. Beng., 41(2), p. 319; type locality : Sind Hills.

1877 Labeo diplostomus Day (nec. Heckel), Fish. India, p. 540 pl. 129, Fig. 2.

1877 Labeo microphthalmus Day, Fish. India, p. 542, pl. 132, Fig. 4.

1877 Labeo sindensis Day, Fish. India, p. 544, pl. 132, Fig. 2; type locality : Deccan, Sind and Punjab.

1889 Labeo diplostomus Day (nec. Heckel), Faun. Brit. Ind. Fish., 1, p. 265.

- 1889 Labeo microphthalmus Day, Faun. Brit. Ind. Fish., 1, p. 268.
- 1889 Labeo sindensis Day, Faun. Brit. Ind. Fish. 1, p. 271.
- 1912 Labeo almorhae Chaudhuri, Rec. Indian Mus., 7, p. 438; type locality : Almora.
- 1912 Labeo rilli Chaudhuri, Rec. Indian Mus., 7, p. 439, p pl. 38, Fig. 4; type locality : Saran, Bihar.
- 1924 Labeo henshawi Fowler, Proc. Acad. nat. Sci. Philad., 76, p. 98; type locality : Kalla Weddee, Loodianali and Burkee.
- 1924 Labeo nigripinnis Fowler (nec. Day), Proc. Acad. nat. Sci. Philad., 76, p. 97; type locality : R. Sutlej at Bilaspur, R. Ganges at Dehra-Dun and R. Gri, branch of R. Jumna.
- 1936 Labeo dero Hora and Mukerji, Rec. Indian Mus., 38, p. 142; type locality : Dehra Dun.
- 1937 Labeo dero Hora, Rec. Indian Mus., 39, p. 44; type locality : Nepal Terai.
- 1937 Labeo dero Shaw and Shebbeare, J. Asiat. Soc. Beng., 3, p. 53, pl. 2, Fig. 7, text Fig. 47; type locality : Terai and Duars, N. Bengal.
- 1949 Labeo dero Menon, Rec. Indian Mus., 47, p. 233, type locality : R. Tamur and Chhatra, E. Nepal.
- 1949 Labeo sindensis Menon, Rec. Indian Mus., 47, p. 233; type locality : Chhatra Bazar, E. Nepal.

- 1960 Labeo dero De Witt, Stanford Ichth. Bull., 7(4), p. 76;
type locality : Biratnagar and vicinity, Nepal.
- 1974 Labeo dero Monon, A check-list of fishes of the Himalayan
and the Indo-Gangetic Plains, Special Publication No. 1,
Inland Fisheries Society of India, Central Inland
Fisheries Research Institute, Barrackpore, India.

VERNACULAR NAMES

	<u>Labeo pangusia</u>	<u>Labeo dero</u>
Assamese :	Heel-gorya	Nepura
Bengali :	Kul-ka-batta, Loane and Chora-machh	Katal kushi and Chora-machh
Hindi :	Dongra	Moili, Gaywah and Bongsa
Manipuri :	Kha-bag	Kha-bag
Khasi :	Kha-kulai	Kha-ski
Garro :	Nawak	Nawak

GEOGRAPHICAL DISTRIBUTION OF L. PANGUSIA AND L. DERO

Day (1878) reported that L. pangusia is available in Sind, the Deccan, North-Western Province, Bengal and Assam. Hora (1921 and 1936), Menon (1954) and Biswas (1978) recorded both L. pangusia and L. dero from Manipur and adjacent areas. Many other workers also reported these two species from

different parts of India such as Shaw and Shebbeare (1937) from North Bengal, Lal and Chatterjee (1962) from Eastern Doon, Motwani ~~et al~~ (1962) from Brahmaputra river etc. These two species have not been reported so far from other parts of the world.:

MATERIALS AND METHODS

MATERIALS AND METHODS

The specimens of Labeo pangusia and L. dero for the present study were collected from three rivers, viz., i) Simsang river (near William Nagar, Meghalaya; 25°30'N latitude and 90°40'E longitude), ii) Lubha river (near Sonapur, Meghalaya; 25°07'N latitude and 92°24'E longitude), and iii) Madhura river (near Kumbhirgram, Assam; 24°55'N latitude and 92°56'E longitude). The collections were made during August, 1978 through November, 1980 from Simsang river, while from Lubha and Madhura rivers during December 1979 to November, 1980 preferably in the second fortnight of each month. Apart from using cast net for collections, specimens were also obtained from different landing and assembling centres.

The total length and weight of the fishes to the nearest centimeter and gramme respectively were recorded in the field itself prior to fixing the fish in 10% formaldehyde for further biological studies.

BIOLOGICAL PARAMETERS : The following biological factor of L. pangusia and L. dero collected from the three river systems selected for the present study.

- (a) Morphometric measurements.
- (b) Meristic characters.
- (c) Biometric index.
- (d) Population structure.

- (e) Food and feeding habit.
- (f) Maturity and spawning.
- (g) Age and growth.

The study is based on 2378 specimens of L. pangusia in the size range of 7.4 cm to 60.5 cm and 290 specimens of L. dero in the size range of 10.6 cm to 47.2 cm from Simsang, Lubha and Madhura rivers.

Intraspecific comparison in different biological parameters of L. pangusia and L. dero from different populations have also been studied.

MORPHOMETRIC MEASUREMENTS :

Total Weight : Total weight were measured to the nearest 0.1 gm in a double-pan physical balance and for smaller specimens, a chemical balance has been used. The following morphometric measurements have been studied according to methods described by Lowe-McConnell (1971).

Total length : Total length has been measured from the tip of the snout to the tip of the tail to the nearest 0.1 centimeter.

Fork length : Distance from tip of the snout to the bifurcation of the caudal fin.

Standard length : It is the distance from the tip of the snout to the caudal base.

Head length : Distance from the tip of the snout to the end of the opercular bone.

Pre-dorsal length : Distance from the tip of the snout to the first dorsal fin ray.

Eye diameter : Distance from the anterior to the posterior margin of the eye in a straight line.

Pre-orbital or Snout length : From the tip of the snout to the front margin of the orbit.

Post-orbital length : Distance from the posterior margin of the orbit to the end of the opercular bone.

Inter-orbital width : From the upper margin of the right orbit to the upper margin of the left orbit as measured from the dorsal surface.

Length of the upper jaw : From the anterior most point of the pre-maxillary to posterior point of the maxillary.

Head depth : Perpendicular distance from the end of the nape to the ventral side of the head.

Body depth : Vertical distance between the dorsal and ventral surface of the body at its greatest depth.

Least height of the caudal peduncle (Least height of the body):

Shortest height of the caudal peduncle between the end of the anal fin and the origin of the caudal fin.

Length of caudal peduncle : Distance from the end of the anal fin to the base of the median caudal rays.

Height of dorsal fin : Height of the longest fin ray of the dorsal fin.

Base of dorsal fin : Height of the longest fin ray of the dorsal fin.

Base of dorsal fin : Distance between the anterior and posterior end of dorsal fin taken along the base of the fin.

Height of pectoral fin : Height of the longest fin ray of the pectoral fin.

Height of ventral fin : Height of the longest fin ray of the ventral fin.

Height of anal fin : Distance between the anterior and posterior of the anal fin taken along the base.

Girth ~~length~~ : Circumference of the body at its deepest point.

MERISTIC CHARACTERS : The following meristic counts were made according to methods outlined by Lowe-McConnell (1971)

(a) Number of spines in the dorsal fin.

- (b) Number of rays in the dorsal fin.
- (c) Number of rays in the pectoral fin.
- (d) Number of rays in the ventral fin.
- (e) Number of spine in the anal fin.
- (f) Number of rays in the anal fin.
- (g) Number of rays in the caudal fin.
- (h) Lateral line scale count represent the number of pored scales on the lateral line.
- (i) Lateral line transverse scales : Scales above lateral line have been counted from the origin of the dorsal fin and counted downward and backward to (but not including) the lateral line scale. Scales below the lateral line have been counted upward and forward from the origin of the anal fin.

All the above mentioned morphometric measurements and meristic counts were made only from the left side of the fish. To study the morphometric characteristics, the regression method has been employed with the formula :

$$Y = a + bx$$

where, 'Y' is the variable character, such as total length, head length etc., 'a' is a constant value to be determined; 'b' is the regression coefficient and 'x' is the total length. The value of "a" and "b" were determined by the following formula :

$$b = \frac{\sum XY - n\bar{x}\bar{y}}{\sum X^2 - n(\bar{x})^2}$$

where, n = total number of length groups; \bar{x} = mean of X and \bar{y} = mean of Y.

BIOMETRIC INDEX : The number of time, each body parameter goes into the total length of the fish was taken as the Biometric index (Tobor, 1974). The characters taken were : Standard length (SL), length of the head (HL), length of the girth (GL). depth of the body (BD), height of the dorsal fin (HD) and diameter of the eye (to the length of the head). For each parameters, a mean index for each 10 cm length groups, has been calculated to find out whether it is constant or varying with the increase in the total length.

LENGTH-WEIGHT RELATIONSHIP :

The length-weight relationship has been calculated by the allometric growth formula as used by Huxley (1924) in the form of : $W = aL^b$; where 'W' stands for weight, 'L' for length, 'a' and 'b' are constants. The equation was transformed into a logarithmic as suggested by LeCren (1951) and has been expressed as :

$$\text{Log}W = \text{Log} a + b \text{ log}L$$

The values of 'a' and 'b' were determined empirically.

The length-weight relationship during the present investigation has been studied with reference to the net weight of the fish i.e. including the gut and gonads. The observed average weight of the species were plotted against the average observed length to examine the nature of parabola. On converting the values to logarithms, the exponential relationship has

been expressed as the linear equation described above. The regression of log-weight on log-length has been calculated by the method of "least squares" by grouping the sample data. The relationship was calculated for different seasons also, to see the seasonal impact. Apart from that, the relationship has been studied for different life stages i.e., juvenile and adults and also for different sex.

CONDITION FACTOR :

Individual variations from general length-weight relationships have been studied under the general name "condition" (LeCren, 1951). Such changes in 'condition' have usually been analysed by means of a condition factor or Ponderal index, which has been calculated by using different formulae by various workers. However, in the present study, the 'condition factor' has been determined by using the following formula (Hile, 1936 and Beckman, 1948) :

$$K = \frac{W \times 10^5}{L^3}$$

where; K = condition factor and W = weight of the fish. The number 10^5 is a factor to bring the ponderal index (K) to near unity (Carlander, 1970).

FOOD AND FEEDING HABITS :

Food and feeding habits of L. pangusia and L. dero were studied by examining a total of 876 and 210 digestive tracts

respectively collected from the three river systems.

The guts were removed from the specimens after measuring and weighing each specimen, to the nearest centimeter and gram respectively and were preserved in 5% formalin for subsequent analysis. The preserved guts were later uncoiled, cleaned off the attached fat and their length and weight were recorded. The ratio between the gut length and total length (R.L.G.) has been estimated by adopting the following formula (Jacobshagen, 1913)

$$\text{R.L.G.} = \frac{\text{GL}}{\text{TL}}$$

where; GL stands for total length of the gut and TL is the total length of the fish.

The feeding intensity or gastro-somatic index (G.S.I.) has been calculated by the following formula (Desai, 1970)

$$\text{G.S.I.} = \frac{\text{Weight of the gut}}{\text{Total weight of the fish}} \times 100$$

Several methods for the enumeration of gut contents have been employed by different workers. However, in the present study the following methods were employed as described by Hynes (1950) and Pillay (1952).

(i) Volumetric method : The nature of the diet of both L. pangusia and L. dero was such that the quantitative analysis of gut contents was only feasible by eye estimation as suggested by Pearse (1915) and Pillay (1952).

(ii) Occurrence method : In this method, the number of guts containing a particular item of food was expressed as a percentage of the total number of guts examined (Hynes, 1950). This method apart from describing the qualitative analysis of the diet also gives the frequency of a particular food item occurred in the gut and thus helps to understand the preference of any particular food item.

The gut contents were also analysed for elucidating seasonal variations in the diet components. The data was also analysed for various size groups in order to see, if there is any basic change in dietary habits of the species at various stages of its growth.

For evaluating the importance of all food items, the "index of pre-ponderance" method (Natarajan and Jhingran, 1961) was employed,

$$I_i = \frac{V_i O_i \times 100}{V_i O_i}$$

where; I_i = Index of preponderance, V_i and O_i represent the percentage volume and occurrence of particular item of food (i) respectively.

MATURITY AND SPAWNING

MATURITY STAGES : A large number of keys for maturity stages have been described in the literature. However, in the present study, the maturity stages were determined following the key as

outlined by Kesteven (1960).

- I. Virgin : Very small sexual organs close to the vertebral column. Testes and ovaries transparent, colourless to grey. Eggs invisible to naked eye.
- II. Maturing Virgin : Testes and ovaries translucent, grey-red. Length half, or slightly more than half of the length of the ventral cavity. Single eggs can be seen with magnifying glass. Spent fishes (resting adult) also categorized in this stage.
- III. Developing : Testes and ovaries opaque, reddish with blood capillaries. Occupy about half of the ventral cavity. Eggs visible to the eye as whitish granular material.
- IV. Developing : Testes reddish white. No milt drops appear under pressure. Ovaries orange reddish. Eggs closely discernible; opaque. Testes and ovaries occupy about two-thirds of ventral cavity.
- V. Gravid : Sexual organs filling ventral cavity. Testes white, drops of milt fall with pressure. Eggs completely round, some already translucent and ripe.
- VI. Spawning : Roe and milt run with slight pressure. Most eggs translucent with few opaque eggs left in ovary.
- VII. Spent : Gonad flaccid and shrinking. Ventral cavity not fully empty. No opaque eggs left in ovary.

MATURITY INDEX OR GONADOSOMATIC RATIO (G.S.I.) : The gonads were weighed to the nearest 0.1 gm in a chemical balance. In order to study the condition of the gonads, the maturity index or gonadosomatic ratio (G.S.R.) or "coefficient of maturity" as proposed by Nikolsky (1963) has been calculated according to the following formula (Kesteven, 1942 and Vladykov, 1956) -

$$\text{G.S.R.} = \frac{\text{Gonad weight} \times 100}{\text{Total body weight}}$$

DETERMINATION OF M_{50} : The percentage of matured fish i.e. of stage IV to VI was examined for each length group of both sexes, and the 50% maturity or M_{50} has been determined as per Hodgkiss and Mann (1978).

OVA DIAMETER STUDY : For ova-diameter study, measurements of ova, were taken from formalin preserved materials. Preliminary examination of the ovaries revealed that within (anterior, middle and posterior part of individual ovary) and among individuals of the paired ovary, there was no significant difference either in relative number or in the mean ova diameter, consequently random sub-samples were taken and subjected to ova-diameter measurement with the help of an ocular micrometer. The diameters of ova along whatever axes they lay parallel to the graduation of the micrometer, were measured to ensure random nature of the readings and unbiased values as suggested by Clark (1934).

LENGTH AT FIRST MATURITY : The length of the fishes (both males and females) at first maturity has been determined by plotting the percentage of the number of males and females in II to VI stages of maturity to the total number of fishes examined, in a particular size group.

ABSOLUTE FECUNDITY : Ovaries from mature (ripe) specimens collected just before breeding were only used for fecundity studies. Both the ovaries were removed from the preserved gravid females of L. pangusia and L. dero of known length and weight. Sub-sampling by weight method (McGregor, 1922) has been employed and fecundity has been calculated from the counts of mature ova in two random sub-samples of the ovary of known weight, after drying-off the excess moisture with the help of a blotting paper, by using the following formula :

$$F = \frac{W \times (N_1 + N_2)}{(W_1 + W_2)}$$

where; F = Fecundity; W = Total weight of the ovary; W_1 and W_2 and N_1 and N_2 are the weights and ova counts respectively for each sub-samples.

RELATIVE FECUNDITY : Relative fecundity was calculated according to the following formula (Toots, 1951; Anokhina, 1963 and Hardisty, 1964)

$$\text{Relative Fecundity} = \frac{\text{Egg number}}{\text{Body weight}}$$

The trends of relationship between (a) fecundity and total length; (b) between fecundity and body weight and (c) between fecundity and ovary weight were examined and a log to log transformation in the form given below (Bagenal, 1978) has been followed :

$$\text{LogF} = \log a + b \log X$$

where; F = Fecundity, X = Variable factors like body length, weight etc., a and b are constants.

AGE AND GROWTH

For determining the age of the fishes, the scale method (Van Oosten, 1929) has been followed. The scales below the dorsal fin and above the lateral line were taken for age determination as per the suggestion of Thomson (1904). The slimy tissues and other extraneous matter attached to the scales were washed away taking care so that margins of the scales should not get damaged. The cleaned translucent scales were, thus, mounted in between two glass-slides with the ends of slides properly tied.

RELATIONSHIP BETWEEN BODY AND SCALE LENGTH : In order to ascertain the logarithmic relationship between body and scale length, the individual measurements obtained were fitted. The regression equation, $Y = a + bx$ (where; Y = Scale length; a = an additive constant, b = the multiplying constant and x = body length) has been calculated by the least square method.

BACK CALCULATION : Length attained at the time of annuli formation were back-calculated for each specimens individually using the following formula (Lee, 1920)

$$L_1 = \frac{L \times S_1}{S}$$

where; L_1 is the length of the fish at the time of annulus formation; L is the length of the fish at the time of capture; S is the scale radius and S_1 is the distance between the focus and each annulus of the scale.

The average of each datum were determined and considered as the length attained at a particular age.

SPECIFIC GROWTH : The specific growth (G) has been calculated for each age and size groups as follows (Bal and Jones, 1960) :

$$G = \frac{(\text{Log } L_2 - \text{Log } L_1) \times 100}{T_2 - T_1}$$

where; L_2 and L_1 were the lengths of the fish at the time of T_2 and T_1 respectively; L_1 and L_2 were the lengths at the beginning and at the end of each year of life. Thus $T_2 - T_1$ is one and specific growth rate expressed as percentage per annum.

DETERMINATION OF MAXIMUM OR ASYMPTOTIC LENGTH (L_∞) : The ultimate or maximum length (L_∞) attained by the fish has been determined graphically at a point when the length at age 'n'

equals length at age $n + 1$. The length at the age of n years were plotted against $n + 1$ years. A line was drawn at 45° through the zero point, which was intersected by the curve and this point of intersection shows the maximum (ultimate) or asymptotic length of the fish (Ford, 1933; Walford, 1946).

RESULTS

RESULTS

MORPHOMETRY AND MERISTIC COUNTS

MORPHOMETRY OF L. PANGUSIA

The mean values of different morphometric measurements of L. pangusia from all the three river systems have been summarized in Table 1 and described below.

Total length : The mean total length of L. pangusia from Simsang, Lubha and Madhura rivers were observed as 36.02 cm, 32.58 cm and 21.84 cm respectively.

Fork length : The mean value of fork length expressed as percentage of total length was found to be 83.37, 85.42 and 85.44 from Simsang, Lubha and Madhura rivers respectively.

Standard length : This, in percentage of total length, was found to be 76.37, 75.38 and 76.14 from Simsang, Lubha and Madhura rivers respectively.

Head length : The average value of head length in percentage of total length, was found to be 17.57, 19.09 and 18.50 from Simsang, Lubha and Madhura rivers respectively.

Body depth : The mean value of body depth expressed as percentage of total length has been observed to be 20.93; 20.60 and 25.87 from Simsang, Lubha and Madhura rivers.

Girth : The average girth expressed as percentage of total length was recorded to be 53.64, 51.75 and 62.18 from Simsang,

Lubha and Madhura rivers respectively.

Pre-dorsal length : In percentage of total length, the average value of pre-dorsal length was observed to be 35.73, 33.89 and 35.67 from Simsang, Lubha and Madhura rivers respectively.

Height of dorsal fin : The mean value of the parameter expressed as percentage of total length was found to be 18.21, 19.12 and 20.19 from Simsang, Lubha and Madhura rivers respectively.

Base of dorsal fin : This, in percentage of total length was found to be 14.02, 12.71 and 17.67 from Simsang, Lubha and Madhura rivers respectively.

Length of pectoral fin : The average value expressed as the percentage of total length was observed to be 17.55, 15.81 and 16.21 from Simsang, Lubha and Madhura rivers respectively.

Length of pelvic fin : The mean value of the length of pelvic fin expressed as percentage of total length was found to be 15.38, 15.56 and 15.43 from Simsang, Lubha and Madhura rivers respectively.

Length of anal fin : The mean value of the length of anal fin expressed as percentage of total length was recorded to be 16.74, 16.08 and 14.10 from Simsang, Lubha and Madhura rivers respectively.

Base of anal fin : This, in percentage of total length was found to be 6.64, 5.59 and 6.04 from Simsang, Lubha and Madhura

rivers respectively.

Length of caudal peduncle : The average value expressed as percentage of total length was found to be 16.44, 15.13 and 15.43 from Simsang, Lubha and Madhura rivers respectively.

Least height of caudal peduncle : The mean value expressed as percentage of total length was observed to be 9.72, 9.39 and 9.48 from Simsang, Lubha and Madhura rivers respectively.

Head depth : The mean value of head depth expressed as percentage of total length was found to be 9.43, 9.03 and 8.02 from Simsang, Lubha and Madhura rivers respectively.

Eye diameter : The mean value of eye diameter expressed as percentage of head length was found to be 17.69, 16.72 and 20.54 from Simsang, Lubha and Madhura rivers respectively.

Pre-orbital length : The mean value of the pre-orbital length expressed as percentage of head length was found to be 53.24, 56.75 and 50.25 from Simsang, Lubha and Madhura rivers respectively.

Post-orbital length : The average value of the post-orbital length expressed as percentage of head length was found to be 39.18, 37.78 and 35.89 from Simsang, Lubha and Madhura rivers respectively.

Inter-orbital length : This, in percentage of head, length, was

Table 1: MORPHOMETRIC ANALYSIS OF LABEO PANGUSIA

Parameters	<u>Simsang River</u>		<u>Lubha River</u>		<u>Madhura River</u>	
	Mean (cm)	% of TL	Mean (cm)	% of TL	Mean (cm)	% of TL
Total length	36.02	100.00	32.58	100.00	21.84	100.00
Fork length	30.03	83.37	27.83	85.42	18.66	85.44
Standard length	27.51	76.37	24.56	75.38	16.63	76.14
Head length	6.33	17.57	6.22	19.09	4.04	18.50
Body depth	7.54	20.93	6.71	20.60	5.65	25.87
Girth	19.32	53.64	16.86	51.75	13.58	62.18
Pre-dorsal length	12.87	35.73	11.04	33.89	7.49	35.67
Height of dorsal fin	6.56	18.21	6.23	19.12	4.41	20.19
Base of dorsal fin	5.05	14.02	4.14	12.71	3.86	17.67
Length of pectoral fin	6.32	17.55	5.15	15.81	3.54	16.21
Length of pelvic fin	5.54	15.38	5.07	15.56	3.37	15.43
Length of anal fin	6.03	16.74	5.24	16.08	3.08	14.10
Base of anal fin	2.39	6.64	1.82	5.59	1.32	6.04
Length of caudal peduncle	5.92	16.44	4.93	15.13	3.37	15.43
Least height of caudal peduncle	3.50	9.72	3.06	9.39	2.07	9.48
Head depth	3.82	9.43	3.61	9.03	2.71	8.02
<u>Parameters</u>	<u>Mean (cm)</u>	<u>% of HL</u>	<u>Mean (cm)</u>	<u>% of HL</u>	<u>Mean (cm)</u>	<u>% of HL</u>
Eye diameter	1.22	17.69	1.04	16.72	0.83	20.54
Pre-orbital length	3.37	53.24	3.53	56.75	2.03	50.25
Post-orbital length	2.48	39.18	2.35	37.78	1.45	35.89
Inter-orbital length	3.44	54.34	3.06	49.20	1.97	48.76
Length of upper jaw	5.02	79.30	5.08	81.67	3.09	76.49

recorded to be 54.34, 49.20 and 48.76 from Simsang, Lubha and Madhura rivers respectively.

Length of upper jaw : This, in percentage of head length, was found to be 79.30, 81.67 and 76.49 from Simsang, Lubha and Madhura rivers respectively.

MORPHOMETRY OF L. DERO

The mean values of different morphometric measurements of this species have been presented in Table 2 and summarized below :

Total length : The average total length of L. dero from Simsang, Lubha and Madhura rivers was recorded to be 16.68 cm, 29.50 cm and 33.26 cm respectively.

Fork length : The average fork length expressed as percentage of total length was found to be 84.11, 87.19 and 85.78 from Simsang, Lubha and Madhura rivers respectively.

Standard length : The mean value of standard length expressed as percentage of total length was found to be 76.62, 75.73 and 79.86 from Simsang, Lubha and Madhura rivers respectively.

Head length : The mean value of head length expressed as percentage of total length was found to be 17.75, 18.00 and 18.55 from Simsang, Lubha and Madhura rivers respectively.

Body depth : This, in percentage of total length was recorded

to be 22.0, 19.12 and 21.44 from Simsang, Lubha and Madhura rivers respectively.

Girth : The mean value of girth expressed as percentage of total length was found to be 47.72, 49.73 and 51.17 from Simsang, Lubha and Madhura rivers respectively.

Pre-dorsal length : The average value of pre-dorsal length expressed as percentage of total length was found to be 34.53, 33.32 and 33.49 from Simsang, Lubha and Madhura rivers respectively.

Height of dorsal length : This, in percentage of total length was observed to be 29.50, 23.93 and 35.57 from Simsang, Lubha and Madhura rivers respectively.

Base of dorsal : The average value of the base of dorsal fin expressed as percentage of total length was found to be 15.17, 15.36 and 15.72 from Simsang, Lubha and Madhura rivers respectively.

Length of pectoral fin : The mean value of the length of pectoral fin expressed as percentage of total length was recorded to be 17.75, 16.68 and 15.54 from Simsang, Lubha and Madhura rivers respectively.

Length of pelvic fin : This, in percentage of the total length was observed to be 15.47, 15.39 and 14.37 from Simsang, Lubha and Madhura rivers respectively.

Length of anal fin : The average value of the length of anal fin expressed as percentage of total length was found to be 15.65, 17.02 and 14.79 from Simsang, Lubha and Madhura rivers respectively.

Base of anal fin : The mean value of the base of the anal fin expressed as percentage of total length was found to be 6.24, 7.22 and 6.49 from Simsang, Lubha and Madhura rivers respectively.

o Length of caudal peduncle : This, in percentage of total length was observed to be 15.83, 14.37 and 16.57 from Simsang, Lubha and Madhura rivers respectively.

Least height of caudal peduncle : This, in percentage of total length was recorded to be 8.15, 9.59 and 9.35 from Simsang, Lubha and Madhura rivers respectively.

Head depth : The average value of head depth expressed as percentage of total length was found to be 8.88, 9.25 and 9.06 from Simsang, Lubha and Madhura rivers respectively.

Eye diameter : The mean value of eye diameter in percentage of head length was recorded to be 17.36, 15.82 and 16.86 from Simsang, Lubha and Madhura rivers respectively.

Pre-orbital length : The average value in percentage of head length was found to be 38.85, 38.79 and 41.00 from Simsang, Lubha and Madhura rivers respectively.

Table 2: MORPHOMETRIC ANALYSIS OF LABEO DERO

Parameters	<u>Simsang River</u>		<u>Lubha River</u>		<u>Madhura River</u>	
	Mean (cm)	% of TL	Mean (cm)	% of TL	Mean (cm)	% of TL
Total length	16.68	100.00	29.50	100.00	33.26	100.00
Fork length	14.03	84.11	25.72	87.19	28.53	85.78
Standard length	12.78	76.62	22.34	75.73	26.56	79.86
Head length	2.96	17.75	5.31	18.00	6.17	18.55
Body depth	3.67	22.00	5.64	19.12	7.13	21.44
Girth	7.96	47.72	14.67	49.73	17.02	51.17
Pre-dorsal length	5.76	34.53	9.83	33.32	11.14	33.49
Height of dorsal length	4.92	29.50	7.06	23.93	11.83	35.57
Base of dorsal fin	2.53	15.17	4.53	15.36	5.23	15.72
Length of pectoral fin	2.96	17.75	4.92	16.68	5.17	15.54
Length of pelvic fin	2.50	15.47	4.54	15.39	4.78	14.37
Length of anal fin	2.61	15.65	5.02	17.02	4.92	14.79
Base of anal fin	1.04	6.24	2.13	7.22	2.16	6.49
Length of caudal peduncle	2.64	15.83	4.24	14.37	5.51	16.57
Least height of caudal peduncle	1.36	8.15	2.83	9.59	3.11	9.35
Head depth	1.88	8.88	3.18	9.25	3.67	9.06
<u>Parameters</u>	<u>Mean (cm)</u>	<u>% of HL</u>	<u>Mean (cm)</u>	<u>% of HL</u>	<u>Mean (cm)</u>	<u>% of HL</u>
Eye diameter	0.51	17.36	0.84	15.82	1.04	16.86
Pre-orbital length	1.15	38.85	2.06	38.79	2.53	41.00
Post-orbital length	1.27	42.91	2.41	45.34	2.71	43.92
Inter-orbital length	1.36	45.81	2.56	48.21	2.73	44.17
Length of upper jaw	2.37	79.93	4.51	84.93	4.86	78.77

Post-orbital length : This, in percentage of head length was found to be 42.91, 45.34 and 43.92 from Simsang, Lubha and Madhura rivers respectively.

Inter-orbital length : The mean value expressed as percentage of head length was found to be 45.81, 48.21 and 44.17 from Simsang, Lubha and Madhura rivers respectively.

Length of upper jaw : This, in percentage of head length was found to be 79.93, 84.93 and 78.77 from Simsang, Lubha and Madhura rivers respectively.

Regression equations for various morphometric parameters studied for L. pangusia and L. dero from the three river systems have been given in Table 3 and 4.

MERISTIC COUNTS OF L. PANGUSIA

The details of the meristic counts for L. pangusia have been presented in Table 5 and summarized below.

Dorsal fin spine : The number of spines in the dorsal fin rays was found to be constant (2) in the specimens from all the three rivers studied.

Dorsal fin rays : The mean value of the number of dorsal fin rays was found to be 11.34, 10.59 and 11.21 from Simsang, Lubha and Madhura rivers respectively.

Pectoral fin rays : The mean value of the number of pectoral fin

Table 3: REGRESSION EQUATIONS OF VARIABLE MORPHOMETRIC CHARACTERS OF LABEO PANGUSIA

Parameters	Simsang River	Lubha River	Madhura River
Standard length (X) on total length (Y)	$Y = -0.1373 + 1.0173X$ (r = 0.9996)	$Y = -0.2062 + 1.8610X$ (r = 0.9912)	$Y = 0.1467 + 1.1261X$ (r = 0.9881)
Head length (X) on total length (Y)	$Y = 0.1162 + 5.6782X$ (r = 0.9880)	$Y = 0.4652 + 5.0571X$ (r = 0.9931)	$Y = 0.6426 + 5.3739X$ (r = 0.9827)
Girth (X) on total length (Y)	$Y = 0.3823 + 1.7204X$ (r = 0.9992)	$Y = -2.2050 + 2.1619X$ (r = 0.9746)	$Y = -0.5372 + 1.6990X$ (r = 0.9932)
Body depth (X) on total length (Y)	$Y = -0.4623 + 4.9557X$ (r = 0.9890)	$Y = -0.1816 + 5.0408X$ (r = 0.9906)	$Y = -1.3167 + 4.2163X$ (r = 0.9796)
Eye diameter (X) on head length	$Y = -0.4725 + 5.2416X$ (r = 0.9754)	$Y = 0.2126 + 6.0416X$ (r = 0.9862)	$Y = 0.6816 + 5.1106X$ (r = 0.9652)

Table 4: REGRESSION EQUATIONS OF VARIABLE MORPHOMETRIC CHARACTERS OF LABEO DERO

Parameters	Simsang River	Lubha River	Madhura River
Standard length (X) on total length (Y)	$Y = 0.0712 + 1.3333X$ ($r = 0.9836$)	$Y = -0.3205 + 1.1640X$ ($r = 0.9781$)	$Y = 0.2234 + 1.1769X$ ($r = 0.9919$)
Head length (X) on total length (Y)	$Y = -0.1254 + 5.5931X$ ($r = 0.9983$)	$Y = -0.0214 + 5.5687X$ ($r = 0.9746$)	$Y = -0.4251 + 5.5610X$ ($r = 0.9923$)
Girth (X) on total length (Y)	$Y = -0.1451 + 2.0417X$ ($r = 0.9689$)	$Y = -0.1056 + 2.1129X$ ($r = 0.9826$)	$Y = 1.9461 + 1.9673X$ ($r = 0.9863$)
Body depth (X) on total length (Y)	$Y = 0.3166 + 4.4023X$ ($r = 0.9927$)	$Y = -0.1879 + 5.2693X$ ($r = 0.9920$)	$Y = -0.7012 + 4.7458X$ ($r = 0.9768$)
Eye diameter (X) on head length (Y)	$Y = -0.4823 + 4.6143X$ ($r = 0.9953$)	$Y = 0.3137 + 6.2485X$ ($r = 0.9924$)	$Y = -0.1341 + 6.2882X$ ($r = 0.9877$)

rays was found to be 16.24, 15.91 and 15.96 from Simsang, Lubha and Madhura rivers respectively.

Pelvic fin rays : The average value of the number of pelvic fin rays was recorded to be 8.88, 8.92 and 8.81 from Simsang, Lubha and Madhura rivers respectively.

Anal fin spine : Number of spines in the anal fin were found constant (2) from all the three rivers.

Anal fin rays : The mean number of anal fin rays was found to be 4.87, 4.98 and 4.95 from Simsang, Lubha and Madhura rivers respectively.

Caudal fin rays : The average number of caudal fin rays was recorded to be 19.84, 21.46 and 20.38 from Simsang, Lubha and Madhura rivers respectively.

Lateral line scales : The mean value of the number of lateral line scales was found to be 42.68, 40.62 and 40.83 from Simsang, Lubha and Madhura rivers respectively.

Number of scales above lateral line : In average, this was found to be 7.63, 7.68 and 7.47 from Simsang, Lubha and Madhura rivers respectively.

Number of scales below lateral line : In average, this was observed to be 5.67, 5.58 and 5.29 from Simsang, Lubha and Madhura rivers respectively.

Table 5: MERISTIC COUNTS OF LABEO PANGUSIA

Parameters	Simsang River		Lubha River		Madhura River	
	Mean	Range	Mean	Range	Mean	Range
Dorsal fin spine	2	const.	2	const.	2	const.
Dorsal fin rays	11.34	10-12	10.59	10-12	11.21	10-12
Pectoral fin rays	16.24	15-17	15.91	14-17	15.96	15-17
Pelvic fin rays	8.88	8-9	8.92	8-9	8.81	8-9
Anal fin spine	2	const.	2	const.	2	const.
Anal fin rays	4.87	4-5	4.98	4-5	4.95	4-5
Caudal fin rays	19.84	18-21	21.46	19-23	20.38	18-22
Lateral line scales	42.68	40-43	40.62	39-42	40.83	40-42
No. of scales above lateral line	7.63	7-8	7.68	6-8	7.47	7-8
No. of scales below lateral line	5.67	5-7	5.58	5-6	5.29	5-6

MERISTIC COUNTS OF L. DERO

The results of the various meristic counts obtained for L. dero have been presented in Table 6 and are summarized below.

Dorsal fin spine : This has been found constant (2) in the specimens from all the three rivers studied.

Dorsal fin rays : The average number of dorsal fin rays was observed to be 15.56, 16.14 and 15.76 from Simsang, Lubha and Madhura rivers respectively.

Pectoral fin rays : The mean value of the number of pectoral fin rays was found to be 14.27, 14.72 and 14.44 from Simsang, Lubha and Madhura rivers respectively.

Pelvic fin rays : The mean value of the number of pelvic fin rays was found to be 8.86, 8.74 and 8.82 from Simsang, Lubha and Madhura rivers respectively.

Anal fin spine : The number of spine in the anal fin was found to be constant (2) in the specimens collected from all the three rivers.

Anal fin rays : The mean number of rays in the anal fin was found to be 4.93, 4.86 and 4.89 from Simsang, Lubha and Madhura rivers respectively.

Caudal fin rays : This, in average was found to be 19.75, 20.47 and 20.24 from Simsang, Lubha and Madhura rivers respectively.

Table 6: MERISTIC COUNTS OF LABEO DERO

Parameters	Simsang River		Lubha River		Madhura River	
	Mean	Range	Mean	Range	Mean	Range
Dorsal fin spine	2	const.	2	const.	2	const.
Dorsal fin rays	15.56	14-17	16.14	15-17	15.76	15-17
Pectoral fin rays	14.27	13-15	14.72	14-15	14.44	13-15
Pelvic fin rays	8.86	8-9	8.74	8-9	8.82	8-9
Anal fin spine	2	const.	2	const.	2	const.
Anal fin rays	4.93	4-5	4.86	4-5	4.89	4-5
Caudal fin rays	19.75	19-21	20.47	19-21	20.24	19-21
Lateral line scales	40.48	40-41	41.17	40-42	40.81	40-42
No. of scales above lateral line	7.82	7-9	7.38	7-8	7.65	7-9
No. of scales below lateral line	6.28	6-7	6.53	6-7	6.34	6-7

Lateral line scales : The mean number of scales in the lateral line was recorded to be 40.48, 41.17 and 40.81 from Simsang, Lubha and Madhura rivers respectively.

Number of scales above lateral line : The mean value was found to be 7.82, 7.38 and 7.65 from Simsang, Lubha and Madhura rivers respectively.

Number of scales below lateral line : The mean value was observed to be 6.28, 6.53 and 6.34 from Simsang, Lubha and Madhura rivers respectively.

BIOMETRIC INDEX OF L. PANGUSIA

For each characters, a mean biometric index for each 10 cm length groups have been calculated to see whether it is constant or varying with increase in total length (Table 7). It has been observed that growth of the head (HL) in relation to total length (TL) is isometric or in other words, exhibits a constant index (Fig. 3). The growth of the head-depth (HD) also shows more or less isometric growth (Fig. 3). The other parameters such as standard length (SL), body-depth (BD), girth (G) and eye-diameter (ED) show allometric growth. The growth of body-depth (BD) and girth (G) illustrates positive allometry whereas, that of eye diameter (ED) in relation to head length (HL) shows a negative allometry (Fig. 3).

Table 7: MEAN BIOMETRIC INDICES IN DIFFERENT LENGTH GROUPS OF
LABEO PANGUSIA

(a) Simsang River

Size Group Ratio	I 0-10 cm	II 10.1-20 cm	III 20.1-30 cm	IV 30.1-40 cm	V 40.1-50 cm	VI 50.1-60 cm
TL/SL	-	1.2814	1.2973	1.3093	1.2607	1.2582
TL/BD	-	5.1714	4.7059	4.7368	4.6444	4.1852
TL/HL	-	5.3253	5.2174	5.3704	5.1149	4.9524
TL/GL	-	1.9674	1.8750	1.8638	1.7443	1.6317
TL/HD	-	5.0278	5.2857	5.3286	5.8645	5.6523
HL/ED	-	4.5333	5.1529	5.2885	7.2510	7.3448

(b) Lubha River

TL/SL	1.3089	1.3009	1.2673	1.3266	1.2845	1.2722
TL/BD	5.0870	4.7421	4.7912	4.5405	4.2889	3.8724
TL/HL	5.1787	5.2604	5.2051	5.2379	5.3862	5.2691
TL/GL	1.9514	1.8846	1.8203	1.9324	1.6954	1.6048
TL/HD	5.3182	5.3333	5.0134	4.8762	5.2895	5.4163
HL/ED	3.9167	4.6154	5.1227	5.5808	6.4081	7.5344

(c) Madhura River

TL/SL	1.2789	1.3087	1.3142	1.2870	1.2824	1.2669
TL/BD	5.2727	4.9216	4.8655	4.7212	4.8675	4.2413
TL/HL	5.3435	5.2188	5.3859	5.4291	5.2049	5.0996
TL/GL	1.8716	1.7841	1.7682	1.8062	1.7224	1.6818
TL/HD	5.5238	4.9118	5.2539	4.9219	5.5283	5.4737
HL/ED	4.1818	4.9163	4.8875	5.1815	6.6173	7.4313

Table 8: MEAN BIOMETRIC INDICES IN DIFFERENT LENGTH GROUPS
OF LABEO DERO

(a) Simsang River

Size Group-	I	II	III	IV
Ratio	10-20 cm	20.1-30 cm	30.1-40 cm	40.1-50 cm
TL/SL	1.2941	1.2973	1.2620	1.2278
TL/BD	4.4392	4.7059	5.1282	4.5604
TL/HL	5.4400	5.2174	5.7325	5.6467
TL/GL	1.9474	1.8750	1.7893	1.7437
HL/ED	4.3951	5.7500	6.8261	7.1429

(b) Lubha River

TL/SL	1.2556	1.3077	1.2725	1.2393
TL/BD	4.6168	4.8571	4.9351	4.7303
TL/HL	5.2990	5.2809	5.5882	5.6133
TL/GL	1.8445	2.0877	1.7431	1.7839
HL/ED	4.7581	5.1383	6.4712	6.9091

(c) Madhura River

TL/SL	1.2603	1.3152	1.2523	1.2359
TL/BD	4.7063	4.6538	4.6648	4.6503
TL/HL	5.4264	5.2489	5.3906	5.7071
TL/GL	1.9021	1.7225	1.9542	1.8304
HL/ED	4.0769	5.8750	5.9327	6.0833

BIOMETRIC INDEX OF L. DERO

For each characters, a mean biometric index for each 10 cm length groups, was calculated and is summarized in Table 8. It is quite clear from Fig. 4 that body depth (BD) in relation to total length (TL) more or less exhibits isometric growth. The growth of the head (HL) and eye-diameter (ED) in relation to total length and head length respectively, show negative allometry whereas standard length (SL) in relation to total length shows a positive allometry (Fig. 4).

POPULATION STRUCTURE

LENGTH FREQUENCY DISTRIBUTION OF L. PANGUSIA

To find out the length frequency distribution, the frequencies have been converted into percentages and plotting the same against the respective length groups (Fig. 5A). It may be seen from Fig. 5A that a single peak in the length frequency distribution has been observed at 25.1 - 30.0 cm length group in Simsang river while the peak has been noticed at 30.1 - 35.0 cm length group in Lubha river. In Madhura river population, the peak has been found at 10.1 - 15.0 cm length group.

LENGTH FREQUENCY DISTRIBUTION OF L. DERO

From Fig. 5B it is clear that the peak of the frequency polygon is at 25.1 - 30.0 cm length group in Simsang river, whereas the peak is at 30.1 - 35.0 cm in Lubha river and at 15.1 - 20.0 cm length group in Madhura river population.

SEASONAL VARIATIONS IN SEX-RATIO OF L. PANGUSIA

It is evident from Fig. 6A that during certain periods of the year, particularly, from March to August, the females predominate over males in the catch. The sex-ratio during this period was observed to be significantly high. Further, it is also seen that females dominated over the males in general throughout the period of the study. In Simsang river, the ratio (male:female) was found to be 1:1.2514 while from Lubha and Madhura rivers the ratios were 1:1.4232 and 1:1.3569 respectively.

SEX-RATIO IN DIFFERENT LENGTH GROUPS OF L. PANGUSIA

It is interesting to note that in the smaller size groups the males dominated over the females or number of males remained almost equal with females unlike the higher length groups where the males were outnumbered by the females (Fig.6C).

SEASONAL VARIATIONS OF SEX-RATIO IN L. DERO

The females were found to be more in numbers almost throughout the year in all the three population studied (Fig. 6B). The overall sex-ratio has been observed to be 1:1.8182, 1:2.0333 and 1:2.5333 from Simsang, Lubha and Madhura rivers respectively.

SEX-RATIO IN DIFFERENT LENGTH GROUPS OF L. DERO

The sex-ratio in different length groups has been shown in Fig. 6D, which indicates that the males are outnumbered

by the females in almost all the length groups. The number of females have been observed significantly higher than the males at 30.1 - 40.0 cm and 40.1 - 50.0 cm length groups.

AGE FREQUENCY DISTRIBUTION OF L. PANGUSIA

The number of specimens found in a particular age groups have been converted into percentages and thereafter plotting the same against the respective age groups. It is clear from Fig. 7A that a single peak has been observed at I-year age group in both Simsang and Lubha river population, whereas in Madhura river the peak has been found at 0-year age group.

AGE FREQUENCY DISTRIBUTION OF L. DERO

In Simsang and Lubha river populations the peak has been observed at II-year age group whereas in Madhura river population the peak has been found at 1-year age group (Fig. 7B).

LENGTH-WEIGHT RELATIONSHIP

LENGTH-WEIGHT RELATIONSHIP OF L. PANGUSIA

The entire length-weight data of L. pangusia were pooled into a single equation and calculated to be :

$$\text{Log}W = -2.0220 + 3.0066 \log L \quad (r = 0.9724)$$

where W = total weight; and L = total length. A high correlation between length and weight is indicated by the correlation

coefficient (r). The derived parabolic equation is as follows:

$$W = .009506 L^{3.0066}$$

LENGTH-WEIGHT RELATIONSHIP IN L. PANGUSIA DURING DIFFERENT SEASONS

The length-weight relationship during different seasons has been calculated to see any impact if any, of seasons on this relationship. The three seasons viz., summer, monsoon and winter have been taken into consideration. The various parabolic equations have been tabulated in Table 9A. It is evident from the results that the value of regression coefficient (b) was maximum (2.9775 and 3.2340 respectively) during monsoon season in the specimens from Simsang and Madhura rivers whereas the maximum 'b' value in the case of specimens from Lubha river has been observed during summer (3.4109).

LENGTH-WEIGHT RELATIONSHIP IN JUVENILES OF L. PANGUSIA

The length-weight relationship in the juveniles is based on the data from the specimens having a length below 15 cm. The regression equations for juveniles were estimated to be :

Simsang River	:	$\text{Log}W = - 1.6774 + 2.6820 \log L$	(r=0.9870)
Lubha River	:	$\text{Log}W = - 2.0026 + 2.9721 \log L$	(r=0.9855)
Madhura River	:	$\text{Log}W = - 1.7699 + 2.7635 \log L$	(r=0.9931)

On plotting the average weight of juveniles against the average observed length, a parabolic curve has been obtained

(Fig. 8A, B, C). The logarithmic graph prepared with the above data showed a straight line relationship (Fig. 8D, E, F).

LENGTH-WEIGHT RELATIONSHIP OF ADULT L. PANGUSIA

The regression equations for adults (having a length of above 15 cm) irrespective of sex were calculated to be :

$$\text{Simsang River} : \text{LogW} = - 1.8034 + 2.8454 \log L \quad (r=0.9921)$$

$$\text{Lubha River} : \text{LogW} = - 2.2080 + 3.0517 \log L \quad (r=0.9804)$$

$$\text{Madhura River} : \text{LogW} = - 2.0044 + 2.9884 \log L \quad (r=0.9966)$$

Further, the length-weight relationships of adult specimens were worked out separately for males and females. The parabolic equations of the length-weight relationships of both males and females have been presented in Table 9A. The regression equations derived for adult males and females of

L. pangusia from the three river systems are :

$$\text{Simsang River} : \sigma^{\uparrow} : \text{LogW} = - 1.6956 + 2.7598 \log L \quad (r=0.9974)$$

$$\text{♀} : \text{LogW} = - 1.8410 + 2.8794 \log L \quad (r=0.9991)$$

$$\text{Lubha River} : \sigma^{\uparrow} : \text{LogW} = - 1.7469 + 2.7858 \log L \quad (r=0.9959)$$

$$\text{♀} : \text{LogW} = - 2.2748 + 3.1970 \log L \quad (r=0.9893)$$

$$\text{Madhura River} : \sigma^{\uparrow} : \text{LogW} = - 1.6893 + 2.7475 \log L \quad (r=0.9925)$$

$$\text{♀} : \text{LogW} = - 2.0982 + 3.0731 \log L \quad (r=0.9947)$$

On plotting the observed length against observed weight, a parabolic curve has been obtained (Fig. 9A, B, C and 10A, B,

Table 9: LENGTH-WEIGHT EQUATIONS OF LABEO PANGUSIA AND L. DERO

A. LABEO PANGUSIA

<u>Life stages</u>	Parabolic Equations		
	Simsang River	Lubha River	Madhura River
Male	$W=0.02016L^{2.7598}$	$W=0.01791L^{2.7858}$	$W=0.02049L^{2.7475}$
Female	$W=0.01442L^{2.8794}$	$W=0.005311L^{3.1970}$	$W=0.001004L^{3.0731}$
Juvenile	$W=0.02102L^{2.6820}$	$W=0.001017L^{2.9721}$	$W=0.01698L^{2.7635}$
<u>Seasons</u>			
Winter	$W=0.01435L^{2.9439}$	$W=0.004065L^{3.2719}$	$W=0.01512L^{2.8701}$
Summer	$W=0.01328L^{2.8336}$	$W=0.002752L^{3.4109}$	$W=0.007586L^{3.0811}$
Monsoon	$W=0.01089L^{2.9775}$	$W=0.003314L^{3.3301}$	$W=0.004496L^{3.2340}$

B. LABEO DERO

Sife stages

<u>Juvenile</u>			
Male	$W=0.008498L^{3.0363}$	$W=0.005860L^{3.1645}$	$W=0.006774L^{3.1269}$
Female	$W=0.006850L^{3.1243}$	$W=0.007454L^{3.0990}$	$W=0.005974L^{3.1270}$
<u>Adult</u>			
Male	$W=0.02854L^{2.6336}$	$W=0.03716L^{2.5847}$	$W=0.01153L^{2.9261}$
Female	$W=0.07160L^{2.7284}$	$W=0.005832L^{3.1779}$	$W=0.0003027L^{3.9688}$

C) and when plotted logarithmically, a straight line relationship was evident in each cases (Fig. 9 D, E, F and 10 D, E, F).

LENGTH-WEIGHT RELATIONSHIP OF L. DERO

The length-weight data of L. dero were pooled together irrespective of population and was calculated to be :

$$\text{LogW} = - 1.9409 + 2.9030 \log L \quad (r=0.9827)$$

The derived parabolic equation is as follows :

$$W = 0.01146 L^{2.9030}$$

LENGTH-WEIGHT RELATIONSHIP IN JUVENILES OF L. DERO

The length-weight data of juveniles were based on the specimens ranging from 10.0 cm to 20.0 cm collected from the three populations (specimens below 10.0 cm were not present in the catch). The parabolic equations of the relationship were given in Table 9B. The regression equations of the length-weight relationships were estimated to be :

$$\text{Simsang River : } \sigma : \text{LogW} = -2.0707 + 3.0363 \log L \quad (r=0.9970)$$

$$\quad \quad \quad \phi : \text{LogW} = -2.1643 + 3.1243 \log L \quad (r=0.9979)$$

$$\text{Lubha River : } \sigma : \text{LogW} = -2.2321 + 3.1645 \log L \quad (r=0.9933)$$

$$\quad \quad \quad \phi : \text{LogW} = -2.1279 + 3.0990 \log L \quad (r=0.9963)$$

$$\text{Madhura River : } \sigma : \text{LogW} = -2.1692 + 3.1269 \log L \quad (r=0.9971)$$

$$\quad \quad \quad \phi : \text{LogW} = -2.2238 + 3.1270 \log L \quad (r=0.9949)$$

The log-log relationship of length and weight was found to be linear in all cases (Fig. 11).

LENGTH-WEIGHT RELATIONSHIP IN ADULTS OF LABEO DERO

The regression equations derived for adult males and females irrespective of population were calculated to be :

$$\text{Males : LogW} = - 1.6553 + 2.7681 \log L \quad (r = 0.9796)$$

$$\text{Females : LogW} = - 2.4620 + 3.3869 \log L \quad (r = 0.9914)$$

The regression equations of males and females from all the three populations were found to be :

Simsang River

$$\text{Males : LogW} = - 1.5445 + 2.6336 \log L \quad (r = 0.9870)$$

$$\text{Females : LogW} = - 1.4901 + 2.7284 \log L \quad (r = 0.9527)$$

Lubha River

$$\text{Males : LogW} = - 1.4299 + 2.5847 \log L \quad (r = 0.6924)$$

$$\text{Females : LogW} = - 2.2342 + 3.1779 \log L \quad (r = 0.9677)$$

Madhura River

$$\text{Males : LogW} = - 1.9382 + 2.9261 \log L \quad (r = 0.9958)$$

$$\text{Females : LogW} = - 3.5190 + 3.9688 \log L \quad (r = 0.9949)$$

The parabolic equations of the length-weight relationships of males and females have been presented in Table 9B and logarithmic relationships were depicted in Fig. 12 which were found to be linear in all the cases.

CONDITION FACTOR

SEASONAL FLUCTUATIONS IN CONDITION FACTOR OF L. PANGUSIA

The values of condition factor of the species (Table 10A) showed almost an uniform trend of variations. It may be seen from the Fig. 13A that 'K' values showed a steady rise from the month of February to attain a peak during April-May in the species from all the river systems studied. The values dropped down in June reaching minimum in July after which once again increased during August-October.

CONDITION FACTOR OF L. PANGUSIA IN DIFFERENT LENGTH GROUPS

The condition factor (K) has been calculated for each 10 cm length groups and presented in Table 11A.

The 'K' value was found to be highest in 10 - 20 cm size group in all the populations studied (Fig. 13C). In the subsequent length groups the 'K' value gradually dropped down to reach its minimum in 50 - 60 cm length groups.

MONTHLY FLUCTUATIONS OR CONDITION FACTOR OF L. DERO

Monthwise averages of condition factor have been calculated for the entire study period to elucidate the seasonal fluctuations and have been presented in Table 10B. It is evident from Fig. 13B that the 'K' factor shows higher values in March-April and again in August-September. Lower 'K' values

Table 10: MONTHLY FLUCTUATIONS IN THE CONDITION FACTOR

A. LABEO PANGUSIA

Months	Simsang River	Lubha River	Madhura River
December 1979	0.8616	0.8965	0.8469
January 1980	0.8374	0.9021	0.8810
February	0.8590	0.9661	0.9083
March	0.9182	0.9614	0.9017
April	0.9789	1.0572	0.9409
May	0.9568	0.8733	0.8923
June	0.9017	0.8556	0.8151
July	0.8432	0.8047	0.7846
August	0.8791	0.8696	0.8520
September	0.8704	0.8908	0.8886
October	0.8653	0.9062	0.9177
November	0.8311	0.8580	0.8491

B. LABEO DERO

December 1979	0.8994	0.9220	0.8924
January 1980	0.8810	-	0.8931
February	0.9178	0.9290	0.9282
March	0.9112	0.9688	0.9473
April	0.9826	0.9775	0.9754
May	0.9344	0.9018	0.9215
June	0.9356	0.8632	-
July	0.8667	0.8771	0.9048
August	0.9408	0.8902	0.9658
September	0.9196	0.9036	-
October	0.8617	-	0.9186
November	0.8585	0.9019	0.8993

Table 11: FLUCTUATIONS IN THE CONDITION FACTOR OF DIFFERENT LENGTH GROUPS

A. LABEO PANGUSIA

Size Group (cm)	Simsang River	Lubha River	Madhura River
C-10.0	-	1.0498	0.9863
10.1-20.0	1.0556	1.0675	0.9978
20.1-30.0	1.0090	1.0491	0.9818
30.1-40.0	0.9802	0.9905	0.9720
40.1-50.0	0.9851	0.9889	0.9676
50.1-60.0	0.9641	0.9853	0.9446

B. LABEO DERO

10.0-15.0	0.9666	0.9845	0.9976
15.1-20.0	0.9891	0.9815	0.9865
20.1-25.0	0.9710	1.0329	0.9816
25.1-30.0	0.9753	0.9715	0.9720
30.1-35.0	0.9383	0.9577	0.9337
35.1-40.0	0.9401	0.9612	0.9495
40.1-45.0	0.9210	0.9545	0.9452

were observed during June-July in all the three populations (Fig. 13B).

CONDITION FACTOR OF L. DERO IN DIFFERENT LENGTH GROUPS

The condition factor, 'K' has been calculated for each 5 cm length groups and presented in Table 11B.

It is evident from Fig. 13D that with the increase in length, the "condition" of the species rises steadily reaching a peak at 25.1 - 30.0 cm length group in the case of individuals from Simsang river and at 20.1 - 25.0 cm length group in the specimens from Lubha and Madhura rivers. In the higher length groups, the 'K' value gradually decreases reaching minimum at 40.1 - 45.0 cm length group.

FOOD AND FEEDING HABITS

COMPOSITION OF GUT CONTENTS IN L. PANGUSIA

Percentage composition of different items in the guts of the species from three population have been summarized in Table 12 which also shows the index of preponderance of various food components.

The gut contents of L. pangusia have been grouped into 8 broad categories, i.e. (i) Bacillariophyceae, (ii) Chlorophyceae, (iii) Myxophyceae, (iv) Vegetable matter, (v) Detritus, (vi) Animal matter, (vii) Sand particles and (viii) Miscella-

Table 12: INDEX OF PREPONDERANCE OF VARIOUS FOOD COMPONENTS IN THE GUTS OF LABEO PANGUSIA

A. Simsang River

Food items	% of Vol.(Vi)	% of Occ.(Oi)	ViOi	$\frac{ViOi}{ViOi} \times 100$	Grading
Bacillariophyceae	14.03	18.38	257.87	14.04	II
Chlorophyceae	4.57	13.14	60.05	3.27	IV
Myxophyceae	0.89	9.68	8.62	0.47	VI
Vegetable matter	0.97	13.07	12.68	0.69	V
Sand particles	64.48	19.21	1238.66	67.46	I
Detritus	13.05	19.21	250.69	13.65	III
Animal matter	1.12	5.11	5.72	0.31	VII
Miscellaneous	0.89	2.20	1.96	0.11	VIII
				<u>100.00</u>	

B. Lubha River

Bacillariophyceae	19.39	20.86	404.48	20.63	II
Chlorophyceae	7.26	12.88	93.51	4.77	IV
Myxophyceae	2.40	6.82	16.37	0.84	V
Vegetable matter	0.65	10.02	6.51	0.33	VII
Sand particles	56.10	20.93	1174.17	59.87	I
Detritus	12.25	20.93	256.39	13.07	III
Animal matter	1.66	5.42	9.00	0.46	VI
Miscellaneous	0.29	2.14	0.62	0.03	VIII
				<u>100.00</u>	

C. Madhura River

Bacillariophyceae	16.99	20.94	355.77	17.54	II
Chlorophyceae	7.75	14.31	110.90	5.47	IV
Myxophyceae	1.91	6.00	11.46	0.57	V
Vegetable matter	0.99	10.37	10.27	0.50	VI
Sand particles	58.22	21.44	1248.24	61.56	I
Detritus	13.53	21.37	289.14	14.26	III
Animal matter	0.47	3.68	1.73	0.09	VII
Miscellaneous	0.14	1.89	0.26	0.01	VIII
				<u>100.00</u>	

neous. The percentage occurrence of each of the food items from the three rivers have been presented in Fig. 14.

i) Bacillariophyceae : This was represented by Amphora, Cyclotella, Cymbella, Diatoma, Diploneis, Fragillaria, Gomphonema, Gyrosigma, Navicula, Nitzschia, Pleurosigma, Surirella, Synedra and Tabellaria. Of these Navicula, Nitzschia, Diatoma, Cymbella and Synedra were found to be the most dominant genera in the diet of the specimens collected from all the three rivers. On average basis, Bacillariophyceae was found 14.03%, 19.39% and 16.99% in the diet contents in the specimens from Simsang, Lubha and Madhura rivers respectively. This group formed second main item in gut contents of L. pangusia.

ii) Chlorophyceae : This group was represented by Ankistrodesmus, Cosmarium, Closterium, Crucigenia, Eresmosphaera, Oedogonium, Pediastrum, Scenedesmus, Sclenastrum and Spirogyra. Of these, Spirogyra was found to be the most abundant group in the guts of the specimens from all the populations studied. Chlorophyceae made upto 4.57%, 7.26% and 7.75% for Simsang, Lubha and Madhura river individuals respectively.

iii) Myxophyceae : This group of algae was represented by Merismopedia, Microcystis, Oscillatoria and Phormidium. None of them was found dominant over other. This group formed 0.89%, 2.4% and 1.91% of the gut contents in the specimens from

Simsang, Lubha and Madhura rivers respectively.

iv) Vegetable matter : Vegetable matter found in the gut of L. pangusia was mainly macro-vegetation. This group formed 0.97%, 0.65% and 0.99% in the guts of the specimens from Simsang, Lubha and Madhura rivers respectively.

v) Detritus : This group formed the third major item in the gut contents of this species. As a whole, detritus formed 13.05%, 12.25% and 13.53% of the gut contents in the specimens from Simsang, Lubha and Madhura rivers respectively.

vi) Animal matter : This group consisted of rotifers, protozoans, copepods and insects. Animal matters formed 1.12% of the gut contents from Simsang river, 1.66% from Lubha river and 0.47% from Madhura river.

vii) Sand particles : This group was observed to be the most dominant item encountered in the guts of the individuals from all the three rivers studied. As a whole, it constituted 64.48%, 56.10% and 58.22% for Simsang, Lubha and Madhura river individuals respectively.

viii) Miscellaneous : Besides the above mentioned food items, few other items like fish scales, fish bones, stones and pebbles were also encountered in the guts of the larger specimens. On average basis, the miscellaneous matters were found to be 0.89%, 0.29% and 0.14% from Simsang, Lubha and Madhura rivers respectively.

SEASONAL FLUCTUATIONS IN THE GUT CONTENTS OF L. PANGUSIA :

The percentage composition of different broad items in the gut contents of L. pangusia has been enumerated in Table 13 and seasonal variations have been shown in Fig. 16 from which it can be seen that there were considerable fluctuations in the percentage of different items during different months of the year.

Bacillariophyceae was encountered in the guts throughout the year. The fluctuations in the percentage composition ranged from 9.76 (August) to 16.94 (December), from 14.03 (August) to 30.07 (January) and from 12.12 (May) to 23.38 (December) in the individuals from Simsang, Lubha and Madhura rivers respectively.

Chlorophyceae varied in its percentage composition from 3.42 (February) to 5.26 (August) in the guts of the individuals from Simsang river. In the individuals from Lubha and Madhura rivers, the percentage composition ranged from 3.46 (July) to 10.41 (September) and from 3.26 (August) to 12.03 (April) respectively.

The percentage composition of Myxophyceae varied from 0.30 (June) to 1.24 (February), from 0.73 (July) to 3.92 (March) and from 1.17 (June) to 2.77 (August) in the guts of the specimens from Simsang, Lubha and Madhura rivers respectively.

Table 13 SEASONAL VARIATION OF VARIOUS BECAID GROUP OF FOOD ITEMS IN LABED PANGENIA

Food Items	January			February			March			April			May			June		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Bacillariophyceae	14.82	30.67	18.71	11.44	22.19	22.66	15.28	15.97	14.90	14.99	13.40	20.71	14.36	18.93	12.12	12.59	17.91	15.40
Chlorophyceae	4.63	8.69	9.07	3.42	7.31	8.74	3.76	5.71	10.03	4.30	4.65	12.03	5.02	5.19	10.65	4.07	7.01	8.14
Phyophyceae	0.72	1.59	1.91	1.24	1.73	1.77	0.97	3.92	2.14	1.01	2.10	2.26	1.06	2.18	1.73	0.30	1.33	1.17
Vegetable matter	0.51	0.61	1.79	0.54	0.91	0.74	1.06	0.76	-	0.92	0.54	2.10	1.22	0.42	2.04	0.59	0.82	0.59
Detritus	12.26	7.05	12.60	12.80	11.30	17.54	10.24	12.39	13.95	8.66	11.71	8.46	12.65	12.66	9.15	18.81	14.24	10.36
Animal matter	1.72	1.16	0.98	0.63	0.47	0.36	0.41	0.64	0.57	0.10	0.15	0.50	0.14	0.16	-	-	0.09	-
Sand & Silt	64.48	50.33	54.50	69.61	55.52	48.19	68.19	60.61	58.11	69.52	65.01	53.66	64.65	60.44	64.28	62.93	58.28	63.64
Miscellaneous	0.86	0.30	0.14	0.24	0.57	-	0.89	-	-	-	0.44	0.28	0.50	-	-	1.01	0.35	0.70

Food Items	July			August			September			October			November			December		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Bacillariophyceae	13.28	14.51	15.61	9.76	14.03	12.58	14.42	22.04	20.00	12.63	17.65	12.34	16.88	21.27	13.35	16.94	23.46	23.36
Chlorophyceae	4.89	3.46	7.03	5.26	6.84	3.26	4.60	10.41	3.60	5.08	6.41	5.97	4.10	6.74	5.63	4.81	9.76	8.82
Phyophyceae	1.09	0.73	2.36	1.22	2.28	2.77	0.98	3.18	2.05	0.71	3.55	1.38	0.70	3.72	1.71	0.87	2.46	1.72
Vegetable matter	0.76	0.36	1.50	1.61	0.20	0.61	1.00	0.26	-	0.94	0.54	0.58	1.16	0.44	0.78	0.83	1.73	1.68
Detritus	19.42	16.78	12.10	13.80	17.94	16.62	13.06	13.14	18.25	12.51	9.65	13.63	14.22	11.68	14.54	10.21	8.48	14.78
Animal matter	0.77	0.11	-	0.78	-	0.45	0.58	3.49	-	0.81	3.81	0.84	2.71	2.52	0.63	2.54	7.28	0.99
Sand & Silt	58.83	63.88	61.40	64.40	58.47	63.65	64.64	47.48	56.10	66.08	55.08	65.09	59.33	51.28	61.36	62.36	46.44	48.68
Miscellaneous	0.96	0.50	-	1.17	0.24	-	0.75	-	-	1.24	0.31	-	1.10	0.38	-	1.44	0.42	-

1. Simang River
2. Labbak River
3. Madhara River

Vegetable matter made up from 0.51% (January) to a maximum of 1.61% (August) in the individuals from Simsang river. In the specimens from Lubha river the percentage composition ranged from 0.20 (August) to 1.73 (December) whereas in the Madhura river specimens, the percentage composition ranged from 0.55 (October) to 2.10 (April).

In the individuals from Simsang river, the percentage composition of detritus ranged from 8.86 (April) to 19.42 (July), whereas in the specimens from Lubha and Madhura rivers, the percentage composition ranged from 7.05 (January) to 17.94 (August) and 8.46 (April) to 18.25 (September) respectively.

Animal matter was not found in the guts throughout the year and its percentage composition varied from 0.10 (April) to 2.71 (November), from 0.09 (June) to 7.25 (December) and from 0.36 (February) to 0.99 (December) in the specimens from Simsang, Lubha and Madhura rivers respectively.

The most dominant item found in the guts of L. pangusia was sand particles which dominated over other items in the gut contents throughout the year. The percentage composition of sand particles was observed to be comparatively high during summer and monsoon months, whereas during winter it was less.

Miscellaneous substances were not available in the guts throughout the year, the percentage composition of this group ranged from 0.09 (March) to 1.44 (December) in the specimens

from Simsang river, from 0.24 (August) to 0.57 (February) for Lubha river individuals and from 0.14 (January) to 0.70 (June) in the specimens from Madhura river.

FOOD COMPOSITION IN VARIOUS SIZE GROUPS OF L. PANGUSIA

The relative importance of different broad items at different length groups of L. pangusia is shown in Fig. 18 and the percentage composition of different items have been presented in Table 14. Salient features of the observations are described below :

Size Group I (0 - 10 cm) : This size group could not be collected from Simsang river. However, from Lubha river population it was observed that sand particles constitute the main bulk (48.68%) of the food and was followed by Chlorophyceae (22.11%) and Myxophyceae (8.18%). Detritus formed 7.78% whereas Bacillariophyceae formed 6.41% of the gut contents. The next in order of preference was Animal matter (6.20%). While Miscellaneous matter formed very small quantities (0.64%), vegetable matter was totally absent in the gut.

Analysis of the gut content of the specimens from Madhura river also showed that sand particles were predominant (40.75%), followed by Chlorophyceae (31.48%). Detritus constituted third major item in the gut (9.94%) followed by Myxophyceae (7.85%) and Bacillariophyceae (7.24%). Animal matter constituted 2.25% of the gut contents whereas vegetable

Table 14: VARIATIONS IN THE FOOD COMPOSITION OF LABEO PANGUSIA IN DIFFERENT SIZE GROUPS

Food items	LENGTH GROUPS (cm)								
	0 - 10.0		10.1 - 20.0		20.1 - 30.0				
	S	L	S	L	S	L			
Bacillariophyceae	-	6.41	7.24	10.28	17.13	16.78	12.29	19.35	14.64
Chlorophyceae	-	22.11	31.48	13.62	10.66	7.46	3.24	3.13	2.44
Myxophyceae	-	8.18	7.85	1.70	3.37	2.64	1.10	1.11	0.56
Vegetable matter	-	-	0.04	0.37	0.25	0.20	0.80	0.70	0.75
Sand particles	-	48.68	40.75	53.80	54.19	56.05	69.00	63.59	66.73
Detritus	-	7.78	9.94	14.59	10.91	15.21	11.52	10.28	13.67
Animal matter	-	6.20	2.25	4.59	3.14	0.51	0.52	0.44	0.06
Miscellaneous	-	0.64	0.45	1.05	0.35	0.15	1.53	0.40	0.15
		<u>30.1 - 40.0</u>		<u>40.1 - 50.0</u>		<u>50.1 - 60.0</u>			
Bacillariophyceae	15.96	23.93	20.35	17.64	22.29	21.82	13.98	27.23	20.11
Chlorophyceae	2.27	2.51	2.18	2.09	2.78	1.15	1.63	2.27	0.75
Myxophyceae	0.87	0.60	0.16	0.60	0.63	0.16	0.18	0.51	0.09
Vegetable matter	1.16	0.54	1.18	0.15	1.16	2.06	1.37	1.25	1.71
Sand particles	67.74	56.50	62.10	65.74	59.96	60.24	66.12	52.78	63.49
Detritus	11.04	15.59	13.94	11.38	12.98	14.57	16.72	15.96	13.85
Animal matter	0.44	0.18	-	0.05	-	-	-	-	-
Miscellaneous	0.52	0.15	0.09	1.35	0.20	-	-	-	-

S = Simsang River; L = Lubha River; M = Madhura River

matter was poorly represented (0.04%) in the gut.

Size Group II (10.1 - 20.00 cm) : In the specimens from Simsang river the bulk of the gut contents comprised of sand particles (53.80%). This followed by Detritus (14.59%), Chlorophyceae (13.62%) and Bacillariophyceae (10.28%). Other constituents were animal matter (4.59%), Myxophyceae (1.70%), vegetable matter (0.37%) and miscellaneous substance (1.05%).

In the individuals from Lubha river, sand particles was found to be 54.19% followed by Bacillariophyceae (17.13%), Detritus (10.91%) and Chlorophyceae (10.66%). Other constituents were Myxophyceae (3.37%), animal matter (3.14%), vegetable matter (0.25%) and miscellaneous (0.35%).

In the specimens of this size group from Madhura river, Sand particles comprised of 56.05%, Bacillariophyceae of 16.78%, Detritus of 15.21%, Chlorophyceae and Myxophyceae of 7.46% and 2.64% respectively. While animal matter formed 0.51% of the gut contents, vegetable matter and miscellaneous matters constituted 0.20% and 0.15% of the diet respectively.

Size Group III (20.1 - 30.00 cm) : In comparison to the previous size group (Group II) the proportion of sand particles was found considerably increased in the guts of the specimens from all the three rivers (69.00%, 63.59% and 66.73% from Simsang, Lubha and Madhura rivers respectively). The next in order of preference was Bacillariophyceae which constituted

12.29% from Simsang river, 19.35% from Lubha river and 14.64% from Madhura river. Detritus came third which constituted 11.52% from Simsang river, 10.28% from Lubha river and 13.67% from Madhura river. Chlorophyceae and Myxophyceae were found much lower than the previous size group (Group II) and constituted 3.24% and 1.10% respectively in the specimens from Simsang river, 3.13% and 1.11% respectively from Lubha river and 2.44% and 0.56% respectively in the individuals from Madhura river. Vegetable matter was found 0.80% of the gut contents from Simsang river 0.70% from Lubha river and 0.75% in the individual from Madhura river. Animal matter and miscellaneous matter formed 0.52% and 1.53%, 0.44% and 0.40%, and 0.06% and 0.15% of the gut contents in the individuals from Simsang, Lubha and Madhura rivers respectively.

Size Group IV (30.1 - 40.0 cm) : Sand particles formed 67.74%, 56.50% and 62.10% of the total volume of the gut contents from Simsang, Lubha and Madhura rivers respectively. Bacillariophyceae constituted second largest items and was found to be 15.96% for Simsang river individuals, 23.93% for Lubha river individuals and 20.35% for Madhura river specimens. Detritus formed the third main item and comprised of 11.04% from Simsang river, 15.59% from Lubha river and 13.94% from Madhura river. Chlorophyceae was found to be 2.27%, 2.54% and 2.18% whereas Myxophyceae formed 0.87%, 0.60% and 0.16% of the gut contents from Simsang, Lubha and Madhura rivers respectively. ~~Vegetable~~ Vegetable matter formed 1.16%, 0.54% and 1.18% of the gut

contents from Simsang, Lubha and Madhura rivers respectively. The percentage composition of animal matter was found to be 0.44 from Simsang river, 0.18 from Lubha river and in the guts of the specimens from Madhura river it was not found. Miscellaneous matter formed 0.52%, 0.15% and 0.09% in the individuals from Simsang, Lubha and Madhura rivers respectively.

Size Group V (40.1 - 50.0 cm) : In the specimens from Simsang river, sand particles formed 65.74% of the gut contents followed by Bacillariophyceae (17.64%) and Detritus (11.38%). Other constituents in this group were Chlorophyceae (2.09%), Myxophyceae (0.60%), vegetable matter (0.15%) animal matter (0.05%) and miscellaneous (1.35%).

Sand particles formed the most abundant item (59.96%) in the specimens from Lubha river followed by Bacillariophyceae (22.29%) and Detritus (12.98%). Other constituents were found to be Chlorophyceae (2.78%), Myxophyceae (0.63%), vegetable matter (1.16%) and miscellaneous (0.20%).

In the individuals from Madhura river, the gut content analysis of this size group revealed that sand particles formed 60.24% of the gut contents. Next in order of abundance was Bacillariophyceae (21.82%), followed by Detritus (14.57%), vegetable matter (2.06%), Chlorophyceae (1.15%) and Myxophyceae (0.16%). Animal matter and miscellaneous substances were not encountered in the gut contents of this size group.

Size Group VI (50.1 - 60.0 cm) : In the specimens of this size group from Simsang river, Sand particles comprised 66.12%, Detritus of 16.72% and Bacillariophyceae 13.98%. Other constituents were Chlorophyceae (1.63%), Myxophyceae (0.18%) and vegetable matter (1.37%).

The percentage composition of sand particles in the specimens from Lubha river was found to be 52.78. The next in order of preference was Bacillariophyceae (27.23%), followed by Detritus (15.96%). Other constituents were Chlorophyceae (2.27%) Myxophyceae (0.51%) and vegetable matter (1.25%).

In the individuals from Madhura river sand particles were found most abundant (63.49%), followed by Bacillariophyceae (20.11%) and Detritus (13.85%). Other constituents were Chlorophyceae (0.75%), Myxophyceae (0.09%) and vegetable matter (1.71%).

In this size group animal matter and miscellaneous substances were found totally absent in the gut contents from all the three populations studied.

COMPOSITION OF GUT CONTENTS IN L. DERO

Percentage composition of different food items (Fig.15) in the guts of L. dero has been summarized in Table 15. The gut contents of L. dero can be grouped into 8 broad categories, i.e. (i) Bacillariophyceae, (ii) Chlorophyceae, (iii) Myxophyceae, (iv) Vegetable matter, (v) Detritus, (vi) Animal matter,

Table 15: INDEX OF PREPONDERANCE OF VARIOUS FOOD COMPONENTS IN THE GUTS OF LABEO DERO

A. Simsang River

Food items	% of Vol.(Vi)	% of Occ.(Oi)	ViOi	$\frac{ViOi}{ViOi} \times 100$	Grading
Bacillariophyceae	10.41	20.53	213.72	10.69	III
Chlorophyceae	3.66	13.68	50.07	2.50	IV
Myxophyceae	0.88	8.16	7.18	0.36	V
Vegetable matter	0.52	10.00	5.20	0.26	VI
Sand particles	64.82	20.53	1330.75	66.56	I
Detritus	19.00	20.53	390.07	19.51	II
Animal matter	0.25	3.68	0.92	0.05	VIII
Miscellaneous	0.46	2.89	1.33	$\frac{0.07}{100.00}$	VII

B. Lubha River

Bacillariophyceae	10.75	22.66	243.60	11.35	III
Chlorophyceae	4.97	9.37	46.57	2.17	IV
Myxophyceae	1.48	6.34	9.38	0.44	V
Vegetable matter	0.75	8.45	6.34	0.30	VI
Sand particles	62.43	22.66	1414.66	65.88	I
Detritus	18.66	22.66	422.84	19.69	II
Animal matter	0.47	3.63	1.71	0.08	VIII
Miscellaneous	0.49	4.23	2.07	$\frac{0.09}{100.00}$	VII

C. Madhura River

Bacillariophyceae	9.84	19.47	191.58	10.08	III
Chlorophyceae	4.81	14.60	70.23	3.69	IV
Myxophyceae	1.05	11.28	11.84	0.62	V
Vegetable matter	0.79	8.63	6.82	0.36	VI
Sand particles	64.07	19.69	1261.54	66.36	I
Detritus	18.01	19.69	354.62	18.65	II
Animal matter	0.51	3.98	2.03	0.11	VIII
Miscellaneous	0.92	2.66	2.45	$\frac{0.13}{100.00}$	VII

(vii) Sand particles and (viii) Miscellaneous.

i) Bacillariophyceae : This group formed 10.41%, 10.75% and 9.84% of the gut contents in the individuals from Simsang, Lubha and Madhura rivers respectively. Bacillariophyceae was represented by following genera : Amphora, Cocconeis, Cyclotella, Cymbella, Diatoma, Diploneis, Fragillaria, Gomphonema, Gyrosigma, Navicula, Nitzschia, Pinnularia, Pleurosigma, Surirella and Synedra. It is found that this group formed third major item in the gut contents of L. dero (Table 15).

ii) Chlorophyceae : On average basis, Chlorophyceae formed 3.66%, 4.97% and 4.81% of the gut contents in the individuals from Simsang, Lubha and Madhura rivers respectively. This group of algae was represented by Ankistrodesmus, Crucigenia, Eresmosphaera, Oedogonium, Pediastrum, Scenedesmus, Sclenastrum and Spirogyra.

iii) Myxophyceae : This group was represented by Merismopedia, Microcystis, Oscillatoria and Phormidium. The percentage composition of Myxophyceae was observed to be 0.88, 1.48 and 1.05 in the specimens from Simsang, Lubha and Madhura rivers respectively.

iv) Vegetable matter : Percentage composition of this group was found to be 0.52, 0.75 and 0.79 for Simsang, Lubha and Madhura river individuals respectively.

v) Detritus : Detritus formed 19.00%, 18.66% and 18.01% of the diet for Simsang, Lubha and Madhura individuals respectively and this group ranked second in order of preference.

vi) Animal matter : Animal matter includes Rotifers, Protozoans, Copepods and Insects. The percentage composition of this group was found to be 0.25, 0.47 and 0.51 in the specimens from Simsang, Lubha and Madhura rivers respectively.

vii) Sand particles : Sand particles were observed to be most dominant group in the gut contents. The average value was found to be 64.82%, 62.43% and 64.07% in the individuals from Simsang, Lubha and Madhura rivers respectively.

viii) Miscellaneous : This group formed 0.46%, 0.49% and 0.92% of the gut contents in the specimens from Simsang, Lubha and Madhura rivers respectively.

SEASONAL FLUCTUATIONS IN THE FOOD COMPOSITION OF L. DERO

The percentage composition of each item of food in the diet of the fish during different months of the year has been presented in Fig. 17 and summarised in Table 16.

Bacillariophyceae was encountered in the guts of L. dero throughout the year. The percentage composition of Bacillariophyceae ranged from a minimum of 6.87 (May) to 14.26 (March) in the individuals from Simsang river, whereas the

Table 16 SEASONAL VARIATION OF VARIOUS BROAD GROUP OF FOOD ITEMS IN LAKEO POND

Food items	January			February			March			April			May			June		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Bacillariophyceae	11.58	12.62	-	9.26	14.26	10.66	12.57	8.76	8.91	9.91	6.87	14.13	12.18	13.08	11.82	-	-	-
Chlorophyceae	5.23	3.83	-	4.39	4.46	3.80	6.11	2.62	4.69	3.28	1.83	3.17	2.81	1.18	2.91	-	-	-
Myxophyceae	1.16	0.90	-	0.91	0.76	1.14	1.08	0.98	0.84	1.03	0.36	0.92	0.92	0.20	1.04	-	-	-
Vegetable Matter	0.23	0.20	-	0.80	0.28	0.88	1.15	1.20	1.08	0.72	0.78	0.64	0.50	0.40	-	-	-	-
Detritus	18.82	17.08	18.40	18.36	21.30	16.62	17.78	18.56	22.86	20.80	18.38	17.42	18.98	23.16	10.10	-	-	-
Animal matter	0.10	1.10	0.12	1.12	-	0.16	0.30	0.18	0.08	0.05	-	0.20	-	-	-	-	-	-
Sand & Silt	62.64	61.89	63.17	64.26	88.88	66.98	59.66	67.18	61.22	63.61	71.02	63.00	68.17	61.14	66.43	-	-	-
Miscellaneous	0.25	1.50	1.08	0.90	-	0.36	1.35	0.88	0.60	0.60	1.10	0.82	0.40	-	-	-	-	-

Food items	July			August			September			October			November			December			
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Bacillariophyceae	-	7.00	7.93	-	10.03	11.33	9.18	-	9.84	-	9.84	-	9.82	6.17	10.80	11.32	10.17	-	-
Chlorophyceae	-	1.80	4.06	-	6.96	3.65	7.40	-	4.78	-	4.78	-	6.43	6.10	4.87	9.14	7.42	-	-
Myxophyceae	-	0.28	1.47	-	0.90	0.84	2.76	-	1.82	-	1.82	-	2.41	1.86	0.44	1.22	1.83	-	-
Vegetable matter	-	0.78	0.44	-	0.60	0.66	0.96	-	1.10	-	1.10	-	0.82	0.20	0.28	1.48	1.20	-	-
Detritus	-	21.62	17.78	-	18.25	19.18	16.88	-	17.78	-	14.86	-	28.06	19.85	18.16	18.94	19.78	-	-
Animal matter	-	-	0.56	-	0.35	1.09	0.46	-	0.25	-	0.25	-	1.08	0.40	-	1.36	1.70	-	-
Sand & Silt	-	68.88	47.04	-	63.76	63.26	62.21	-	68.08	-	68.14	-	87.30	68.47	65.78	59.74	60.80	-	-
Miscellaneous	-	-	0.78	-	1.18	0.32	0.45	-	0.82	-	1.10	-	0.70	0.48	-	0.80	1.70	-	-

1. Simsang River
2. Laebha River
3. Madhara River

percentage composition in the specimens from Lubha and Madhura rivers ranged from 8.91 (April) to 14.13 (May) and from 6.17 (November) to 12.57 (March) respectively.

Highest percentage of Chlorophyceae was recorded during January (5.23%) and minimum during June (1.15%) in the individuals from Simsang river. The percentage composition of Chlorophyceae for Lubha river and Madhura river individuals ranged from 2.91 (June) to 8.43 (November) and from 1.80 (July) to 7.42 (December) respectively.

The percentage composition of Myxophyceae varied from 0.30 (June) to 1.15 (January) in the individuals from Simsang river, from 0.84 (April) to 2.76 (September) in the specimens from Lubha river and from 0.28 (July) to 1.63 (January) in the individuals from Madhura river.

The percentage of vegetable matter ranged from 0.20 (February) to 1.20 (April), from 0.52 (November) to 1.48 (December) and from 0.30 (November) to 1.30 (January) in the individuals from Simsang, Lubha and Madhura rivers respectively.

The fluctuations in the percentage composition of Detritus ranged from 17.78 (October) to 23.16 (June), from 16.58 (September) to 22.56 (April) and from 14.86 (October) to 21.62 (July) in the individuals from Simsang, Lubha and Madhura rivers respectively.

Animal matter varied from 0.10% (January) to 1.09% (September) in the specimens from Simsang river, from 0.08% (April) to 1.36% (December) in the specimens from Lubha river and from 0.05% (April) to 1.70% (December) in the specimens from Madhura river.

Sand particles were found to be most dominant item throughout the year. It was observed that the sand particles were comparatively less frequent from December to February and also during August and September.

Miscellaneous matter ranged from 0.25% (January) to 1.10% (May), from 0.36% (March) to 0.80% (December) and from 0.40% (May) to 1.70% (December) in the specimens from Simsang Lubha and Madhura rivers respectively.

FOOD COMPOSITION IN VARIOUS SIZE GROUPS OF L. DERO

The relative importance of different food items in different length groups has been shown in Fig. 19 and percentage composition of food items has been presented in Table 17.

Size Group I (10 - 20 cm) : From Simsang river population the most dominant item encountered in the guts was sand particles (62.94%), followed by Detritus (16.92%), Chlorophyceae (9.74%) and Bacillariophyceae (6.95%). Other constituents were Myxophyceae (1.89%), animal matter (0.75%), vegetable matter (0.25%) and miscellaneous (0.56%).

Table 17: VARIATIONS IN THE FOOD COMPOSITION OF LABEO DERO IN DIFFERENT SIZE GROUPS

Food items	10.0-20.0			SIZE GROUPS (cm)						30.1-40.0			40.1-50.0		
	S	L	M	20.1-30.0			30.1-40.0			40.1-50.0			S	L	M
				S	L	M	S	L	M	S	L	M			
Bacillariophyceae	6.95	7.34	6.17	9.91	8.41	10.40	11.73	12.17	9.19	13.05	15.08	13.60			
Chlorophyceae	9.74	12.32	13.56	2.24	3.41	2.26	1.73	2.64	1.89	0.93	1.51	1.53			
Myxophyceae	1.89	4.39	2.18	0.79	0.84	1.02	0.40	0.33	0.71	0.44	0.36	0.29			
Vegetable matter	0.25	0.27	0.30	0.43	0.86	0.75	0.58	0.75	1.01	0.82	1.12	1.10			
Sand particles	62.94	58.31	58.49	68.20	67.03	66.07	65.82	62.38	66.38	62.32	62.00	65.35			
Detritus	16.92	15.06	16.07	17.42	18.67	18.34	19.54	21.38	20.10	22.12	19.53	17.53			
Animal matter	0.75	1.51	1.93	0.25	0.32	0.10	-	0.05	-	-	-	-			
Miscellaneous	0.56	0.80	1.30	0.76	0.46	1.06	0.20	0.30	0.72	0.32	0.40	0.60			

S = Simsang River; L = Lubha River; M = Madhura River

From Lubha river population the food analysis of the specimens belonging to this size group revealed that sand particles formed 58.31% of the gut contents. The next in order of preference was Detritus (15.06%), followed by Chlorophyceae (12.32%) and Bacillariophyceae (7.34%). Myxophyceae formed 4.39% of the gut contents while animal and vegetable matters formed 1.51% and 0.27% respectively. Miscellaneous matter comprised 0.80% of the diet from Lubha river population.

From Madhura river, the maximum single item was encountered in the guts was sand particles (58.49%). Detritus (16.07%) and Chlorophyceae (13.56%) were the next two dominant items. Myxophyceae formed 2.18% while animal and vegetable matters constituted 1.93% and 0.30% of the total food taken respectively. Miscellaneous matter formed 1.30% of the gut contents.

Size Group II (20.1 - 30 cm) : Sand particles constituted 68.20% of the total gut contents, followed by Detritus (17.42%) and Bacillariophyceae (9.91%) in the specimens from Simsang river. Other constituents were Chlorophyceae (2.24%), Myxophyceae (0.79%), animal matter (0.25%), vegetable matter (0.43%) and miscellaneous (0.76%).

From Lubha river population the percentage composition of different items were found as follows : Sand particles (67.03), Detritus (18.67), Bacillariophyceae (8.41),

Chlorophyceae (3.41), Myxophyceae (0.84), vegetable matter (0.86), animal matter (0.32) and miscellaneous (0.46).

In the specimens from Madhura river sand particles comprised 66.07% of the gut contents, followed by Detritus (18.34%) and Bacillariophyceae (10.40%). Other constituents were Chlorophyceae (2.26%), Myxophyceae (1.02%), vegetable matter (0.75%), animal matter (0.10%) and miscellaneous (1.06%).

Size Group III (30.1 - 40 cm) : In the Simsang river individuals, sand particles constituted 65.82% of the gut contents. Next in order of abundance was Detritus (19.54%). Bacillariophyceae and Chlorophyceae were represented by 11.73% and 1.73% respectively. Myxophyceae comprised 0.40% of the gut contents. While animal matter was not found in the guts, vegetable matter constituted 0.58% of the diet. Miscellaneous matter formed only 0.20% of the total food taken.

In the individuals from Lubha river, the percentage composition of sand particles were found to be 62.38, followed by Detritus (21.38) and Bacillariophyceae (12.17). The percentage composition of the other items were Chlorophyceae (2.64), Myxophyceae (0.33), animal matter (0.05), vegetable matter (0.75) and miscellaneous (0.30).

From Madhura river also, sand particles were found to be most abundant item forming 66.38% of the gut contents. The next was Detritus (20.10%). Bacillariophyceae formed 9.19% of

the gut contents. Other food items were, Chlorophyceae (1.89%), Myxophyceae (0.71%), vegetable matter (1.01%) and miscellaneous (0.72%). Animal matter was not found in the guts of this size group.

Size Group IV (40.1 - 50 cm) : In this size groups sand particles were represented by 62.32% of the gut contents and Detritus by 22.12%. The next in order of abundance was found to be Bacillariophyceae (13.05%). The other constituents of the food encountered in the specimens from Simsang river were, Chlorophyceae (0.93%), Myxophyceae (0.44%), vegetable matter (0.82%) and miscellaneous (0.32%). Animal matter was absent in the gut contents of this size group.

In the specimens of this size group from Lubha river, sand particles comprised 62.00%, Detritus of 19.53% and Bacillariophyceae and Chlorophyceae of 15.08% and 1.51% respectively. Vegetable matter comprised 1.12% and miscellaneous formed 0.40% of the gut contents whereas animal matter was totally absent in the guts of this size group.

In the Madhura river specimens, sand particles and Detritus constituted 65.35% and 17.53% of the gut contents. These followed by Bacillariophyceae (13.60%) and Chlorophyceae (1.53%). Myxophyceae formed only 0.29% in the guts. While animal matter was not found in the guts from this population, vegetable matter made up 1.10% and miscellaneous formed 0.60% of the gut contents.

FEEDING INTENSITY : The observation on the feeding intensity based on Gastrosomatic index (G.S.I.) has been summarized below :

SEASONAL VARIATION IN G.S.I. OF L. PANGUSIA

Seasonal variations in G.S.I. of the species collected from three rivers have been tabulated (Table 18A) to elucidate the monthly fluctuations in the feeding intensity. It is clear from Fig. 20A that there is a seasonal fluctuation in the feeding intensity showing sharp rise and fall. The G.S.I. shows a steady increment from February reaching minimum in July after which the value again increased during the period of August to October. From November to January again low G.S.I. values were observed in all the population studies (Fig. 20A).

SEASONAL VARIATION IN G.S.I. OF L. DERO

The monthly fluctuations in the G.S.I. values for the entire study period have been depicted in Fig. 20B. It is clear from Fig. 20B, that there are two periods of relatively intensive feeding. The first is during March to May and the second is during August to September. The fluctuation in the G.S.I. values was found to be almost similar in the three populations studied, the difference being only in the magnitude (Table 18B). The feeding is minimal during monsoon (June and July) and also during winter months (November to January).

Table 18: AVERAGE GASTROSOMATIC INDEX (G.S.I.) IN VARIOUS MONTHS

A. LABEO PANGUSIA

Months	Simsang River	Lubha River	Madhura River
December 1979	2.6933	2.6131	1.6569
January 1980	2.1793	2.7978	1.3627
February	3.0518	3.7064	3.1763
March	4.4005	5.6223	3.4246
April	5.7386	6.7876	4.1564
May	3.9278	3.7352	3.6351
June	2.6352	2.5609	3.2658
July	2.8512	2.1067	2.5025
August	5.2893	3.8068	3.2722
September	3.8711	4.1733	2.4978
October	4.2755	4.3716	2.6316
November	3.0336	3.1354	1.7930

B. LABEO DERO

December 1979	2.3697	2.9562	1.8044
January 1980	2.3223	-	1.6079
February	3.9534	3.4141	2.2128
March	4.0657	4.7977	4.0136
April	4.7428	5.0851	4.4741
May	3.0376	4.5537	5.1619
June	2.2219	3.2140	-
July	1.9024	-	2.1212
August	4.0454	-	3.6641
September	5.0620	5.2845	-
October	3.8936	-	2.8678
November	2.4156	2.1239	2.0109

FLUCTUATIONS IN G.S.I. IN DIFFERENT LENGTH GROUPS OF L. PANGUSIA

The G.S.I. values in different length groups have been presented in Table 19A. It was observed in the present study that the G.S.I. value gradually increased up to 20.1 - 30 cm length group in the specimens from Simsang and Lubha rivers and up to 30.1 - 40 cm length group in the specimens from Madhura rivers (Fig. 20C), whereafter the feeding intensity was found to be reduced with the increase in length.

FLUCTUATIONS IN G.S.I. IN DIFFERENT LENGTH GROUPS OF L. DERO

From Fig. 20D it may be seen that lowest feeding intensity (G.S.I.) has been observed in length group I (10 - 20 cm) and the highest in length group III (30.1 - 40 cm) in the specimens from Simsang river and in length group IV (40.1 - 50 cm) in the specimens from Lubha and Madhura rivers. The G.S.I. value in different length groups of L. dero did not fluctuate widely (Table 19B).

RELATION BETWEEN GUT LENGTH AND BODY LENGTH IN L. PANGUSIA

The length of the gut (Y) plotted against the total length (X) which shows that the length of the gut increases in proportion to total length of fish. The logarithmic relationships of these two parameters were found to be :

$$\text{LogY} = 0.4122 + 1.3940 \log X \text{ (Simsang River)}$$

$$r = 0.9814$$

Table 19: GASTROSOMATIC INDEX (G.S.I.) IN VARIOUS LENGTH GROUPS

A. LABEO PANGUSIA

Size Group (cm)	Simsang River	Lubha River	Madhura River
0-10.0	-	2.7086	2.4628
10.1-20.0	3.5893	4.1886	3.3714
20.1-30.0	4.2365	4.0622	5.1725
30.1-40.0	4.4228	5.3719	5.4056
40.1-50.0	4.5871	5.2147	5.3851
50.1-60.0	3.4163	4.3052	3.3795

B. LABEO DERO

10.0-20.0	3.3052	4.2319	3.1954
20.1-30.0	4.0210	4.3336	4.4428
30.1-40.0	4.8687	4.4212	4.5146
40.1-50.0	4.3422	5.2281	4.8211

$$\text{LogY} = 0.2689 + 1.4721 \log X \text{ (Lubha River)}$$

$$r = 0.9762$$

$$\text{LogY} = 0.0137 + 1.6409 \log X \text{ (Madhura River)}$$

$$r = 0.9950$$

RELATIONSHIP BETWEEN GUT LENGTH AND BODY LENGTH IN L. DERO

The logarithmic relationship between gut length (Y) and body length (X) was found to be :

$$\text{LogY} = 0.0469 + 1.6559 \log X \text{ (Simsang River)}$$

$$r = 0.9924$$

$$\text{LogY} = 0.0063 + 1.6832 \log X \text{ (Lubha River)}$$

$$r = 0.9892$$

$$\text{LogY} = 0.0999 + 1.6298 \log X \text{ (Madhura River)}$$

$$r = 0.9965$$

RELATIVE LENGTH OF THE GUT (R.L.G.) OF L. PANGUSIA

The variations in the relative length of the gut (R.L.G.) of the species from different population have been shown in Table 20A.

The R.L.G. value shows a gradual increase from 7.0978 (10.1 - 20 cm length group) to 10.9251 (50.1 - 60 cm length group) in the specimens from Simsang river, whereas from Lubha and Madhura river populations the R.L.G. values were observed to vary from 3.3953 (0 - 10 cm) to 10.0482 (50.1 - 60 cm) and from 3.0494 (0 - 10 cm) to 9.8731 (50.1 - 60 cm) respectively.

Table 20: RELATIVE LENGTH OF THE GUT (R.L.G.) IN VARIOUS LENGTH GROUPS

A. LABEO PANGUSIA

Size Groups (cm)	Simsang River	Lubha River	Madhura River
0-10.0	-	3.3953	3.0494
10.1-20.0	7.0978	7.8418	6.4031
20.1-30.0	10.5118	9.9386	10.2783
30.1-40.0	10.4600	11.2814	10.9272
40.1-50.0	12.7334	10.7894	10.5594
50.1-60.0	10.9251	10.0482	9.8731

B. LABEO DERO

10.0-15.0	5.5816	6.0000	5.8790
15.1-20.0	8.0057	6.3444	7.6154
20.1-25.0	9.1327	8.8304	9.6809
25.1-30.0	9.8419	11.6072	10.9145
30.1-35.0	11.5263	11.7477	12.0090
35.1-40.0	12.0053	11.8730	12.1158
40.1-45.0	11.6787	11.6525	12.1053

It is further observed that the increment of the R.L.G. value has increased steadily upto 30 cm length (Fig. 21A), thereafter the increment slowed down.

RELATIVE LENGTH OF THE GUT (R.L.G.) OF L. DERO

The R.L.G. value of different groups of L. dero has been presented in Table 20B. It is seen from the Table 20B that R.L.G. value at 10 - 15 cm length group was found to be 5.5816, 6.0000 and 5.8790 whereas at 40.1 - 45 cm length group the R.L.G. value was found to be 11.6787, 11.6525 and 12.1053 in the specimens from Simsang, Lubha and Madhura rivers respectively. It is found that the R.L.G. value showed a gradual increase up to 30 cm length and thereafter the ratio decreased (Fig. 21B).

MATURITY AND SPAWNING

MATURITY AND SPAWNING IN L. PANGUSIA

CYCLE AND MATURATION : The various maturity stages during different months have been calculated and presented in Table 21. The condition of the gonads progressed from immature (Stage I) in October to January to maturity (stage IV) in March and spawning stage (Stage VI) in May - June. The specimens of stage VII (spent) were encountered in July and were found to be present till September. From October to January all the specimens encountered were either 1st or 2nd stages of maturity. It is interesting to note that some maturing virgin or resting adult specimens (Stage II) were encountered throughout the year from all the three populations.

Table 21: OVA DIAMETER IN DIFFERENT STAGES OF MATURATION OF
LABEO PANGUSIA

Stages of maturity	Degree of maturation	Month of availability	Mean ova diameter (mm)	Range of ova diameter (mm)
I	Immature or virgin	October to January	0.1320	0.0165-0.2475
II	Maturity virgin or Resting adult	Throughout the year	0.3383	0.2310-0.4455
III	Developing	February to March	0.5695	0.4620-0.6765
IV	Developed	March to May	0.8003	0.6930-0.9075
V	Gravid	April to May	1.0318	0.9240-1.1388
VI	Spawning	May to July	1.2624	1.1716-1.3530

Table 22: OVA DIAMETER IN DIFFERENT STAGES OF MATURATION OF
LABEO DERO

Stages of maturity	Degree of maturation	Months of availability	Mean ova diameter (mm)	Range in ova diameter (mm)
I	Immature or virgin	September to January	0.1073	0.0165-0.1650
II	Maturing virgin or Resting adult	Almost throughout the year	0.2723	0.1812-0.3465
III	Developing	March to April	0.4590	0.3620-0.5280
IV	Developed	March to May	0.6396	0.5445-0.7095
V	Gravid	April to May	0.8167	0.7260-0.8910
VI	Spawning	May to July	1.0313	0.9075-1.0725

OVA-DIAMETER STUDY : The mean ova-diameter of different stages of maturity from different populations has been presented in Table 21. To find out the ova-diameter frequency during different stages of ovarian development of L. pangusia, a graph has been plotted by converting the frequencies into percentages and plotting the same against the respective ova-diameter groups (Fig. 22).

The ovaries of the species from all the three populations were found to contain only one batch of maturing ova clearly demarcated from the immature stock. The size of the fully mature ova in stage V ranged from 0.9240 to 1.1388 mm were encountered in May. The ripe ova (stage VI) were found to range between 1.1716 and 1.3530 mm. No ova of intermediate size between small and big in the mature ovary could be observed. The spent ovary (Stage VII) contained degenerating ova.

GONADO-SOMATIC RATIO (G.S.R.) : The gonadosomatic ratio (G.S.R.) or maturity index, which is an indicator of the state of maturity and gonadal development, has been calculated for males and females separately and has been presented in Table 23A. Seasonal changes in the coefficient of maturity (G.S.R.) of males and females have been presented in Fig. 24.

From Fig. 24 it is clear that in the case of L. pangusia, the G.S.R. increases progressively from February onwards reaching its maximum in June. In July a sudden decline

Table 23: AVERAGE GONADOSOMATIC RATIO (MATURITY INDEX) IN VARIOUS MONTHS

A. LABEO PANGUSIA

Months	Simsang River		Lubha River		Madhura River	
	Male	Female	Male	Female	Male	Female
December 1979	0.2421	0.6087	0.2993	0.6842	0.3042	0.6339
January 1980	0.2698	0.5908	0.2814	0.5833	0.3770	0.6894
February	0.2882	0.7374	0.3216	0.6654	0.6226	0.7091
March	0.5008	1.6954	0.7635	2.8310	0.7118	0.7486
April	0.5859	4.2425	0.8266	5.1376	0.8235	2.0004
May	0.7536	8.4047	0.8754	11.5637	0.8447	9.3056
June	0.9519	12.3126	0.9441	19.8231	0.9332	15.7939
July	0.8942	5.2944	0.9387	13.4338	0.8658	11.8404
August	0.5058	3.9793	0.3012	6.8764	0.5433	0.8330
September	0.4162	0.4969	0.3141	0.6782	0.3013	0.7332
October	0.2088	0.3596	0.2847	0.4255	0.2107	0.7452
November	0.2961	0.5168	0.3162	0.5735	0.2757	0.6271

B. LABEO DERO

December 1979	0.2966	0.1830	0.2246	0.1831	0.1286	0.1498
January 1980	0.2257	0.1705	-	-	0.1774	0.1572
February	0.2861	0.3305	-	0.4003	0.1887	0.1193
March	0.4243	0.8916	0.2851	1.0340	0.5132	0.4923
April	0.5361	3.9627	0.5102	7.5059	0.5029	3.2755
May	0.6828	8.9934	0.6734	17.3211	0.8926	16.9873
June	0.7482	15.4147	-	18.2145	-	-
July	0.6938	11.6253	-	--	-	13.9049
August	0.4079	2.0303	-	-	0.2123	1.5712
September	0.2463	0.4991	0.1292	0.1756	-	-
October	0.1540	0.4878	-	-	0.1882	0.7533
November	0.1376	0.2081	0.2176	0.2008	0.1331	0.1274

in G.S.R. is observed and, thereafter the value drops down gradually and to reach its minimum during October-November. It is apparent from Fig. 24 that the G.S.R. increases or declines more sharply in females than the males. The trend of seasonal fluctuations in G.S.R., however, was found similar in all the populations studied.

SIZE AT FIRST MATURITY : In the present study stages IV to VI of gonadal maturity has been considered as mature gonad. It can be seen that in the case of male, maturity first appeared in specimens belonging to length group 251- 30 cm from Simsang and Lubha river populations (Table 24). However, mature males were encountered even at 201- 25 cm length group (Table 24) from the Madhura river population. In all the three populations the maturity in females first appeared at 251- 30 cm length group. It is clear from Fig. 26A that 50% of the males and females mature at length group of 251- 30 cm.

The length and weight of the smallest mature male and female of L. pangusia encountered from different rivers were :

	<u>Simsang river</u>		<u>Lubha river</u>		<u>Madhura river</u>	
	L(cm)	W(gm)	L(cm)	W(gm)	L(cm)	W(gm)
Male	25.0	192.54	25.4	157.87	22.8	136.65
Female	26.6	216.30	26.8	179.82	25.5	166.76

AGE AT FIRST MATURITY : Both male and female specimens were found to be matured at 1⁺ year. Some female specimens, however, were found to attain maturity for the first time at the age of 2⁺ years.

SPAWNING SEASON : The cycle of maturation and seasonal gonadosomatic ratio provided good indications of the extent of the development of ovaries with respect to the time of the year. The ripe (stage VI) males and females of L. pangusia were observed during May and June from all the populations studied and the spent stage were available up to August - September. The gonadosomatic ratio were found to be maximum during May - June and the minimum during October - November.

Thus, the observations based on the data on maturity studies of L. pangusia indicate that the species has restricted breeding season and that also for a shorter duration. The factors contributing to the restricted spawning for shorter duration, is the maturation of single batch of ova that are spawned out in a single spawning burst during the spawning season. Though in the present study spent fishes were encountered during last part of May and also during September, but the peak breeding season of L. pangusia has been observed to be during June - July.

FECUNDITY

ABSOLUTE FECUNDITY : In L. pangusia individual fecundities varied considerably from individual to individual and ranged from 1,89,626 in the specimens from Simsang river measuring 35.6 cm in total length and 532.70 gms in total weight to 5,40,034 in the specimen measuring 56.1 cm in total length and 1525 gms in total weight (Table 25A). In the individuals from Lubha river, the fecundity varied from 2,26,788 in the specimens measuring 35.5 cm in length and weighing 470.80 gms to 8,14,897 in the specimens measuring 60.5 cm in length and weighing 5100 gms (Table 25b). In the specimens from Madhura river the fecundity was found to be ranged from 2,25,471 in the individual measuring 36.0 cm in length and 560.0 gms in weight to 6,36,900 in the individual measuring 53.5 cm in length and 2316.00 gms in weight (Table 25C).

RELATIVE FECUNDITY : In L. pangusia, the relative fecundity was found to range from 345 to 414 in the specimens from Simsang river, from 105 to 546 in the individuals from Lubha river and from 263 to 503 in the specimens from Madhura river. In all the populations, relative fecundity was found to be comparatively high in the younger size groups (Table 25, A, B & C).

The relationship of fecundity with total length, total weight, ovary weight and age have been calculated and summarized below :

Table 25A: FECUNDITY OF LABEO PANGUSIA FROM SIMSANG RIVER

Total length (cm)	Body weight (gm)	Ovary weight (gm)	Fecundity	Relative fecundity
35.6	532.70	90.73	1,89,626	356
38.8	650.82	118.08	2,62,180	403
40.7	779.65	141.81	2,81,278	361
42.4	844.65	178.47	3,45,098	409
44.7	950.82	205.25	3,60,518	379
46.9	1020.00	235.95	4,21,951	414
48.7	1133.33	238.10	4,32,070	388
50.4	1237.50	258.64	4,71,155	381
53.1	1350.00	293.35	4,96,016	367
54.9	1465.00	312.29	5,05,614	345
56.1	1525.00	336.37	5,40,034	354

Table 25B: FECUNDITY OF LABEO PANGUSIA FROM LUBHA RIVER

Total length (cm)	Body weight (gm)	Ovary weight (gm)	Fecundity	Relative fecundity
35.5	470.80	95.18	2,26,788	482
36.5	572.60	117.06	2,64,673	462
38.8	657.80	178.33	3,58,937	546
40.5	821.13	186.07	3,66,996	447
42.5	853.73	226.12	4,07,694	478
44.4	922.80	234.40	4,23,564	459
46.7	938.10	252.79	4,53,773	484
48.4	963.13	277.74	4,87,989	507
50.3	1425.00	367.29	5,92,800	416
52.7	2180.00	377.60	6,06,040	278
54.6	2265.00	434.38	6,68,515	251
56.7	3360.00	477.24	7,46,880	133
58.8	4422.00	492.15	7,64,310	105
60.5	5100.00	490.80	8,14,897	160

Table 25C : FECUNDITY OF LABEO PANGUSIA FROM MADHURA RIVER

Total length (cm)	Body weight (gm)	Ovary weight (gm)	Fecundity	Relative fecundity
36.0	560.00	103.41	2,25,471	403
38.5	646.83	141.27	2,61,573	404
40.5	806.30	191.85	3,87,724	481
42.5	846.50	216.16	4,25,622	503
44.6	893.27	234.98	4,40,561	493
46.7	940.53	247.97	4,35,767	463
48.4	956.25	270.66	4,61,252	482
50.4	1166.00	287.27	4,65,035	399
52.6	2243.00	373.60	5,89,909	263
53.5	2316.00	401.32	6,36,900	275

(i) FECUNDITY VERSUS TOTAL LENGTH : The logarithmic relationship between fecundity (F) and total length (L) of L. pangusia has been worked out separately for different populations and the regression equations and coefficient of correlations (r) were presented in Table 26A. When expressed logarithmically a straight line relationship was found (Fig, 27D, 28D, 29D) which indicated that fecundity increased in proportion of the length of the fish. It is also evident from Table 26A that fecundity of L. pangusia increases at the powers of 1,5132, 2,2074 and 2.0188 of fish length from Simsang, Lubha and Madhura rivers respectively.

(ii) FECUNDITY VERSUS BODY WEIGHT : On plotting the log values for body weight (W) and fecundity (F), a straight line relationship has been observed (Fig, 27E, 28E, 29E). The derived regression equations are presented in Table 26A which indicate that fecundity of the species increases at the rates of 0.6991, 0.5206 and 0.6051 for every unit increment of the body weight from Simsang, Lubha and Madhura rivers respectively.

(iii) FECUNDITY VERSUS OVARY WEIGHT : The regression equations between fecundity (F) and ovary weight (OW) from different populations were worked out separately and shown in Table 26A. Like other parameters, logarithmic representation showed a straight line relationship (Fig. 27F, 28F, 29F) and showed an increasing trend in fecundity with the increase in the ovary weight. It is evident from Table 26A that fecundity

Table 26: REGRESSION EQUATION OF FECUNDITY WITH DIFFERENT PARAMETERS

A. LABEO PANGUSIA

Parameters	Simsang River	Lubha River	Madhura River
Total Length(L) & fecundity (F)	LogF=3.0923+1.5132logL r=0.9692	LogF=1.9916+2.2074logL r=0.9770	LogF=2.2960+2.0188logL r=0.9133
Total weight(W) & fecundity (F)	LogF=3.5294+0.6991logW r=0.9799	LogF=4.0674+0.5206logW r=0.9184	LogF=3.8177+0.6051logW r=0.8901
Ovary weight(Ow) & fecundity (F)	LogF=3.8780+0.7277logOw r=0.9810	LogF=3.8973+0.8466logOw r=0.9978	LogF=3.9241+0.7210logOw r=0.9821
B. <u>LABEO DERO</u>			
Total length (L) & fecundity (F)	LogF=0.5843+2.8554logL r=0.9251	LogF=4.1020logL-1.3720 r=0.8808	LogF=4.5699logL-2.0948 r=0.9694
Total weight (W) & fecundity (F)	LogF=2.3274+0.9825logW r=0.9116	LogF=1.6262+1.2517logW r=0.8434	LogF=1.8581+1.1875logW r=0.9618
Ovary weight(Ow) & fecundity (F)	LogF=3.5768+0.8221logOw r=0.9905	LogF=3.6841+0.7849logOw r=0.9517	LogF=3.7391+0.7572logOw r=0.9887

of L. pangusia increases at the powers of 0.7277, 0.8466 and 0.7210 for every unit increment of the ovary weight from Simsa.g, Lubha and Madhura rivers respectively.

(iv) FECUNDITY VERSUS AGE : The fecundity of L. pangusia has been found to increase with age. The relationship between fecundity and age of this species is shown in Fig. 33A, B & C.

MATURITY AND SPAWNING IN L. DERO

CYCLE OF MATURATION : The various maturity stages observed from the three populations are summarized in Table 22. The condition of the gonad progressed from Stage I (immature) in September - January to maturity (Stage IV), in March and spawning stage (Stage VI) in May. 'Spent' conditions (Stage VII) were observed from June onwards and were available upto August - September. From October to January specimens collected were either in their first or second stages of maturity.

OVA-DIAMETER STUDY : The mean ova-diameter of different stages of maturity from different populations has been given in Table 22. The ova-diameter study revealed seven stages of maturity. These stages were in agreement with those delineated macroscopically following the classification of Kesteven (1960). To find out the ova-diameter frequency during different stages of ovarian development of L. dero, a graph has been plotted by converting the frequencies into percentage and plotting the same against the respective ova-diameter groups (Fig. 23). The

size of the mature ova (Stage V) ranged from 0.7260 to 0.8910 mm and the ripe ova (Stage VI) were found to range between 0.9075 and 1.0725 mm. Like L. pangusia in this species also, no ova of intermediate size between small and big ova could be observed.

GONADOSOMATIC RATIO (G.S.R.) : The seasonal fluctuations of G.S.R. for males and females have been presented in Table 23B.

It is clear from Fig. 25 that the G.S.R. showed a wide fluctuation. However, its maximum value has been observed during May - June, and the minimum during September - November. The rise and fall in the G.S.R. values were more prominent in females than in males and almost similar seasonal trend of fluctuations were observed in all the populations studied.

SIZE AT FIRST MATURITY : It can be seen from Table 27 that in case of males, maturity first appeared in the specimens belonging to the length group of 201- 25 cm whereas in the case of females, the maturity first appeared in the specimens belonging to length group 251- 30 cm. It is clear from Fig. 26B that 50% of the specimens (both male and female) mature at 251- 30 cm length group in all the populations studied.

The length and weight of the smallest mature male and female of L. dero from different populations were recorded to be as follows :

Table 27: PERCENTAGE OF MATURITY AT VARIOUS LENGTH GROUPS OF LABEO DERO

Size Groups (cm)	Sex	Immature (Stage I)		Maturing (Stage II & III)		Mature (Stage IV to VI)	
		Simsang	Lubha Madhura	Simsang	Lubha Madhura	Simsang	Lubha Madhura
10.0-15.0	M	100.00	100.00	-	-	-	-
	F	100.00	100.00	-	-	-	-
15.1-20.0	M	60.00	60.00	40.00	40.00	-	-
	F	66.67	66.67	33.33	33.33	-	-
20.1-25.0	M	28.57	25.00	57.14	50.00	14.29	25.00
	F	36.36	40.00	63.64	60.00	-	-
25.1-30.0	M	-	-	33.33	40.00	66.67	60.00
	F	-	-	56.25	58.33	43.75	41.67
30.1-35.0	M	-	-	-	-	100.00	100.00
	F	-	-	-	-	100.00	100.00
35.1-40.0	M	-	-	-	-	100.00	100.00
	F	-	-	-	-	100.00	100.00
40.1-45.0	M	-	-	-	-	100.00	100.00
	F	-	-	-	-	100.00	100.00
45.1-50.0	M	-	-	-	-	-	-
	F	-	-	-	-	100.00	100.00

	<u>Simsang River</u>		<u>Lubha River</u>		<u>Madhura River</u>	
	L(cm)	W(gm)	L(cm)	W(gm)	L(cm)	W(gm)
Male	22.5	128.36	23.5	147.96	21.0	98.45
Female	24.2	172.15	25.2	188.60	24.8	152.45

AGE AT FIRST MATURITY : In the present study it is observed that maturity in both males and females first appeared in the individuals belonging to "0" year group. However, 100% maturity in the case of females was observed in the specimens belonging to 1⁺ year group.

SPAWNING SEASON : The result of maturity cycle of L. dero indicated that specimens having fully riped gonads of spawning stage (stage VI) were available from May onwards and the "spent" stage (stage VII) were recorded during June and were available upto August-September. The maximum G.S.R. was observed during May-June and a sharp decline in G.S.R. was observed in July indicating the beginning of the spawning. The fully ripen ova (Stage VI) was also found in May - June. Thus, it can be informed that the spawning season of L. dero starts from May and lasts upto August - September, the peak breeding season being June and July.

FECUNDITY

ABSOLUTE FECUNDITY : Total number of eggs (absolute fecundity) of L. dero varied considerably from individual to individual and ranged from 91,034 in the specimen measuring 32.0 cm and 492.60

Table 28A: FECUNDITY OF LABEO DERO FROM SIMSANG RIVER

Total length (cm)	Body weight (gm)	Ovary weight (gm)	Fecundity	Relative fecundity
32.0	492.60	46.41	91,034	185
35.4	547.40	49.64	94,515	173
36.8	546.20	57.34	1,03,556	190
37.3	588.60	53.04	1,00,193	170
39.7	746.10	82.86	1,40,613	188
40.2	793.50	94.37	1,66,563	210
41.3	807.30	96.39	1,65,212	205
42.1	844.85	100.00	1,65,700	196
44.3	1172.50	124.45	1,91,515	163
47.2	1237.50	151.53	2,33,205	188

Table 28B: FECUNDITY OF LABEO DERO FROM LUBHA RIVER

Total length (cm)	Body weight (gm)	Ovary weight (gm)	Fecundity	Relative fecundity
35.2	479.00	42.88	93,907	196
36.5	552.20	58.38	1,26,190	229
37.1	561.40	47.23	85,156	152
38.4	584.50	77.86	1,45,520	249
39.8	657.50	87.29	1,72,223	262
40.1	764.20	88.21	1,49,163	195
41.5	806.80	101.67	1,74,262	216
42.7	828.00	128.46	2,32,641	281

Table 28C: FECUNDITY OF LABEO DERO FROM MADHURA RIVER

Total length (cm)	Body weight (gm)	Ovary weight (gm)	Fecundity	Relative fecundity
33.3.	335.60	36.69	89,083	265
34.9	422.10	36.53	80,627	191
35.7	414.00	42.72	96,205	232
36.4	476.70	55.31	1,17,091	246
37.1	532.30	53.44	1,00,147	188
38.4	609.50	81.14	1,54,407	253
39.8	686.75	87.06	1,47,131	214
41.6	810.00	109.91	1,80,033	222
42.8	917.80	136.28	2,32,903	254

gm in total length and total weight respectively to 2,33,205 in the specimen measuring 47.2 cm and 1237.50 gm in total length and total weight respectively from Simsang river population (Table 28A). From Lubha river, the fecundity ranged from 85,156 in the specimen measuring 37.1 cm in total length and weighing 561.40 gm in total weight to 2,32,641 in an individual measuring 42.7 cm in total length and 828.00 gm in total weight (Table 28B). In the individuals from Madhura river, the fecundity varied from 80,627 in the specimen measuring 34.9 cm in length and weighing 422.10 gm to 2,32,903 in the specimen measuring 42.8 cm in length and 917.80 gm in weight (Table 28C).

RELATIVE FECUNDITY : In L. dero, the relative fecundity ranged from 163 to 210 for individuals from Simsang river, from 152 to 281 for specimens from Lubha river and from 188 to 265 for specimens from Madhura river (Table 28 A, B, C).

The relationship between fecundity and total length, fecundity and total weight, fecundity and ovary weight and fecundity and age have been calculated and are presented below:

(i) FECUNDITY VERSUS TOTAL LENGTH : On plotting the log values of the fecundity (F) against log of total length (L), a straight line relationship was found (Fig. 30D, 31D, 32D) which indicated that the fecundity of this species increased in proportion to the total length. The regression equations and correlation coefficient (r) of the relationship were presented in Table 26B which showed that fecundity increased at the rate

of 2,8554, 4,1020 and 4,5699 for every unit increment of the body length from Simsang, Lubha and Madhura rivers respectively.

(ii) FECUNDITY VERSUS BODY WEIGHT : The logarithmic relationship between fecundity (F) and total weight (W) has been shown in Fig. 30E, 31E, 32E. The regression equations of this relationship have been calculated separately for each population and presented in Table 26B. It is apparent from Table 26B that fecundity increases at the rate of 0.9825, 1.2517 and 1.1875 for every unit increment of body weight in the individuals from Simsang, Lubha and Madhura rivers respectively.

(iii) FECUNDITY VERSUS OVARY WEIGHT : The regression equations and correlation coefficient (r) of this relationship have been presented in Table 26B. On plotting the logarithmic values for ovary weight (OW) and fecundity (F) a straight line relationship has been observed (Fig. 30F, 31F, 32F). It is observed that fecundity increases at the rate of 0.8221, 0.7849 and 0.7572 for every unit increment of ovary weight in the individuals from Simsang, Lubha and Madhura rivers respectively.

(iv) FECUNDITY VERSUS AGE : On plotting the fecundity values against age it is observed that fecundity of L. dero increases with increasing age (Fig. 33D, E, F).

AGE AND GROWTH

RELATIONSHIP BETWEEN BODY LENGTH AND SCALE LENGTH IN L. PANGUSIA

In order to ascertain the relationship between the body and scale length, the average measurement of different length groups and the average of the corresponding scale length obtained were plotted graphically. This yielded a straight line relationship (Fig. 34A, B & C). The results showed that an increase in the length of the scale, bears a constant relationship with the increase in the length of fish. The regression equations of body length over scale length in L. pangusia from different populations were recorded to be as follows :

$$\text{Simsang river : } \text{LogL} = 0.8264 + 0.9607 \log S$$

$$r = 0.9986$$

$$\text{Lubha river : } \text{LogL} = 0.8855 + 0.9167 \log S$$

$$r = 0.9764$$

$$\text{Madhura river : } \text{LogL} = 0.8901 + 0.9419 \log S$$

$$r = 0.9926$$

RELATIONSHIP BETWEEN BODY LENGTH AND SCALE LENGTH IN L. DERO

The log-log relationship between body length and scale length in L. dero was found to be linear (Fig. 34D, E, F). The regression equations were calculated to be :-

$$\text{Simsang river : } \text{LogL} = 0.8059 + 0.9739 \log S$$

$$r = 0.9882$$

$$\text{Ludha river : } \text{LogL} = 0.8361 + 0.9449 \log S$$

$$r = 0.9905$$

Madhura river : $\text{LogL} = 0.7827 + 0.9784 \log S$

$$r = 0.9767$$

TIME OF ANNULUS FORMATION IN THE SCALE : For justification of the determination of age from the growth checks, it is necessary to establish the annual nature of their deposition. In order to study, the time of formation of the annulus, the outer margins of the scales of fishes caught in different months were examined.

In both L. pangusia and L. dero, the study indicated that during the months of September to February, the margins of all the scales were mainly transparent while from March onwards, the percentage of opaque margins was higher (Fig. 35A & B).

CALCULATED LENGTH AT EACH ANNULUS BY BACK CALCULATION IN

L. PANGUSIA : The back calculated length from the fishes of different ages in L. pangusia has been given in Table 29A and the average length at each annulus has also been shown in Fig. 36A, B & C.

L. pangusia was found to attain maximum length in the first year itself from all the populations studied (Fig. 36A, B & C). Afterwards, the increment in length retarded in subsequent years. It was also observed that the specimens from Lubha river grow faster than the specimens from Simsang and Madhura rivers (Table 29A).

Table 29: MEAN CALCULATED LENGTH AT EACH ANNULUS AS DETERMINED BY BACK CALCULATION

A. LABEO PANGUSIA

Age (years)	Simsang River: (length in cm)	Lubha River (length in cm)	Madhura River (length in cm)
I	28.93	28.68	26.85
II	33.13	34.40	32.03
III	38.05	40.05	37.45
IV	44.26	46.50	42.87
V	49.94	52.87	47.49
VI	54.18	56.23	51.42

B. LABEO DERO

I	22.67	21.91	20.25
II	28.56	27.66	26.72
III	33.74	32.97	32.24
IV	37.88	37.15	36.62
V	41.47	40.37	40.55
VI	44.60	-	-

CALCULATED LENGTH AT EACH ANNULUS BY BACK CALCULATION IN

L. DERO : The back calculated length of different ages of L. dero has been given in Table 29B and average length at each annulus has also been reported in Fig. 36D, E, & F.

From the Fig. 36 it may be seen that the growth in length of this species was found to be maximum in the first year in all the three populations. Comparatively rapid growth (in length) was observed in the first three years after which the growth rate declined. The yearly increment in length was found better in the specimens from Simsang river than those of other two rivers (Table 29B).

FITTING OF GROWTH EQUATION IN L. PANGUSIA : The Ford-Walford growth was plotted in Fig. 37A, B & C from which it can be seen that the ultimate or asymptotic length (L_{∞}) of L. pangusia from Simsang, Lubha and Madhura rivers were found to be 65.80 cm, 68.10 cm and 61.60 cm respectively. The maximum lengths of this species encountered in the present study were 58.5 cm, 60.5 cm and 54.6 cm from Simsang, Lubha and Madhura rivers respectively which were close to the theoretical length (L_{∞}).

FITTING OF GROWTH EQUATIONS IN L. DERO : The ultimate or asymptotic length (L_{∞}) of L. dero from different populations was calculated by Ford-Walford method (Fig. 37D, E & F). The ultimate lengths from Simsang, Lubha and Madhura rivers were observed to be 49.0 cm, 50.90 cm and 45.75 cm respectively which were slightly longer than the maximum length recorded in

the present study. The longest specimens of L. dero were observed to be 47.2 cm, 42.7 cm and 42.8 cm from Simsang, Lubha and Madhura rivers respectively.

AVERAGE LENGTH AND WEIGHT OF L. PANGUSIA AT THE TIME OF VARIOUS ANNULI FORMATION : The average length and weight of L. pangusia at the time of various annuli formation have been given in Table 30A. It can be seen from Table 30A that after the completion of the first year, the average lengths attained by this species were 25.98 cm, 27.76 cm and 24.27 cm from Simsang, Lubha and Madhura rivers respectively. It can also be revealed from Table 30A that the weight of this species from all the three rivers, increases sharply from 3rd year onwards. The increment in weight was found higher in the older size groups (Fig. 38A). It has been observed that though there is no significant differences in lengths attained by male and female in different ages, however, the weight of the females is relatively higher than the male of the same age group. The average length and weight of L. pangusia from Lubha river were found to be higher than those of the specimens from Simsang and Madhura rivers in the corresponding age groups (Table 30A).

AVERAGE LENGTH AND WEIGHT OF L. DERO AT THE TIME OF VARIOUS ANNULI FORMATION : The average length and weight of L. dero at the time of various annuli formation have been shown in Table 32 from which it can be seen that after completion of the first year the mean length attained by L. dero from Simsang,

Table 30: AVERAGE SIZE AND WEIGHT AT THE TIME OF VARIOUS ANNULI FORMATION

A. LABEO PANGUSIA

No. of completed annuli	Simsang River		Lubha River		Madhura River	
	Length (cm)	Weight (gm)	Length (cm)	Weight (gm)	Length (cm)	Weight (gm)
I	25.98	168.73	27.76	228.87	24.27	146.40
II	32.89	337.39	35.15	414.42	32.23	293.63
III	40.80	541.84	41.52	686.58	38.63	492.74
IV	47.78	882.56	47.24	927.37	44.81	786.52
V	51.39	1174.20	53.58	1605.40	49.58	973.66
VI	55.83	1422.50	55.68	2748.20	52.50	1580.00

B. LABEO DERO

I	21.03	105.78	19.42	109.44	19.50	73.14
II	30.29	209.27	30.73	232.27	27.93	181.75
III	34.26	321.69	34.61	366.92	33.86	301.18
IV	39.50	493.16	38.50	536.72	37.50	478.47
V	42.50	686.57	40.83	771.53	40.00	684.81
VI	47.20	962.46	-	-	-	-

Lubha and Madhura rivers were 21.03 cm, 19.42 cm and 19.50 cm and at the end of the second year were 30.29 cm, 30.73 cm and 27.93 cm respectively.

Like L. pangusia, the increment in weight of L. dero was found minimum in the first year and from third year the weight increases sharply in all the populations studied (Fig. 38B). There is no significant difference in length and weight between males and females of this species, but in the higher age groups females were found to be heavier than the males.

ABSOLUTE AND RELATIVE (SPECIFIC) GROWTH IN L. PANGUSIA : The absolute and relative growth in L. pangusia from various river systems studied were given in Table 31. The average growth of L. pangusia after the completion of 6 years were found to be 55.83 cm in length and 1422.50 gms in weight from Simsang river, 55.68 cm in length and 2748.20 gms in weight from Lubha river and 52.50 cm and 1580 gms in length and weight respectively from Madhura river. The absolute growth curve of this species from various rivers representing the average sizes at the time of formation of the successive six annuli (Fig. 36A, B & C). It was observed in the present study that the growth in length was comparatively more rapid in the first four years and out of these four years, the growth in length in the first year being nearly half of the total length attained in the entire life (Table 31).

Table 31: ANNUAL GROWTH INCREMENTS OF LABEO PANGUSIA IN LENGTH AND WEIGHT

Duration between checks	GROWTH IN LENGTH			GROWTH IN WEIGHT								
	Growth increment in (cm)			Growth increment in gms.			Percentage of total growth (Relative growth)					
	S	L	M	S	L	M	S	L	M			
0-I	25.98	27.76	24.27	46.53	49.86	46.23	168.73	228.87	146.40	11.86	8.33	9.27
I-II	6.91	7.39	7.96	12.38	13.27	15.16	168.66	185.55	147.23	11.86	6.76	9.32
II-III	7.91	6.37	6.40	14.17	11.44	12.19	204.45	272.16	119.11	14.37	9.90	12.60
III-IV	6.98	5.72	6.18	12.50	10.27	11.77	340.72	240.79	293.78	23.95	8.76	18.59
IV-V	3.61	6.34	4.77	6.47	11.39	9.09	291.64	678.03	187.14	20.50	24.67	11.84
V-VI	4.44	2.10	2.92	7.95	3.77	5.56	248.30	2114.80	606.34	17.46	41.58	38.38
	55.83	55.68	52.50	100.00	100.00	100.00	1422.50	2748.20	1580.00	100.00	100.00	100.00

S = Simsang River; L = Lubha River; M = Madhura River.

The relative or specific growth (G) decreases gradually with increase age of L. pangusia (Fig. 36A, B & C). The maximum relative growth was observed between 0⁺ and 1⁺ year and the minimum was observed in between 5⁺ and 6⁺ years.

The growth increment in weight of this species was found more or less constant upto the 3rd year, but from the 4th year onwards the increment in weight was observed to be very fast (Fig. 38A).

ABSOLUTE AND RELATIVE (SPECIFIC) GROWTH IN L. DERO : The absolute and relative (specific) growth in L. dero from different population studied were presented in Table 32.

Occurrence of a very rapid growth in length is indicated in the first three years. Like L. pangusia in this species also, the growth in length in the first year was found to be maximum (Fig. 36D, E, & F). The average growth at the end of 5th year was observed as 47.20 cm in length and 962.46 gms in weight from Simsang river. The absolute growth at the end of 4th year was found to be 40.83 cm and 40.00 cm in length and 771.53 gms and 684.81 gms in weight from Lubha and Madhura rivers respectively (Table 32).

Relative growth in L. dero was found to be 44.55% to 48.75% at the end of 1⁺ year, thereafter the relative growth rate was progressively declined. The percentage of total growth (relative growth) in weight was found more or less constant upto 3rd year afterwhich the weight of the species increased rapidly (Fig. 38B).

Table 32: ANNUAL GROWTH INCREMENTS OF LABEO DERO IN LENGTH AND WEIGHT

Duration between checks	GROWTH IN LENGTH						GROWTH IN WEIGHT					
	Growth increment in cm.			Percentage of total growth(Relative growth)			Growth increment in gms.			Percentage of total growth (Relative growth)		
	S	L	M	S	L	M	S	L	M	S	L	M
0-I	21.03	19.42	19.50	44.55	47.56	48.75	105.78	109.44	73.14	10.99	14.19	10.68
I-II	9.26	11.31	8.43	19.62	27.70	21.08	103.49	122.83	108.61	10.75	15.92	15.86
II-III	3.97	3.88	5.93	8.41	5.50	14.82	112.42	134.65	119.43	11.68	7.45	17.44
III-IV	5.24	3.89	3.64	11.10	9.53	9.10	171.47	169.80	177.29	17.82	22.01	25.89
IV-V	3.00	2.33	2.50	6.36	5.71	6.25	193.41	243.81	206.34	20.10	30.43	30.13
V-VI	4.70	-	-	9.96	-	-	275.89	-	-	28.66	-	-
	47.20	40.83	40.00	100.00	100.00	100.00	962.46	771.53	684.81	100.00	100.00	100.00

S = Simsang River; L = Lubha River; M = Madhura River.

DISCUSSION

DISCUSSION

MORPHOMETRY AND MERISTIC COUNTS

In the case of both, L. pangusia and L. dero intraspecific variations in some morphometric characters and meristic counts have been observed (Table 1 and 2). Significant variations in the morphometry of L. pangusia were observed in some of the parameters, such as body depth, girth, base of dorsal fin and in inter-orbital length (Table 1). However, in L. dero statistically significant difference (at 5% level) could only be observed in the case of height of dorsal fin. Such variations can only be attributed to the different ecological conditions which suggest the adaptability of the organisms to their new environment as has also been pointed out by many workers (Schmidt, 1921; Vladykow, 1934; Taning, 1944; Lindsay, 1954; Fage, 1958; Barlow, 1961; Tandon, 1977; Suzuki and Yamaguchi, 1980; Kaur, 1981; Dasgupta, 1982).

According to Gould (1966) ratios between different morphological characters of the same species does not necessarily be constant due to variation resulting from differences in sex, race, nutrition and other environmental factors. Therefore, in the present study too, variations in morphometric measurements may be attributed to the diverse environmental factors.

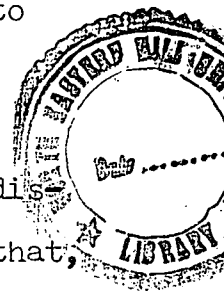
Various authors have shown that morphometric characters of fish can vary under the influence of environment and in particular, thermal factor during the period of incubation and

the beginning of larval life (Schmidt, 1921; Vladykov, 1934; Taning, 1944; Lindsay, 1954; Fage, 1958 and Barlow, 1961).

Variations in the body proportions in the same species according to hydrographic conditions have also been recorded by various authors (Hubbs, 1922; Barlow, 1961). They associated these variations due to the effects of growth period and of the relative differentiations which determines the number of vertebrae and of segments.

Meristic counts of L. pangusia and L. dero were also observed to differ from one population to other (Table 5 and 6). Various authors (Schmidt, 1921; Vladykov, 1934; Taning, 1944; Lindsay, 1954 and Barlow, 1961) have reported that meristic characters exhibit plasticity under the influence of environmental factors especially temperature, during the early period of life-stage. According to Hubbs (1922) and Taning (1944), variation occurs in the number of rays in the unpaired fins in several species, which is also related to an adaptation to movement of water of various density.

According to Day (1878) and Hora (1936) the most distinguishing character between L. pangusia and L. dero is that, in the former snout is without groove and with distinct lateral lobes whereas in the latter, snout with a groove and without lateral lobes. Apart from these differences a considerable difference in other parameters between L. pangusia and L. dero have also been observed in the present study such as body depth,



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girth, height of dorsal fin, eye diameter and pre-orbital length and these were found to be greater in L. pangusia (Table 1 and 2). It is interesting to note that pre-orbital length, is greater than post-orbital length in the case of L. pangusia whereas in L. dero, the case has been found to be reverse (Table 1 and 2).

In L. dero, the mature males were found to have prolongation of the anterior rays of the dorsal fin. Hora and Misra (1936) also observed similar elongation of the dorsal fin in mature males of L. dero. Apart from the elongation of the dorsal fin in the mature males, the "pearl organs" (a term generally used for small cornified, epidermal tubercles which appear on the head of the various cyprinoid fishes during breeding) time are very greatly enlarged and as a result of the very fleshy snout the groove becomes comparatively much deeper than in the males. Thus, according to Hora and Misra (1936) L. dero exhibits sexual dimorphism and supports the present results.

It has been observed in the present study that except the variation in length in the dorsal fin of L. dero, the difference in the morphometric parameters between males and females of L. pangusia and L. dero are not so well defined. However, it has been observed that the females of both the species are generally larger in size, whereas in the mature males the pectoral fins were found slightly longer than those of the females.

Nikolsky (1963) stated that males and females often differ in the length and shape of the fins. According to him, in the males of many Cyprinoids, both the paired and the unpaired fins of males are slightly larger than the females. He also cited examples of some species where male and female were found to differ in length and shape of the fins. For example, in the males of certain Lake Baikal and Sculpins, Cotio comephorus, the thoracic fins were found to be significantly larger. He further stated that in Xiphophorus (Fam. Poccilidae) there is a long outgrowth of the caudal fin in males, whereas in the males of many Pleuronectids of the family Bothidae, the rays of the dorsal fin are elongated and so on. In majority of cases the difference between the structure of the fins in males and females is connected with the peculiarities of reproduction, as for example, the dorsal fin which is larger in the males than in the females of grayling, Thymallus, and increases still further toward the time of spawning, creates a turbulence close to the spawning fish during the spawning process, and delays the dispersal of the sperm by fast currents (Brown, 1938). The larger size of the pelvic fins of the male tench (Tinca tinca) also facilitates a more successful fertilization of the eggs and their attachment to plant stalks (Nikolsky, 1963). Hence, such a difference in the morphometric characters of males and females may be regarded as sexual-dimorphic characters.

Biometric study of L. pangusia and L. dero revealed that the eye diameter becomes smaller in relation to head length

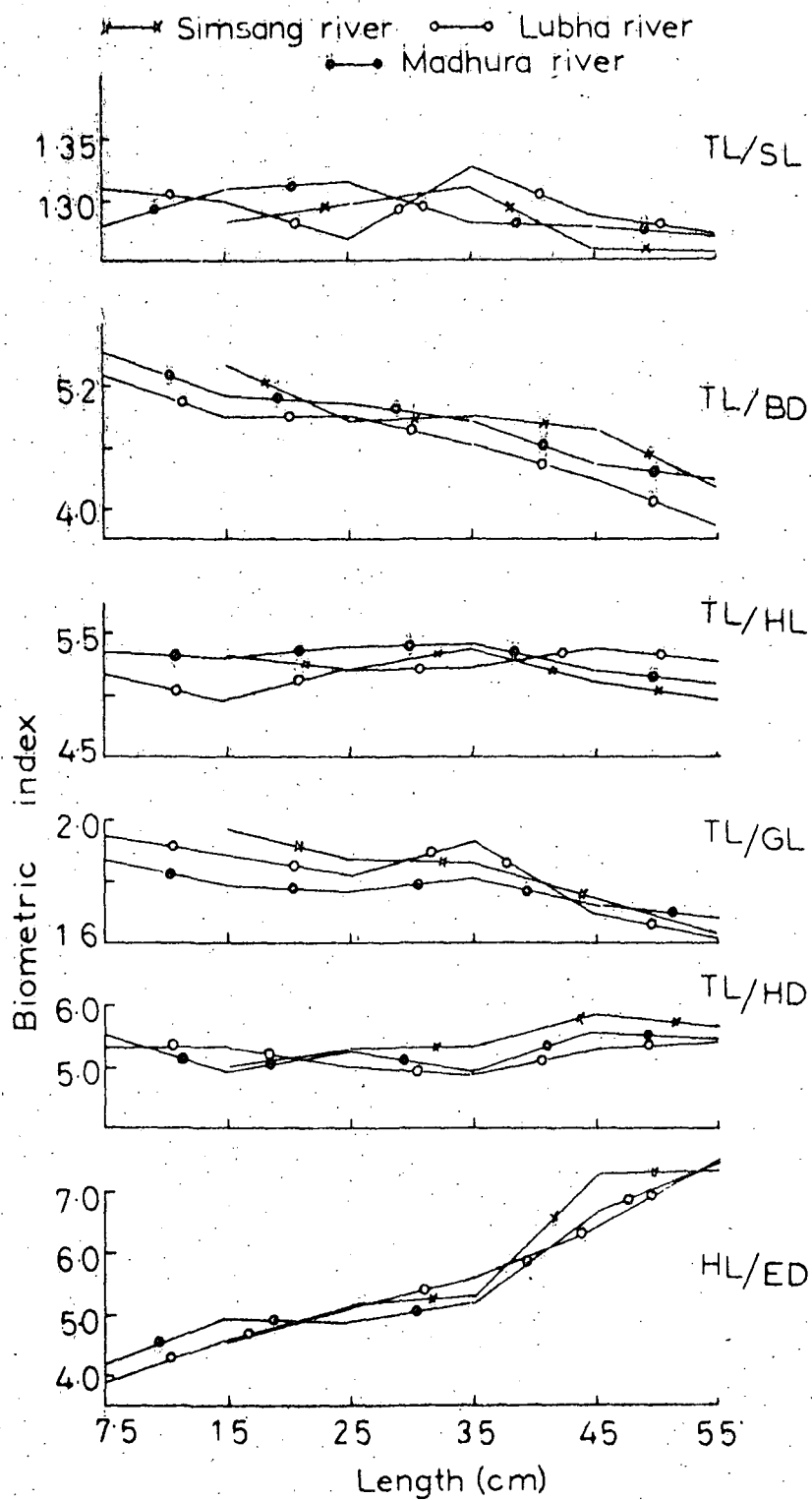


Fig. 3. Biometric indices of Labeo pangusia

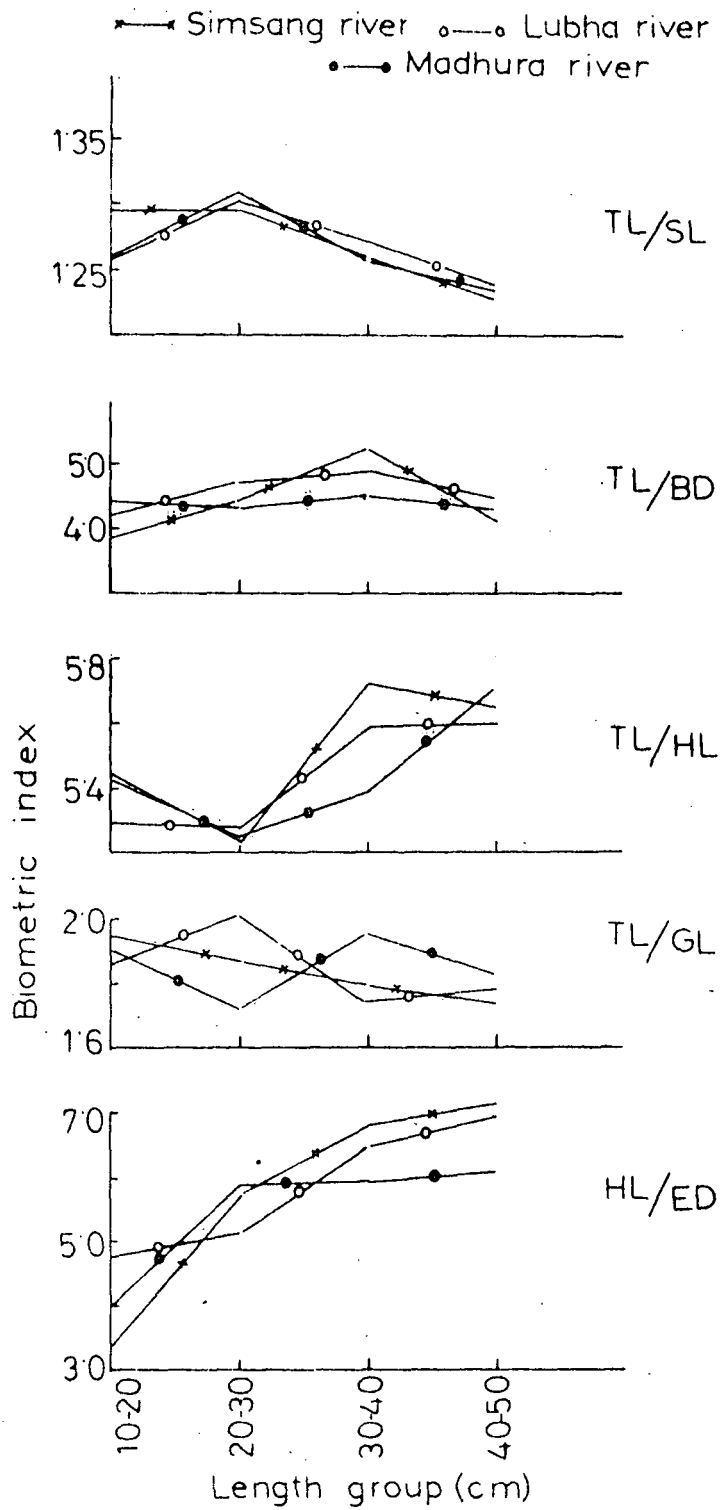


Fig. 4. Biometric indices of Labeo dero

(Figs. 3 and 4). A similar case has been reported by Tobor (1974) for Lates niloticus, Kaur (1981) for Channa gachua and Dasgupta (1982) for Acrossocheilus hexagonolepis. The biometric indices of head length and head depth in the case of L. dero were found more or less constant in the present study. According to Bayagbona (1963) a constant index in any of the biometric indices indicates that the growth of the biometric character in relation to its reference length is isometric. The body depth and girth in L. pangusia shows positive allometry (Fig. 3) which means the species becomes relatively deeper as it grows in length.

POPULATION STRUCTURE

Young specimens of L. pangusia and L. dero particularly specimens belonging to 0-year and 1-year age groups were dominant in the present collection which may be due to high mortality rate of bigger individuals apart from selectivity of the gears used.

In the present study, it is seen that females of L. pangusia and L. dero were more in numbers than males in all the three populations. According to Nikolsky (1963), the sex ratio varies considerably from species to species, but in the majority of species it is close to one. The sex-ratio differs from one population to another of the same species, and may vary from year to year in the same population. Collins (1971) and Klingbeil (1978) have stated that the dominance of females in

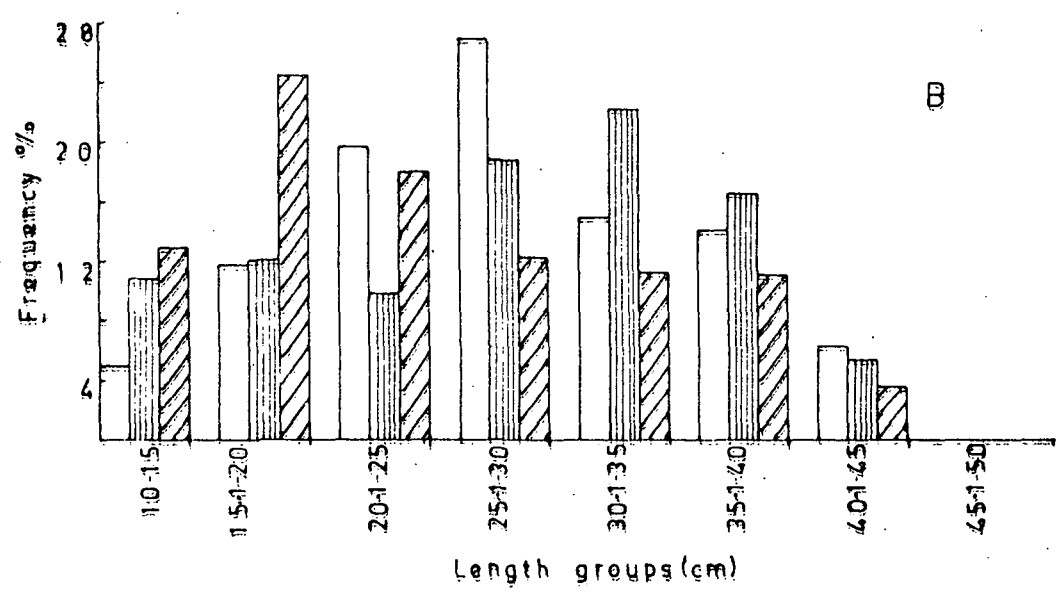
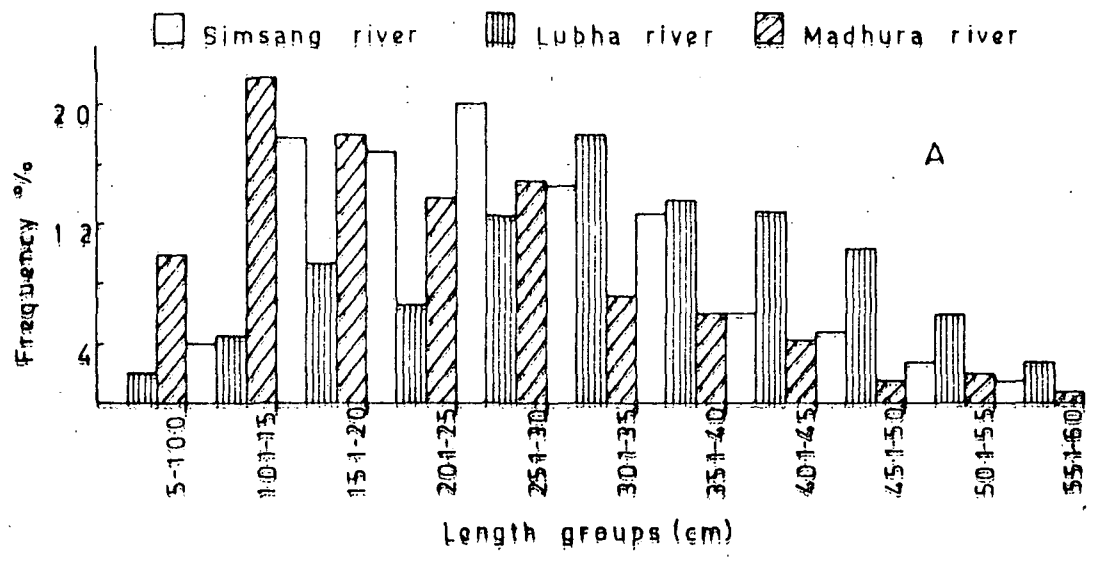


Fig. 5 Length-frequency distribution of (A) *L. pangusia* and (B) *L. dero*

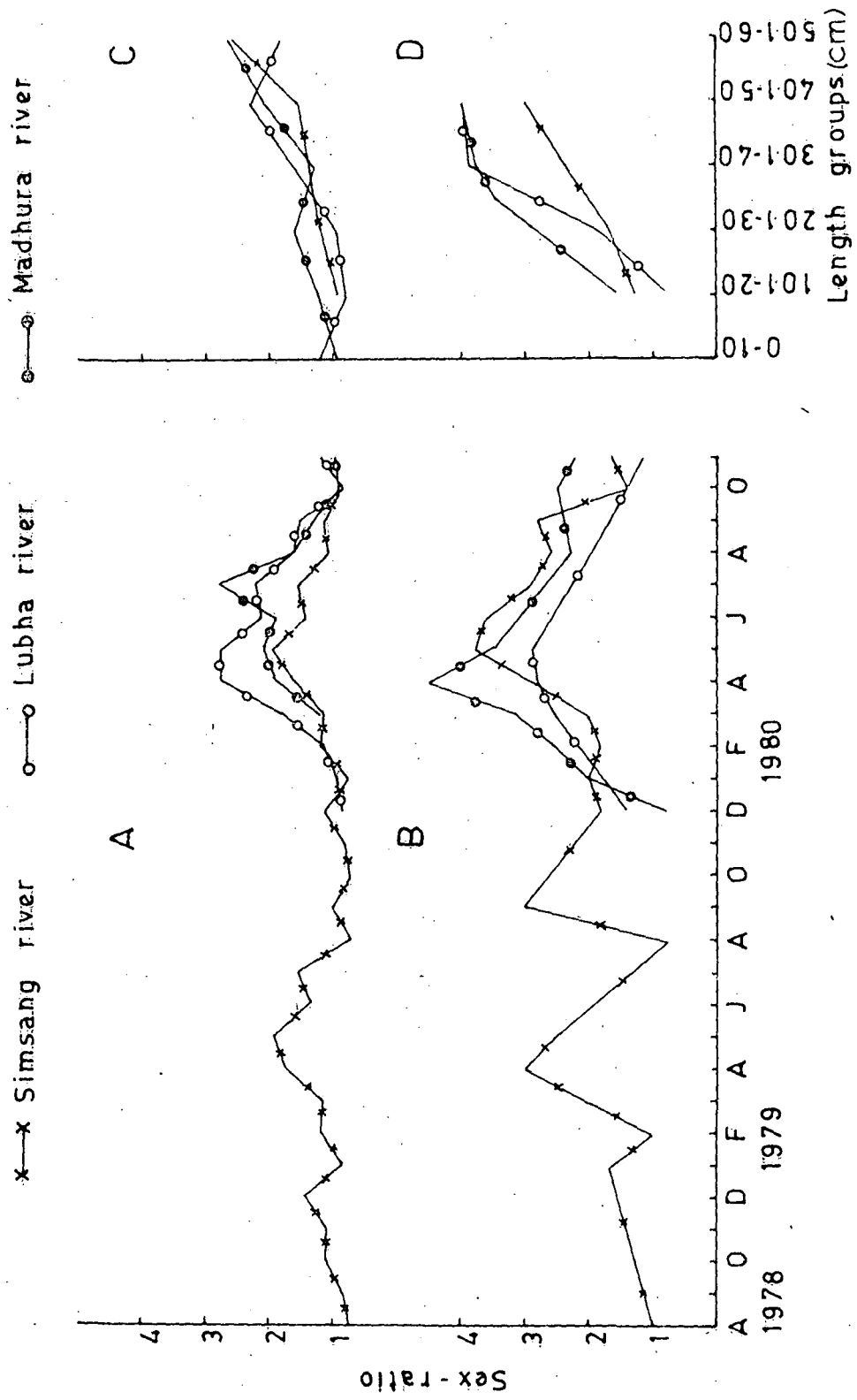


Fig. 6. A & B Sex-ratio in different months
 C & D Sex-ratio in different length groups

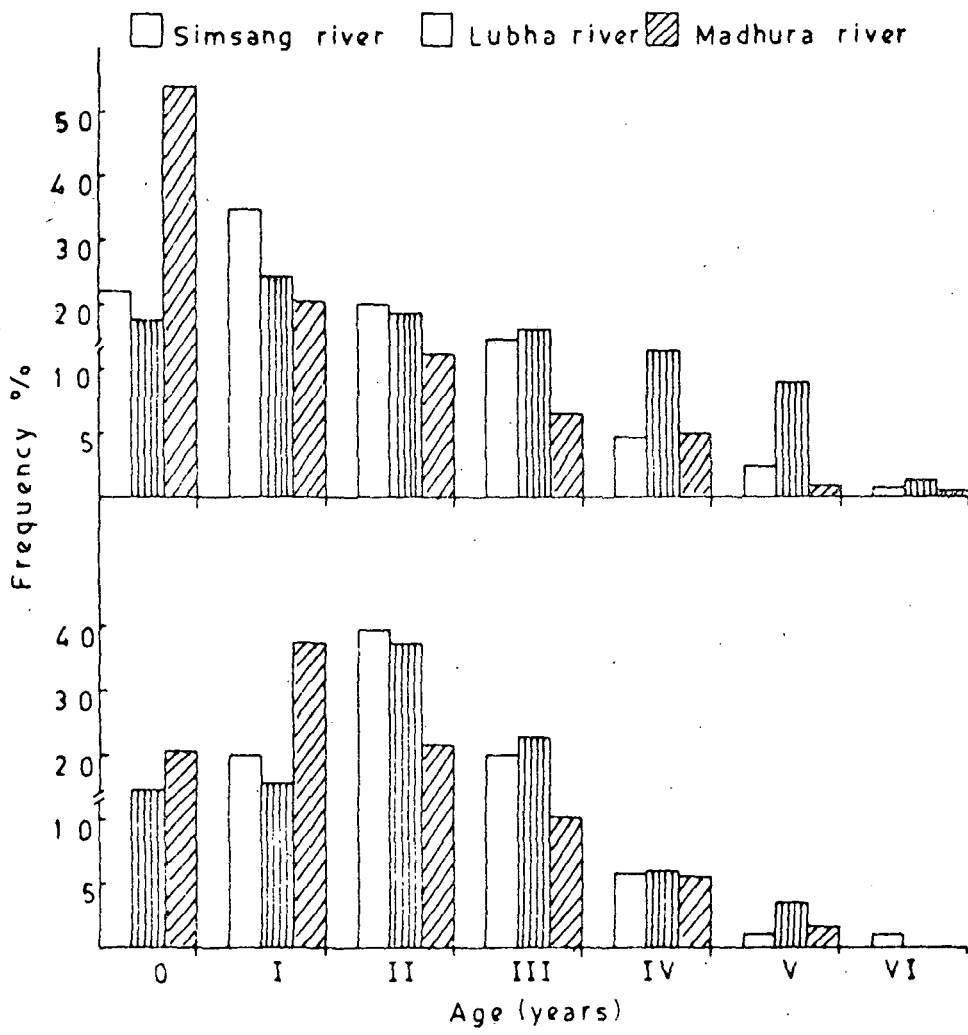


Fig. 7 Age frequency distribution of Labeo pangusia (A) and Labeo dero (B)

commercial fishery samples could be explained by assuming that differential mortality or growth rate affected females and males. According to them if males have shorter life span than the females, more females would be expected in the older age groups. Conversely, the sex-ratio would be expected to drop when recruitment of young fish occurred. One might expect the same trend, when females grew faster or larger than males. Hora and Misra (1936) also observed that in nature the number of females greatly exceeds that of males.

A possible explanation for the general abundance of females particularly in the older size groups may be that the sexes differ in their vulnerability to cast nets. The females are generally heavier than the males in both L. pangusia and L. dero particularly during maturing and spawning season (March to July), which perhaps makes the females sluggish and less agile than the males making them easily catchable. Differential mortality may also be a cause of differences in sex-ratios. Similar phenomena were also observed by Bhatnagar (1972) in L. fimbriatus. Some authors (Menon, 1950; Bhatnagar, 1963 and 1972) also opined that strain of spawning in males perhaps makes them less viable which affect the sex-ratio of the population.

LENGTH-WEIGHT RELATIONSHIP

The body weight recorded for both the species studied from different river systems showed an increasing trend with the increase in total length. It is clear from the result on

length-weight relationship (Table 9) that there exists interspecific variations in the exponential values of both the species. Lal and Dwivedi (1965) and Sekheran (1968) have also observed interspecific variations in the power function (b) of length in relation to body weight in Rita rita and Sardinella albella and S. gibbosa respectively at different stages of their growth. Hughes et al. (1974) while studying the effect of growth and gills and accessory respiratory organs of Saccobranchus (=Heteropneustes) fossilis have mentioned the compressed body shape of the species, a probable cause of increase in the power function ($b=3.325$).

The regression coefficient (b) showed variations in different seasons even in the same population. Further, it has been observed that the 'b' value of the females was found to be generally higher than the males in all seasons. This indicates that the females have better condition and growth than the males. The length-weight data also reveal that the female has a deeper body than the male in both the species which supports the observations made by Olatunde (1979) in Etropius niloticus and Schilbe mystus.

The variations in the exponential value (b) of fishes is generally supposed to be under the influence of numerous factors viz., seasonal fluctuations in environmental parameters, physiological conditions of the fish at the time of collection, sex, gonadal development and nutritive conditions of the

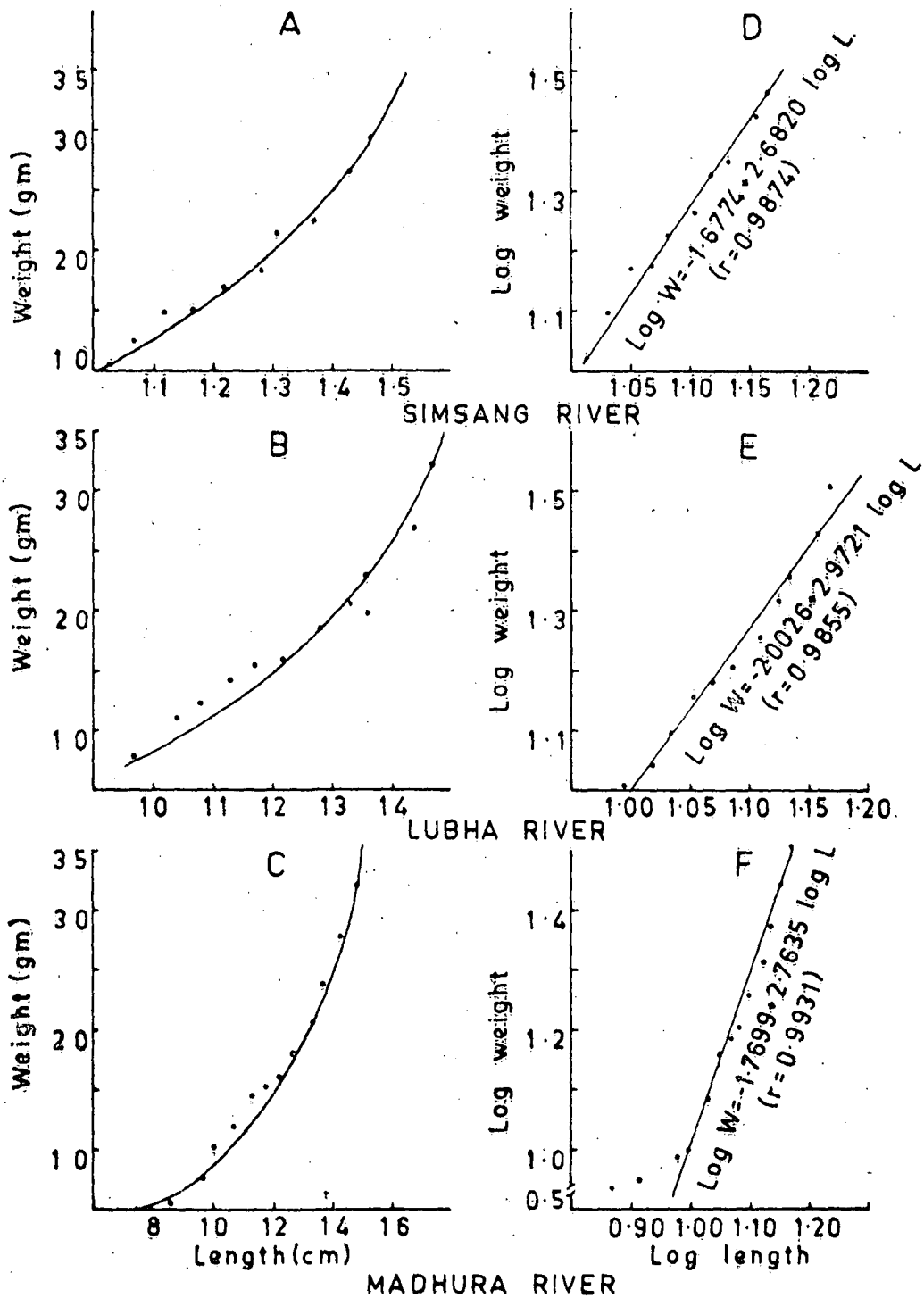


Fig. 8. Parabolic curve (A,B & C) and log-log relationship (D,E & F) between length and weight in the juveniles of Labeo pangusia

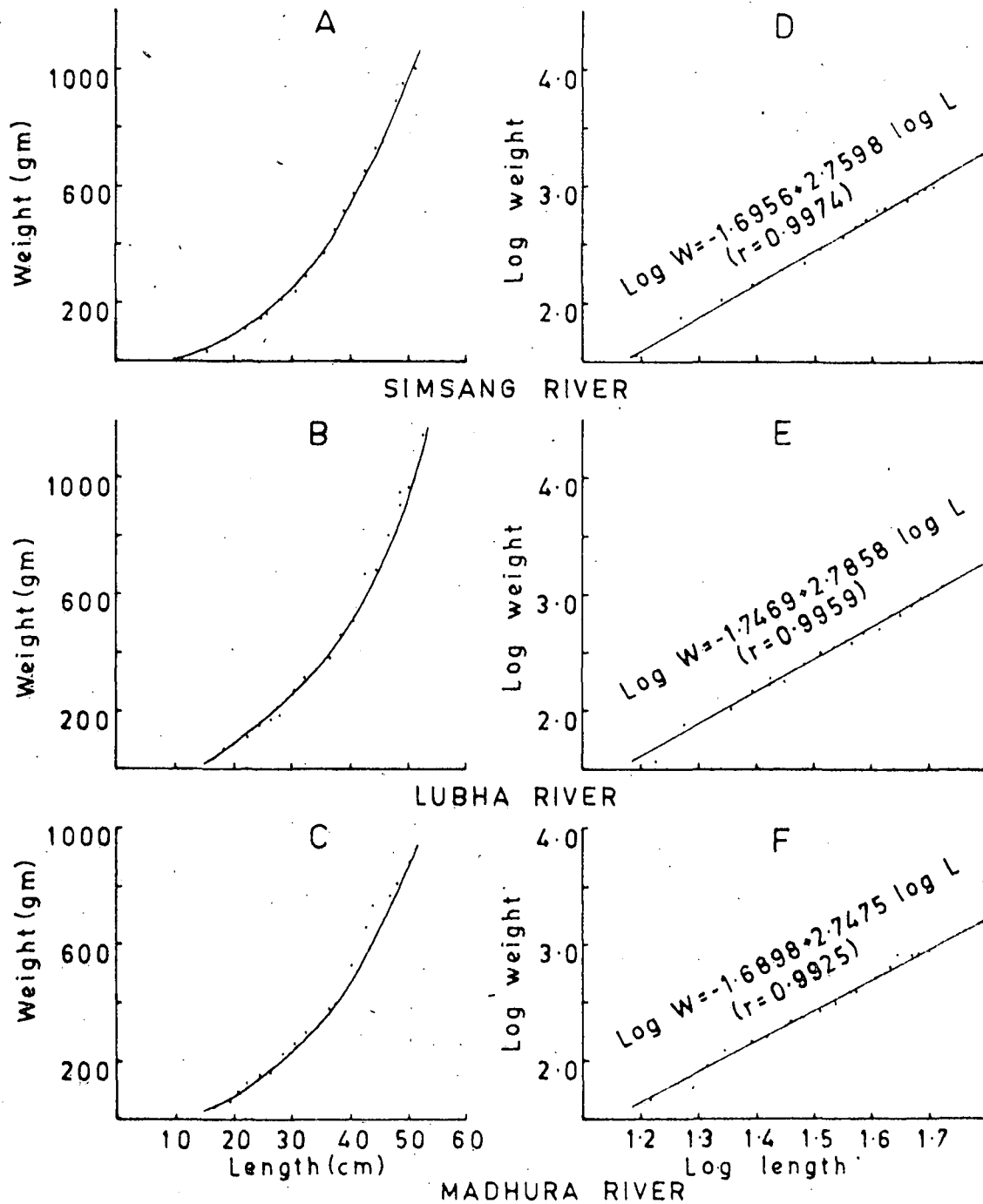
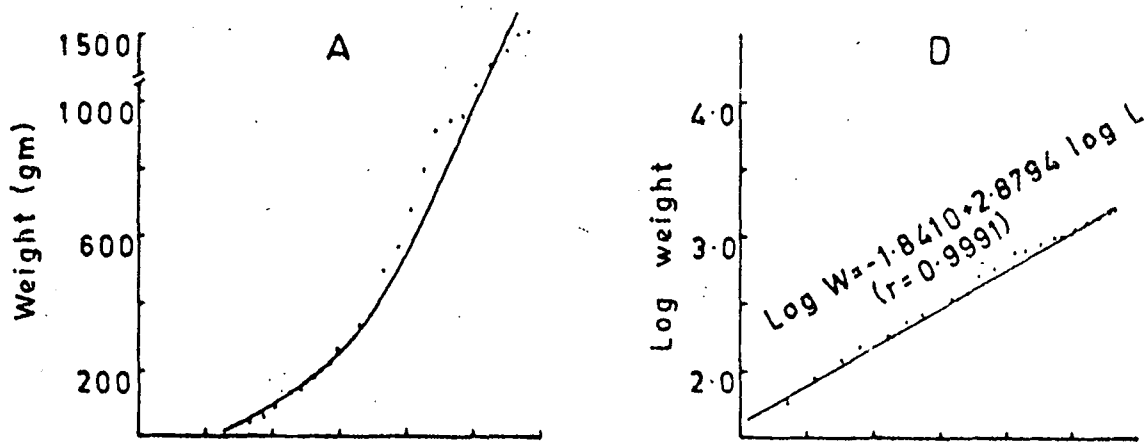
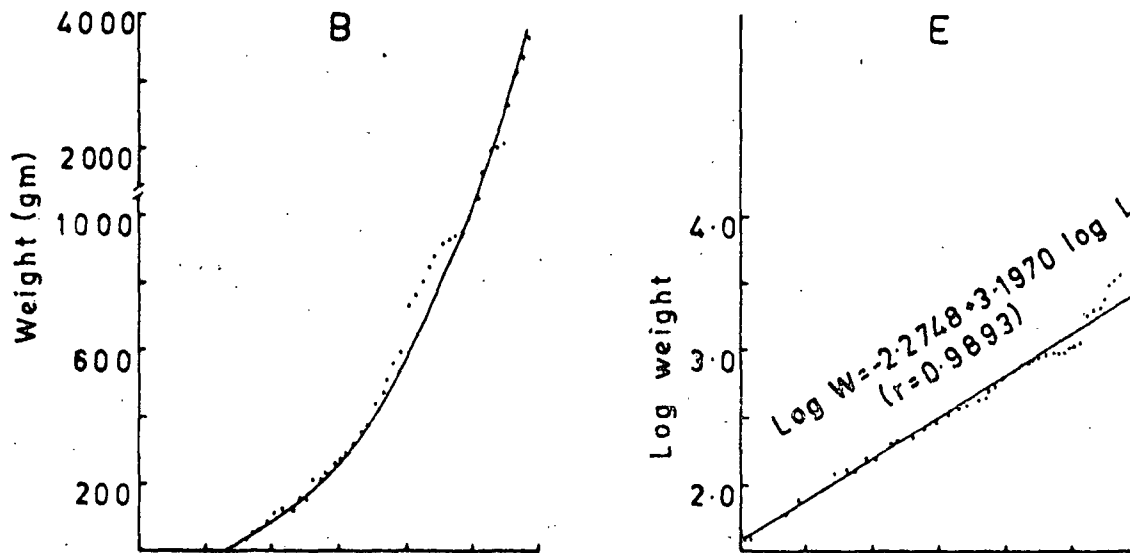


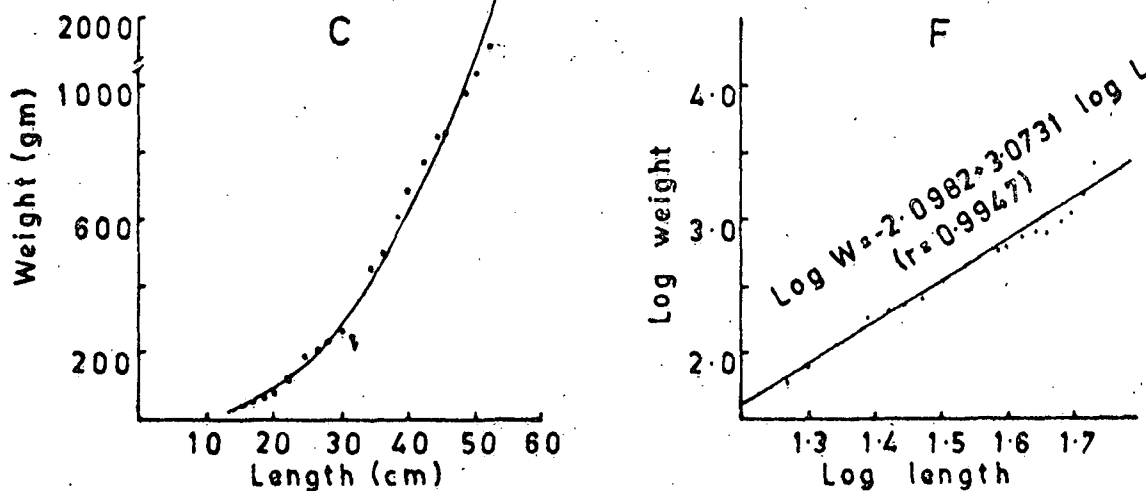
Fig. 9. Parabolic curve (A & B) and log-log relationship (D, E & F) between length and weight in the males of Labeo pangusia



SIMSANG RIVER



LUBHA RIVER



MADHURA RIVER

Fig.10. Parabolic curve (A,B & C) and log-log relationship (D,E&F) between length and weight in the females of Labeo pangusia

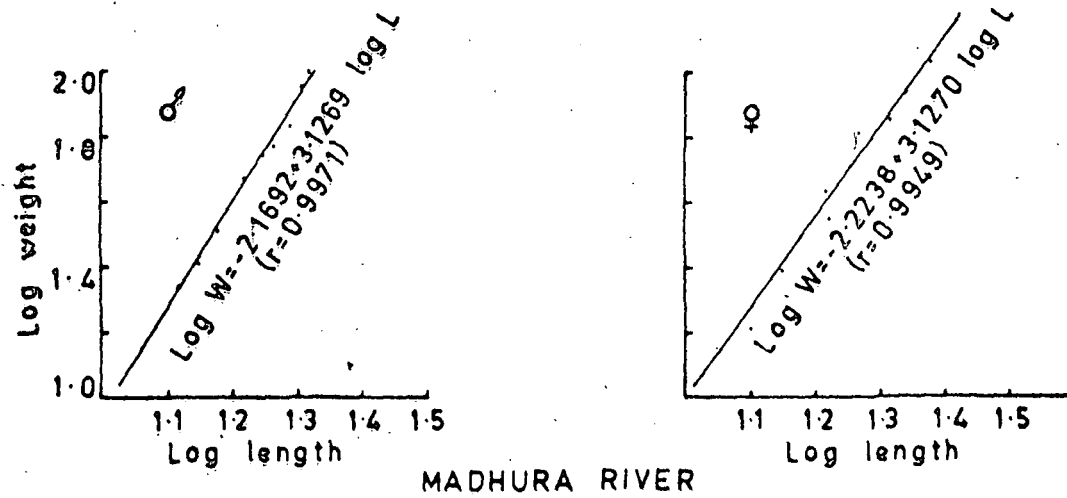
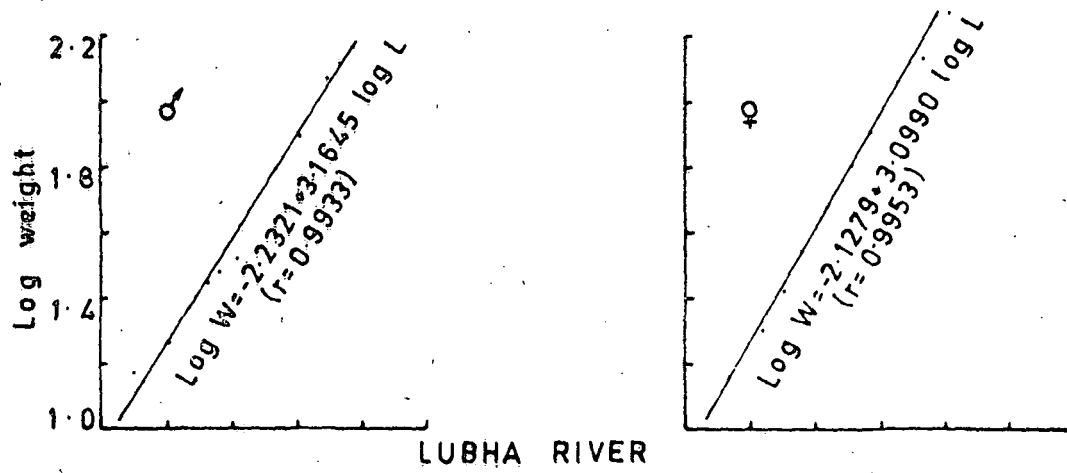
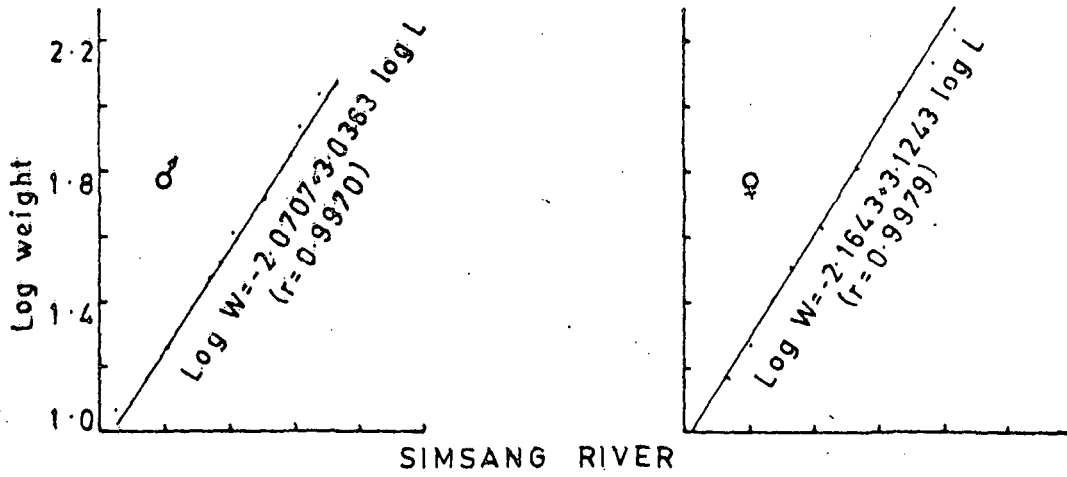


Fig.11. Log length-weight relationship in the juveniles of Labeo dero.

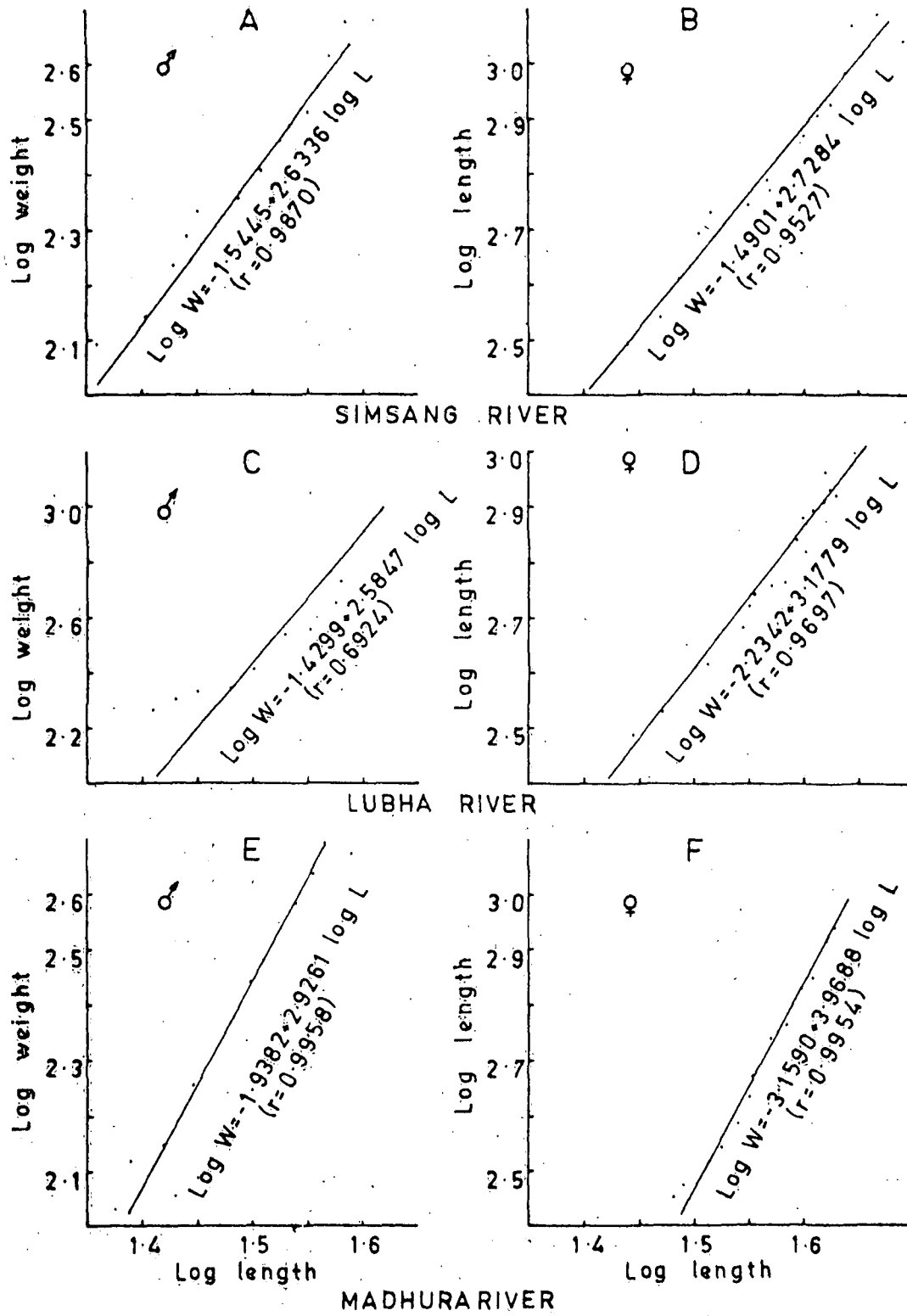


Fig.12 Log length-weight relationship in the adult of Labeo deero

environment of the fishes (Sinha, 1973; Kaur, 1981 and Dasgupta, 1982). Hence, it is quite likely that the variations in the exponential values might be due to the reasons stated above as the specimens were collected from three different river systems. The exponential values for both the species were found to vary in different seasons (summer, monsoon and winter), in different eco-systems indicating that there exists intra-specific variations too.

According to Hile (1936) and Martin (1949) the value of exponent 'b' usually range between 2.5 and 4.0. Allen (1938) suggested that the value for 'b' remains constant at '3.0' for an ideal fish. In the present study, the value of 'b' as obtained for L. pangusia is 2.8454 from Simsang river, 3.1517 from Lubha river and 2.9884 from Madhura river whereas in the case of L. dero, it is 2.8126 from Simsang river, 3.0251 from Lubha river and 3.2973 from Madhura river. It is important to determine at least the orders of magnitude in the ponderal index of the power function (b) of length in relation to body weight. The values of 'b' in different species of Labeo worked out by various authors have been compiled in Table 33. It is evident from the Table 33 that the values in almost all the species of Labeo, approximates the cube law and hence keeping the suggestion of Hile (1936) and Martin (1949) in view, the fishes of this genus can be considered as "Ideal". The higher exponent values during monsoon season in both the species may be due to gonadal development as suggested by Frost (1945) and Huxley (1932).

Table 33: REGRESSION CO-EFFICIENT (b) OF LENGTH-WEIGHT
RELATIONSHIP OF CERTAIN LABEO SPECIES

Species	Regression Co-efficient (b)	Reference
<u>L. bata</u>	Male : 3.3109	Chatterjee <u>et al.</u> (1977)
	Female : 3.2026	
	Juvenile : 3.3822	
<u>L. calbasu</u>	Pooled : 3.1858	Rao (1972)
	Male : 3.0300	Pathak (1975)
	Female : 2.9683	
<u>L. capensis</u>	Male : 3.0222	Baird and Fourie (1978)
	Female : 3.0980	
<u>L. dero</u>	Male : 2.9120	Present author
	Female : 3.2042	
<u>L. fimbriatus</u>	Male : 3.1449	Bhatnagar (1972)
	Female : 3.2138	
	Juvenile : 2.8719	
<u>L. gonius</u>	Pooled : 2.7347	Rao (1976)
	Pooled : 3.0865	Parameswaran <u>et al.</u> (1974)
	Male : 3.1010	Chatterjee (1980)
	Female : 3.0981	
	Juvenile : 3.1222	
<u>L. niloticus</u>	Pooled : 3.1401	Hashem (1972)
<u>L. pangusia</u>	Male : 2.7627	Present author
	Female : 3.0809	
	Juvenile : 2.7394	
<u>L. rohita</u>	Pooled : 3.0240	Khandker and Haque (1968)
	Male : 3.2275	Khan (1972)
	Female : 3.1439	
	Juvenile : 3.3611	

Beverton and Holt (1957) suggested that the departure from 3.0 of 'b' value, is rather rare. However, Narasimhan (1970) reported that the value of 'b' increases in the carnivorous fish, Trichiurus lepturus, which devour big prey. According to Soni and Kathal (1979) the higher value of 'b' (4.36) obtained for Cirrhina mrigala, was due to the presence of large quantities of sand and mud in their stomach, resulting in an increase in the total weight. According to Tesch (1971), the exponent (b) value of "3" indicates that a fish grows isometrically while Le Cren (1951) expressed that the value of the exponent gives an indication of condition; if the value of the exponent (b) remains same in each season. Vasnetsov (1953a) stated that during their development fish typically pass through several stages or stanzas, each of which may have its own length-weight relationship. However, in the present study the value of 'b' in the juveniles of L. pangusia was found to be less than 3.0, which may be due to their feeding preference towards algal and animal matters (Table 14). In the adult specimens the higher 'b' value than the juveniles might be due to the presence of detritus and good amount of sand particles in their stomach as observed in the present study (Table 14) which supports the views of Soni and Kathal (1979) and Kaur (1981).

CONDITION FACTOR

It has been seen that there are seasonal fluctuations in the 'K' values in both L. pangusia and L. dero. The varia-

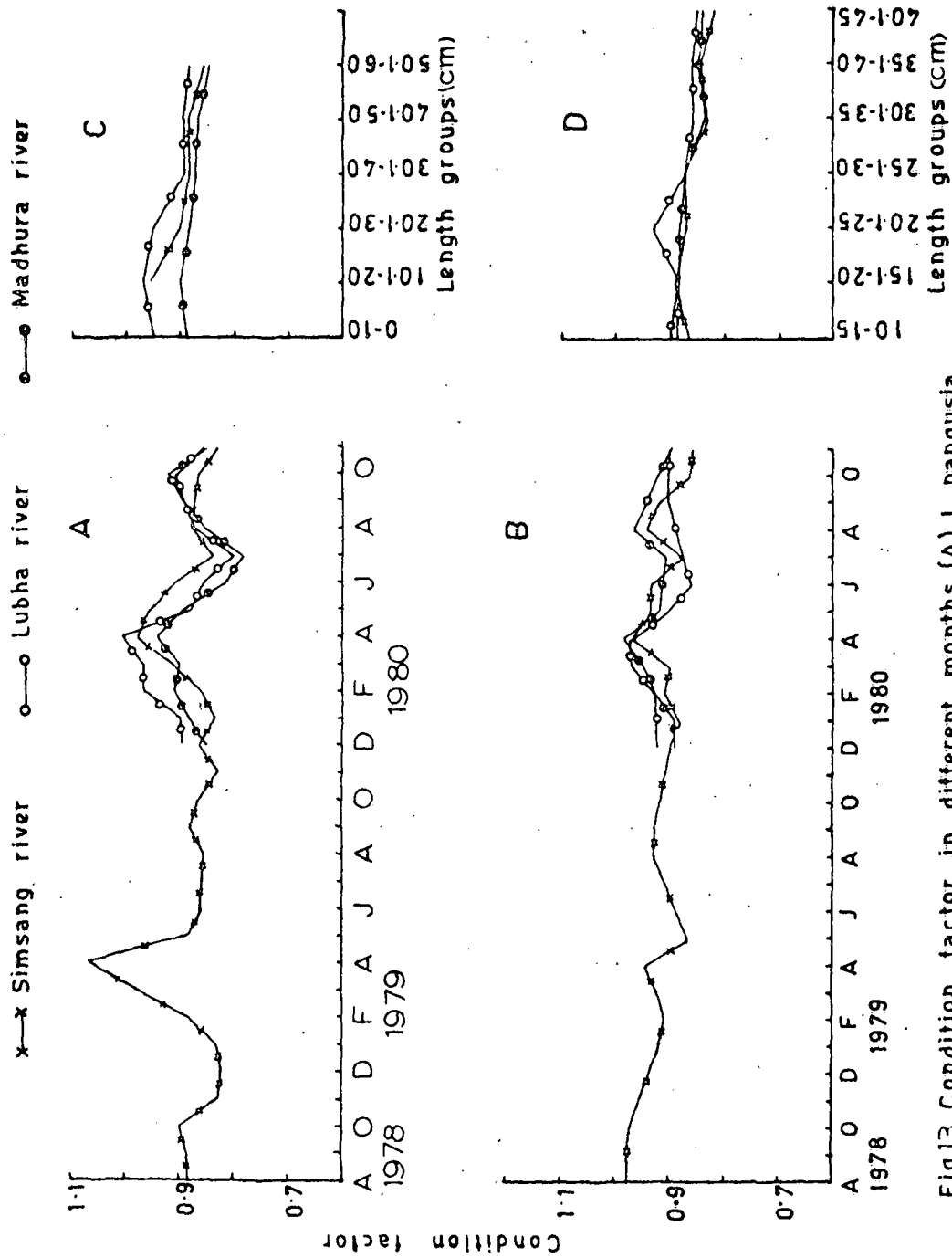


Fig.13. Condition factor in different months (A) L. pangusia
 (B) Labeo dero and different length groups
 (C) Labeo pangusia and (D) L. dero

tions in the condition factor may be attributed to different factors, such as food availability, gonadal maturity and abiotic factors of the system, as has also been suggested by many workers (Le Cren, 1951; Jhingran, 1972; Bashirullah, 1975; Kaur and Nasar, 1984). According to them, knowledge about the changes in the 'K' values with the increase in length may yield evidences reflecting the size at first maturity, while the seasonal fluctuations may reflect the spawning cycle of a fish as the 'K' is influenced by gonadal condition. However, in the present study, it has been seen that the smaller size groups of both the species have higher condition values indicating juveniles have better 'condition'. Many workers (Menon, 1950; Pillay, 1954; Sarojini, 1957; and Varghese, 1961) have also observed a higher 'K' values in the juveniles of other species.

The result further suggests that the increase in the weight of the body due to the weight of maturing gonads followed by a decrease due to spawning, is also reflected in the 'K' values of the fish. Weatherley (1972) stated that even among the members of one population sampled on a single date, there may be considerable variation in the 'K' values with length which is further supported by results obtained in the present study. According to him, fish population display considerable changes in average condition, reflecting normal seasonal fluctuations in their metabolic balance and in the maturation pattern and subsequent release of reproductive products. Even the state of fullness of the alimentary canal may influence

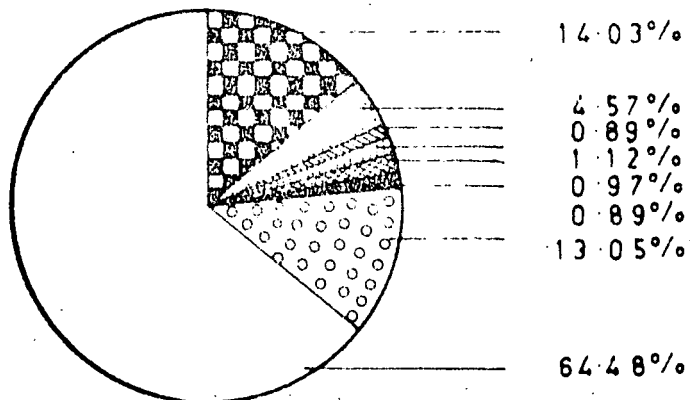
'K' factor. It has been observed in the present study that during August-September, the feeding intensity of both the species increased (Table 18) and subsequently the 'K' factor too, increased. The increment in the 'K' values during March-April may primarily be due to maturation of gonads.

From November to January, the 'K' factor was found to be lowered down in both the species. This indicates that the condition factor is not only influenced by the maturation of the gonads and the food present in the alimentary canal but might also be due to certain other environmental factors too as suggested by Kaur (1981) and Dasgupta (1982).

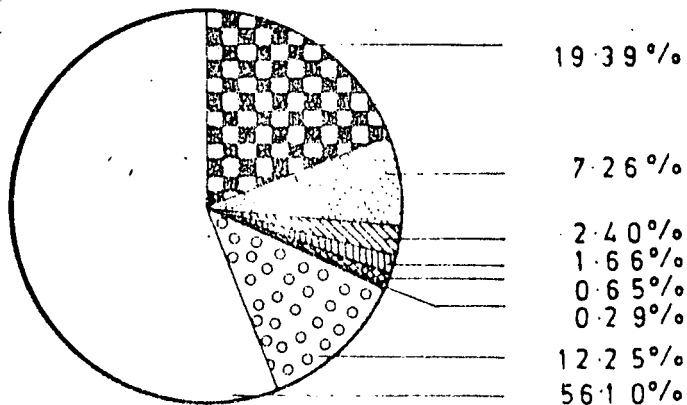
FOOD AND FEEDING HABITS

Nikolsky (1963) classified the food of fishes into three main categories i.e. (1) basic food, (2) secondary food and (3) incidental food. He further classified the feeding habit of fishes according to the amount of variation in the types of food consumed by them. According to him (Nikolsky, 1963) the fishes are either (i) euryphagic (feeding on a variety of foods) or (ii) stenophagic (feeding on a few different types of food) or (iii) monophagic (feeding on only a single type of food).

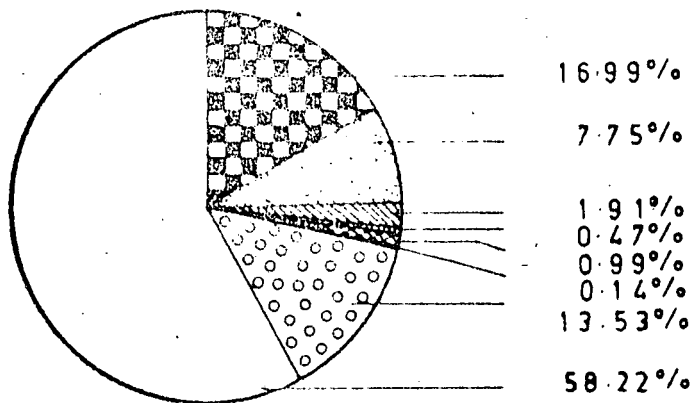
Accordingly, the basic food of L. pangusia and L. dero as observed in the present study may be considered as detritus and diatoms as both of these together comprised 27 - 40% of the



SIMSANG RIVER



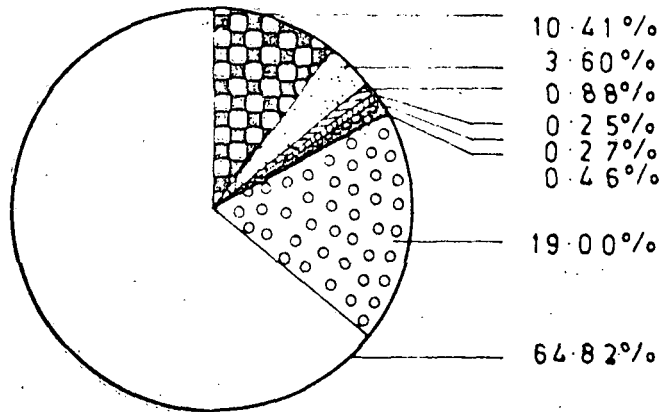
LUBHA RIVER



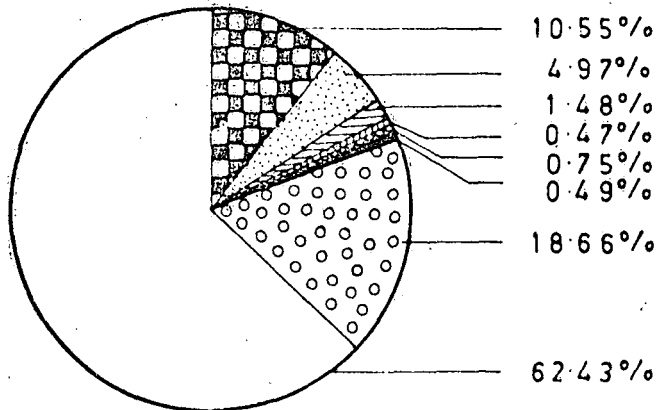
MADHURA RIVER

■ BACILLARIOPHYCEAE ■ CHLOROPHYCEAE ■ MYXOPHYCEAE
 ■ ANIMAL MATTER ■ VEGETABLE MATTER ■ MISCELLANEOUS
 ○ DETRITUS □ SAND AND SILT

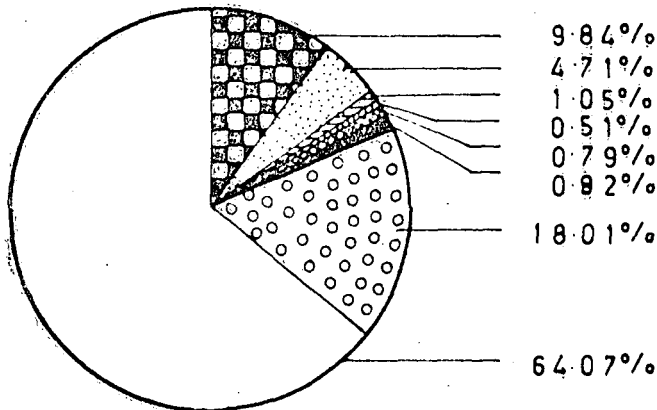
Fig.14. Percentage composition in different broad groups of food items of Labeo pangusia



SIMSANG RIVER



LUBHA RIVER



MADHURA RIVER


 BACILLARIOPHYCEAE
  CHLOROPHYCEA
  MYXOPHYCEAE
 ANIMAL MATTER
  VEGETABLE MATTER
  MISCELLANEOUS
 DETRITUS
  SAND AND SILT

Fig.15. Percentage composition in different broad groups of food items for Labeo deero

total gut contents. Sand particles though found in high percentages in the guts cannot be considered as basic food of these two species and it is believed that sand particles enter in the guts along with detritus due to browsing habit of both the species along the river bottom. Chlorophyceae and Myxophyceae may be considered as secondary foods of L. pangusia and L. dero. The remaining items found in the guts were regarded as incidental food, due to the fact that they form a very small fraction of the gut contents and occur without any regularity in different months (Table 13 and 16).

It has been observed from the results that there exists seasonal variations of different food items in the gut contents of L. pangusia and L. dero. Similar results have also been observed by various workers in different fishes (Bhatnagar and Karamchandani, 1970; Khan, 1972; Chatterjee et al., 1978; Kaur, 1981, Dasgupta, 1982 and many others).

The gut content analysis in different seasons showed that algal matter (Bacillariophyceae, Chlorophyceae and Myxophyceae) declined in both L. pangusia and L. dero during monsoon months, whereas the case was contrasting with sand particles and detritus. The latter items were found predominant during monsoon months in the guts of L. pangusia and L. dero from all the populations. This may be due to abrupt changes brought about by floods in the ecological conditions in the river by uprooting the food organisms from their substrata

Fig.16. Seasonal variations in different broad groups of food items of L. pongusia

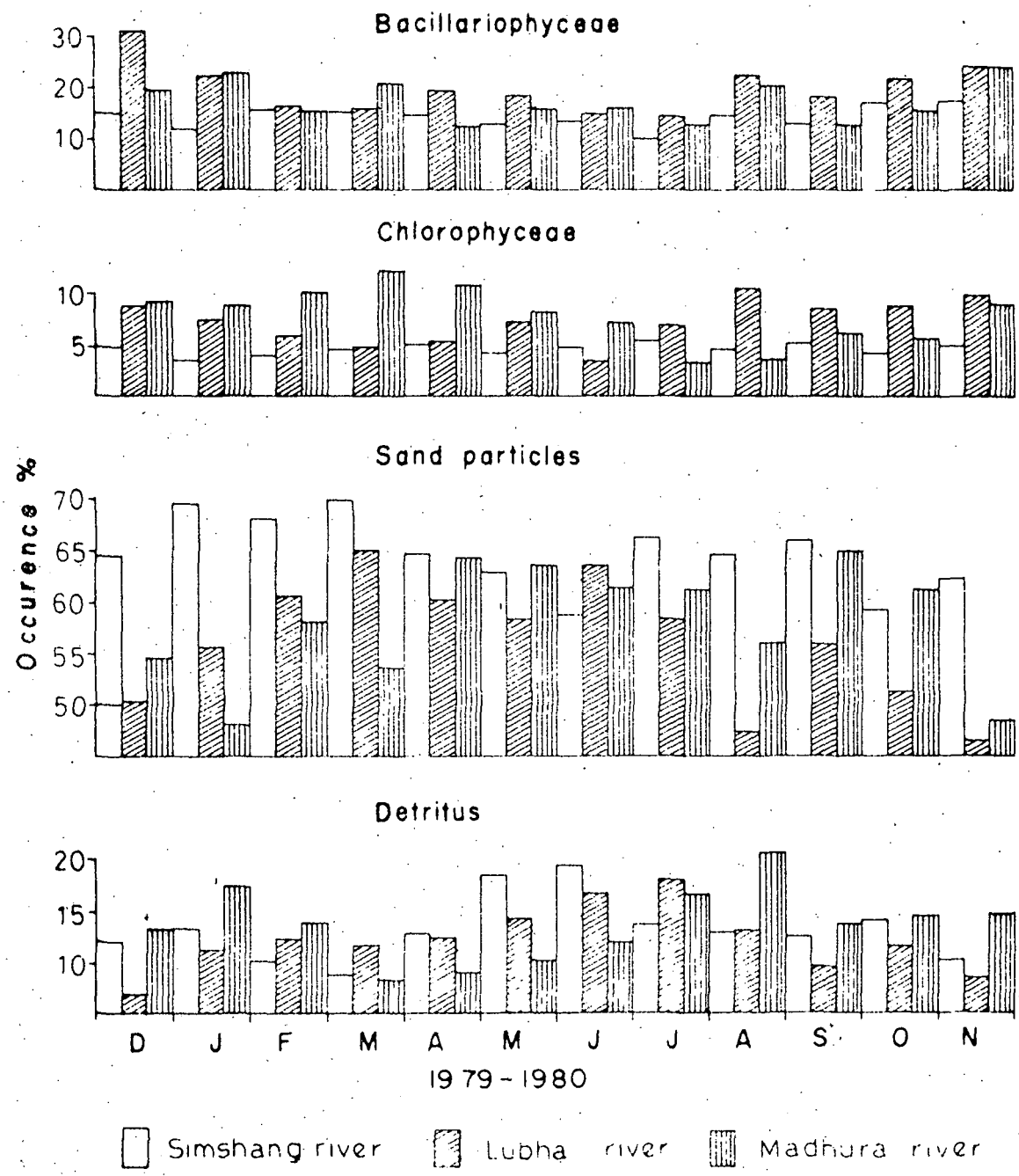
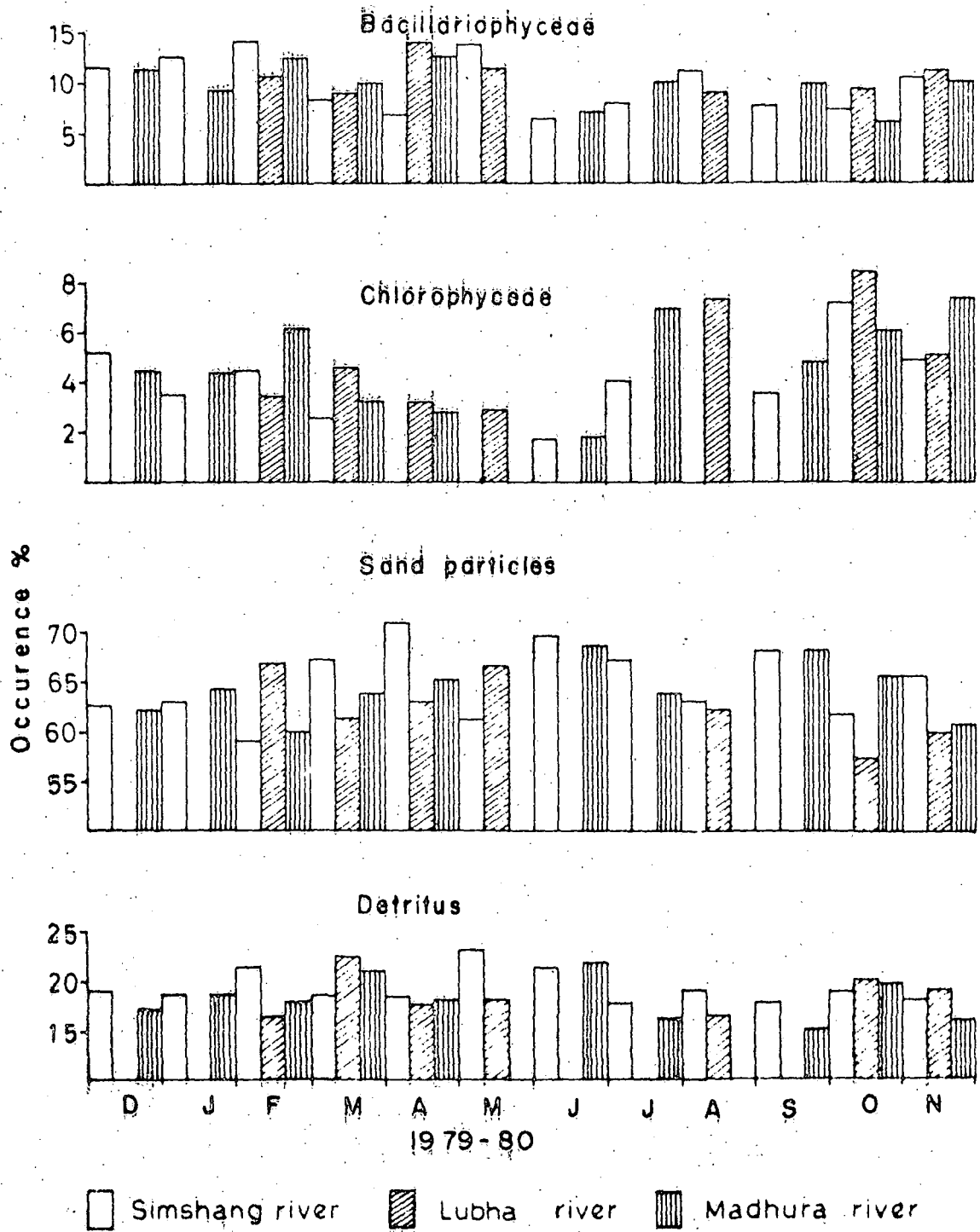


Fig. 17. Seasonal variations in different broad groups of food items of Labeo dero



and thereby largely obliterating the feeding grounds. According to Bhatnagar and Karamchandani (1970) phytoplankton production during monsoon months is highly influenced by turbidity resulting in less planktonic food available to the fish.

Since, the type of food taken by L. pangusia and L. dero depends on the availability of food organisms in their feeding ground, it can be assumed that the algal matters encountered in the guts of both the species were available in abundance in the habitats under study. According to Islam (personal communication) Navicula is the most dominant genera among diatoms available in the North-Eastern region of India. Among other genera of Bacillariophyceae Nitzschia, Fragillaria, Cymbella and Synedra are moderately abundant. He further observed that Spirogyra is the most dominant genera among Chlorophyceae. The above mentioned genera of Bacillariophyceae and Chlorophyceae also most frequently occurred in the gut contents of both L. pangusia and L. dero. Thus, both the fishes do not exhibit any particular selectivity even within the broad groups of their food items and can perhaps subsist on whatever planktonic organisms are available in the habitat.

A change in diet with increase in size of fishes has been reported by Keast (1966), Larsen (1967), De Silva (1973a), Adams (1976) and Kakuda and Matsumoto (1978). In the present study also, a change in the diet from omnivorous type to herbivorous type has been observed as the fishes grow in length. The present study has also shown that feeding intensity is high among the

smaller individuals which may be owing to the fact that the metabolic activities are generally higher in young ones. Similar results have also been reported by Hardy (1924), Marshall et al. (1939), De Silva (1973a), Kaur (1981) and Dasgupta (1982) in other species.

It is interesting to note that both L. pangusia and L. dero subsist more on the diet of animal origin and algal matter (blue and blue-green algae) when they are young (below 20 cm length). The quantity of detritus and sand particles were found comparatively less in their diet. As the fishes grow in size the proportion of sand particles and detritus increases while the proportion of algal and animal matters in the diet gradually decreased. However, the carnivorous nature of feeding habit of young fishes was explained by Alikunhi (1952). According to him the food of the major carp fries contain an average 80% of animal matter in their food consisting mainly crustacean larvae and rotifers. He further attributed that the carp fries are sight feeders and surface dwellers. They can distinguish between the undesirable items of food from the desirable ones. Therefore, the eyes appears to play a major role in selection of food. The alimentary canal of the major carp fry is also adapted for carnivorous diet. Sinha and Moitra (1975) reported that simple mucosal folds in the different regions of the alimentary canal in the fry are specialized for the simple zooplanktonic food which they normally ingest.

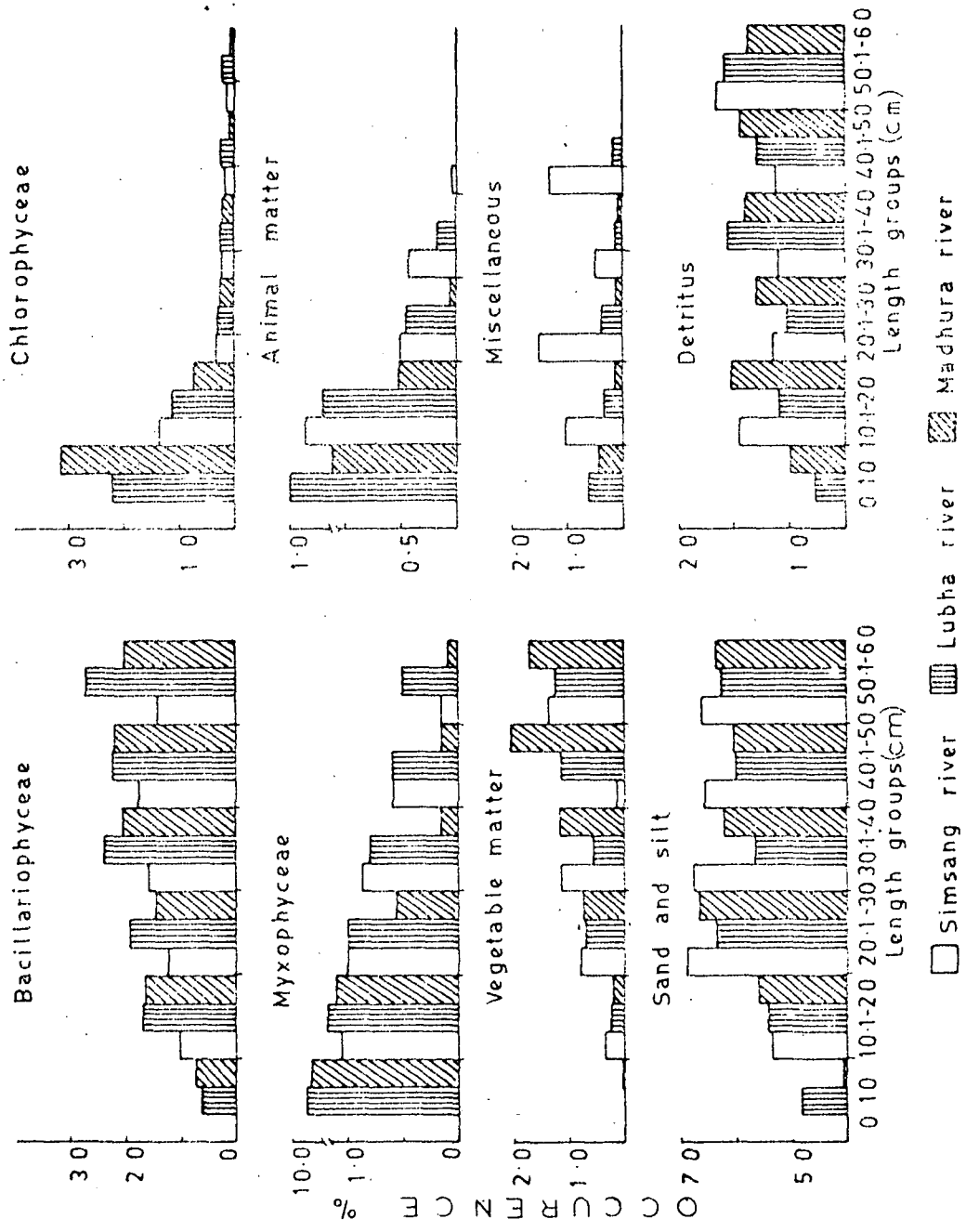


Fig.18. Variations in the broad groups of food items in different length groups of Labeo pangusia

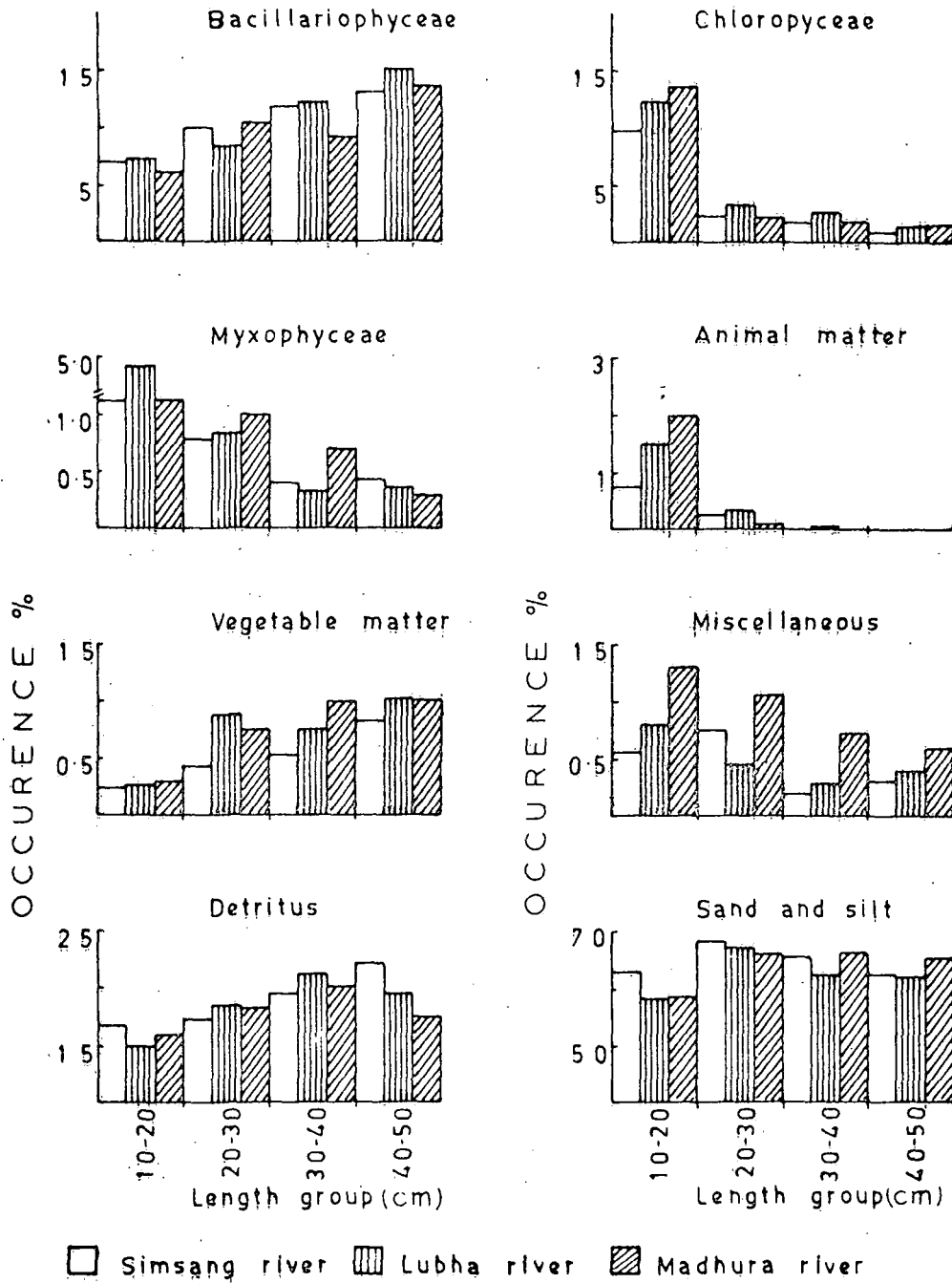


Fig.19. Variations in different broad groups of food items in different length groups of Labeo dero

It has also been observed in the present study that the adult L. pangusia and L. dero prefer only macrovegetation. It is noteworthy that semidigested macrovegetation was consistently encountered in smaller quantity in the guts during the monsoon months, when the terrestrial vegetations are brought into the river through the catchment area by rain water. These macrovegetation also form a part of the diet of the fishes during monsoon months which may be due to decrease of diatoms and algae by the scouring action of the flood as suggested by Bishop (1973).

The percentage of large quantities of sand particles and detritus, together with algal forms in the guts of L. pangusia and L. dero indicate that both the species feed at the river bottom and in the pockets of the shallow marginal areas. The inferiorly situated and more or less fimbriated mouth, coupled with the occurrence of large quantities of sand particles and detritus in the guts of both the species indicate their browsing habit. Similar type of feeding habit in L. fimbriatus has also been reported by Bhatnagar and Karamchandani (1970).

According to Alikunhi and Rao (1951) while browsing in the river bottom the epiphytic and attached diatoms might have also been taken in by the fish along with the filamentous algae. The fact that unicellular green algae which are truly planktonic, were rarely encountered in the guts of the adults of L. pangusia and L. dero, the mere presence of diatoms in the

guts of both the species, therefore, does not provide sufficient evidence to consider these fishes as plankton feeders.

The present study also reveals that both the species devour their food from illitrophic zone - the layer of bottom mud in which benthic microflora, diatoms are most abundant followed by blue-green and green algae (Allen, 1936; Fox and Amstein, 1936 and Morris, 1936). The occurrence of large quantities of sand particles in the guts of adult specimens, as already stated probably enter accidentally while browsing in the river bottom. Similarly, comparatively less quantities of sand particles found in the guts of young specimens might be due to the fact that they do not exploit their food exclusively from the bottom strata of the river.

The present result supports the view of Nikolsky (1969) that the fish fauna of high latitudes are usually adapted to eating various types of food, on account of the high variability of the available food. The range of food organisms may vary greatly from area to area, even as regards to principal food, specially in freshwater conditions. Representative of association from high altitudes are usually at an advantage when the food base is labile, since they tend to be euryphagous; conversely, those from the lower latitudes are so when the food base is stable.

Feeding intensity of L. pangusia and L. dero were examined through studies of gastrosomatic index (G.S.I.) which

indicates that male and female of both the species feed intensively when they are immature (Stage I). The maturing fishes (Stage II and III) showed considerable increase in the feeding intensity while matured fishes (Stage IV to VI) showed a slackening in feeding. Spent fishes were again found to feed actively. This increase and decrease in feeding intensity was more prominent in females than males. A significant difference was found in the feeding intensity in both the sexes during the spawning period. Males exhibit higher feeding intensity than females during the spawning months and, as a whole feeding intensity was found higher in males almost throughout the year than the females. However, females feed more actively during post-spawning months than the males. The intensity of feeding in juveniles were found more or less constant throughout the year except during monsoon periods. A slight drop in the feeding intensity has also been noted in December and January which may be due to low temperature during these two months.

The G.S.I. values also reveal that the feeding intensity of both the species has a decreasing trend with the approach of the maturation phase of gonads reaching minimum in June and July. Reduced feeding of both L. pangusia and L. dero was noticed during this season, which is described as 'Spawning fast' by many authors (Frost, 1954; Buss, 1961 and Lawler, 1965). The feeding intensity improves during the post-spawning months (August-September) and also during the advent of summer (March - April). The low feeding intensity in the winter months

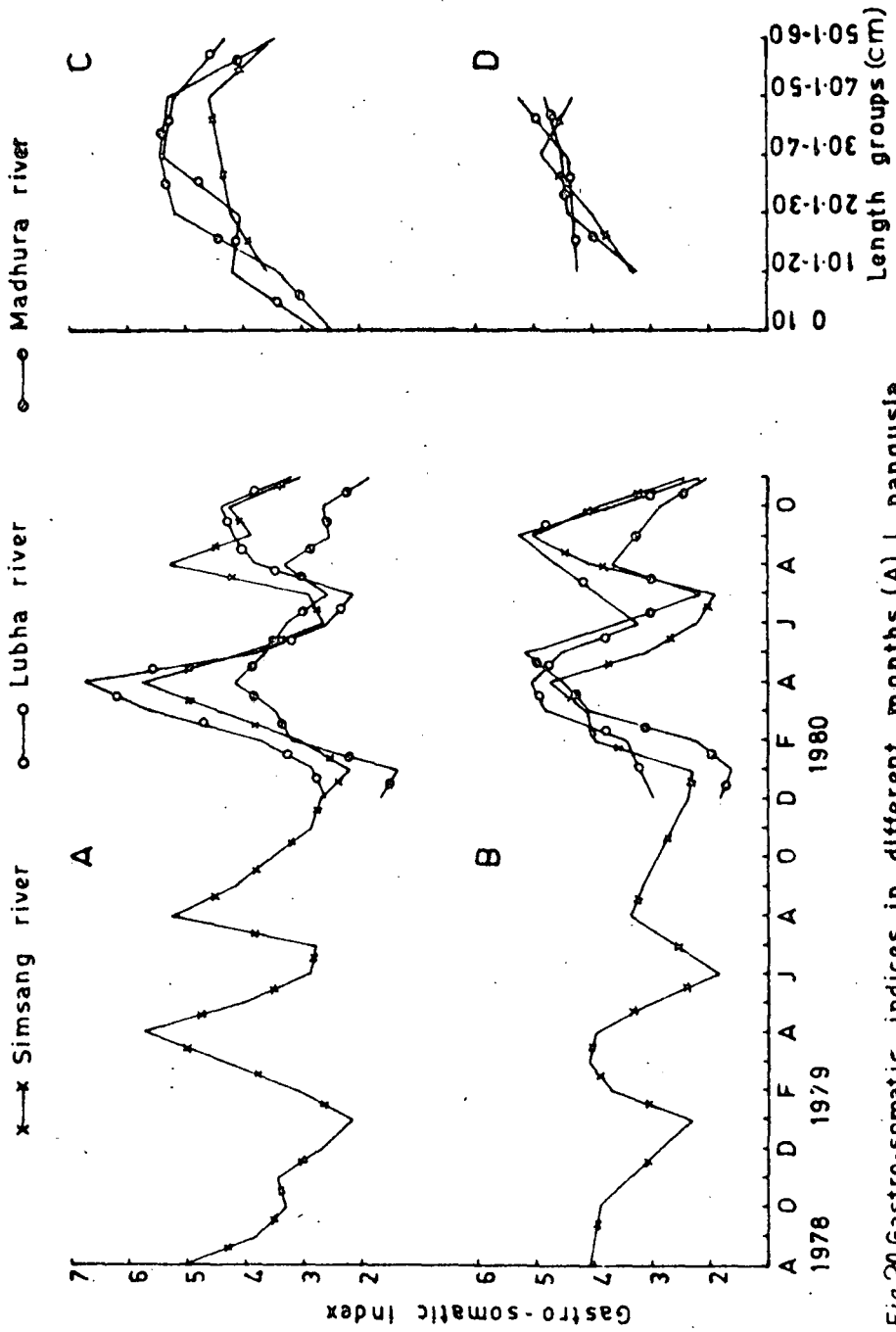


Fig.20. Gastro-somatic indices in different months (A) *L. pangusia* (B) *L. dero* and different length groups (C) *L. pangusia* and (D) *L. dero*

may be due to the low physiological activity of both the species during this period.

According to Das and Moitra (1963) in the herbivorous fishes feeding was invariably more in April, May and June, while in most cases it was less during July - August (during the onset of monsoon) when the fishes reproduce; and poor during winter months. From March to May, most of the fishes ingested large amounts of algal food. This was presumably because of the phytoplankton periodicity (Das and Srivastava, 1955) during these months.

Thus, it can be inferred that mature L. pangusia and L. dero resort to subdued feeding with the approach of breeding season and the feeding improves only after the spawning phase is over. The poor feeding during breeding season may be attributed to the development of gonads which, occupy the major space of the abdominal cavity. Hardy (1924); Fage and Veillet (1938); Menon (1950); Jhingran (1961); Desai (1970) and Pathak (1975) have recorded similar observation in various other species.

In the case of L. pangusia and L. dero low feeding activity was observed during monsoon even in the immature fishes. According to Bhatnagar and Karamchandani (1970) this is entirely due to inadequate availability of food organisms in the flooded river which seems to be true in the present study. During this period the decline in the abundance of algae which constitute the main food of the fish is also attributed to high

turbidity and poor light intensity in the environment because of overcast sky which, as is well known, interfere with the process of photosynthesis, resulting in poor survival and growth of plankton population as a whole. Thus, the low feeding intensity in the fishes during monsoon months is due to non-availability of food organism in the environment.

It has been observed in the present study that R.L.G. values of L. pangusia and L. dero increase with the increasing length of the fishes. According to Suyehiro (1941), Mookerjee and Das (1945), Al-Hussaini (1949) and Das and Moitra (1958) there is a correlation between the food habits and the R.L.G. of fishes. The length of the gut is almost equal to or in some cases less than the length of the fish in carnivores while in herbivores, it is longer, hence the increase being proportionate to the vegetable matter consumed. According to them, in fishes which change over from an initial carnivorous food habit to a predominantly herbivorous diet, the exact size at which this change over is affected can be determined indirectly from the ratio between the length of the fish and length of the gut (R.L.G.). Alikunhi and Rao (1951) also opined that the length of the gut of an animal is known to depend on the nature of the food they consume, the length increases with increasing proportions of vegetable matter in the diet. Mookerjee and Das (1945) and Das and Srivastava (1979) stated that R.L.G. among carps vary, evidently due to varied nature of diet, at different stages of their development.

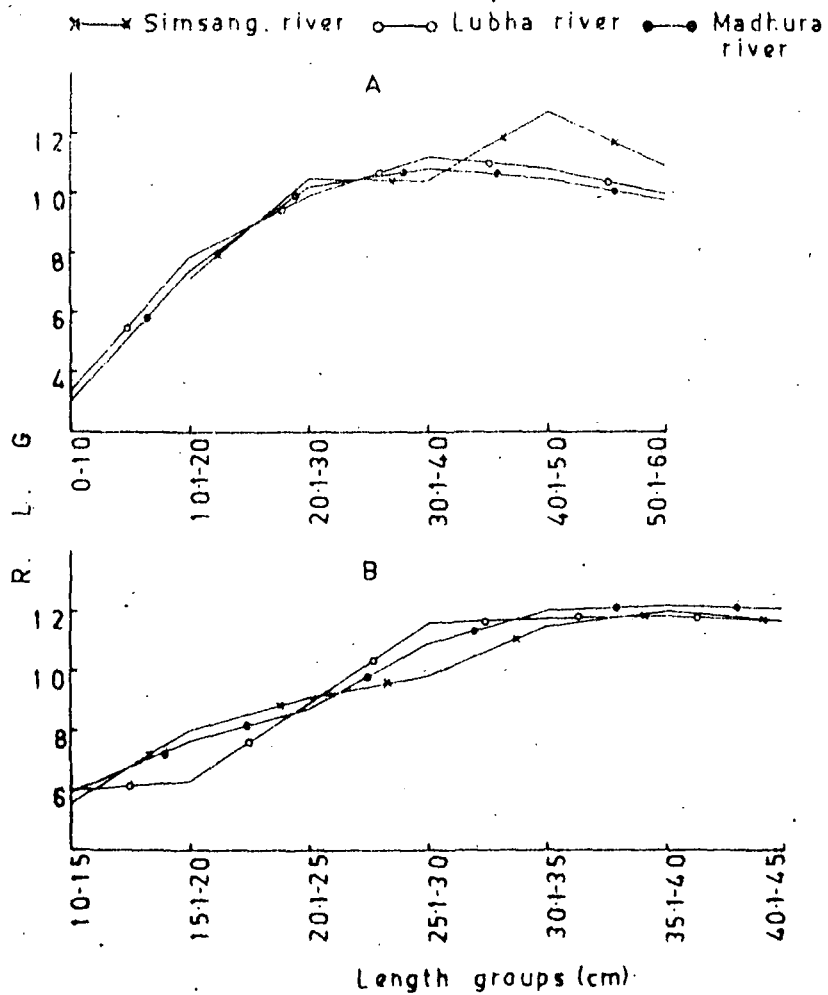


Fig. 21. Relative length of the gut (R.L.G) of (A) Labeo pangusia and (B) Labeo dero

The length of the gut in the fry of L. pangusia and L. dero (less than 10 cm in length) was found to be one and half times of their body length on an average basis. According to Alikunhi (1952) in major carp fries, the alimentary canal is adapted for a carnivorous diet and hence their R.L.G. becomes low.

The R.L.G. value of adult L. pangusia and L. dero was found to be very high (12 to 15). According to Girgis (1952), R.L.G. value is lowest in the fry stage and highest in the large fishes. Das and Moitra (1958) stated that in the adult cyprinoids the relative length of the intestine, varies from 60% of the body length in Chela bacila to 1500% in Hypophthalmichthys molitrix.

It is well known that R.L.G. value has a close relationship with the nature of food of the fish. According to Sinha and Moitra (1976), as the fish grow in length, there will be a change in their food habits from the carnivorous to herbivorous through the omnivorous types. The fingerlings gradually become omnivorous. Consequently, the value of R.L.G. gradually increases and alimentary canal gets coiled in order to digest and absorb the portion of the vegetable nature of food which they normally ingest in the fingerling and adult stages.

According to Verigina (1977) the longest intestine is found in fishes, whose food is poor in nutritional substances and certain large numbers of coarse items. This is especially

found in detritophage (subsists on detritus) Labeo. Many authors (Moitra and Bhowmick, 1967; Odum, 1968; Verigina, 1977) observed that an increase in intestinal length with an increase in the total body length was due to the presence of roughage component in the diet. They also observed that the diet of detritophagous fishes contain a large quantity of roughage.

There has been a considerable debate on the importance of detritus in the diet of fishes. David et al. (1969) stressed on the importance of detritus as fish food. Karamchandani and Mishra (1978) opined that Labeo boggut draws nutrition from mud and sand and also from decayed organic matter, particularly when the plankton content in the guts is strikingly very low. But experiments conducted by some workers (Prinslow et al., 1974 and Verigina, 1977) indicated that the detritus has a doubtful nutritive value.

In the present study, detritus and diatoms have been found to be the main food items in the adult of both L. pangusia and L. dero. Sinha (1976) viewed that since the adult L. calbasu prefers deeper zones, the eyes seem to have little importance in selection of food. Therefore, due to availability of less light, they mainly depend on sand and vegetable debris and hence the R.L.G. value in the adult specimens of L. calbasu is maximum and the intestine gets enormously coiled. Similar features have also been observed by Biswas and Nasar (1981) in L. pangusia and L. dero.

However, in the present study, the R.L.G. values of L. pangusia and L. dero was found to differ from one population to other (Table 12A & B). Aganovic and Vokovic (1966) also noted sufficient fluctuations in the intestinal length of Aulopige hugelli from different regions; the length varied from 167.87 to 241.37% (with individual variations for one place of 100 - 180% and for another place of 192 - 315%). A survey on the availability of food in these two environments showed that the first group had more favourable conditions and the main food was chironomids larvae. The food complex of the second group was poor, consisting mostly of detritus and bottom dwelling invertebrates.

The R.L.G. values of some Labeo species have been compiled in Table 34. The R.L.G. values of different Labeo species are quite comparable with the R.L.G. values of L. pangusia and L. dero. From this Table it may be seen that the food of the genus Labeo consists mainly of detritus and microscopic and filamentous algae and hence, each of the species of the genus Labeo is having high R.L.G. values.

Thus, the nature of the diet, feeding habit and relative gut length of L. pangusia and L. dero revealed that both the species are detritophagous and bottom dwellers.

MATURITY AND SPAWNING

There are numerous accounts of seasonal reproductive

Table 34: RELATIVE LENGTH OF THE GUT (R.L.G.) AND FEEDING HABITS OF SOME LABEO SPECIES

Species	R.L.G.	Food and Feeding habits	References
<u>L. calbasu</u>	22.00 2.22-13.20	Vegetable matter - bottom feeder Herbivorous	Alikunhi & Rao (1951) Das & Srivastava (1979).
<u>L. dero</u>	2.8431-14.9364	Sand particles, detritus & diatoms - bottom feeder	Present author
<u>L. fimbriatus</u>	17.0	Diatoms, mud & sand & decayed organic matter - bottom feeder	Bhatnagar & Karamchandani (1970)
<u>L. gonius</u>	10.442	Fresh & decaying plant matter, mud & sand phytoplankton & algae - bottom feeder	Parameswaran <u>et al.</u> (1974)
<u>L. horie</u>	15.6	Microscopic & filamentous algae, detritus, - bottom feeder	Matthes (1963)
<u>L. kontius</u>	11.0	Algae, sand & mud, diatoms - bottom feeder	Alikunhi & Rao (1951)
<u>L. lineatus</u>	16.1	Algae and detritus - bottom feeder	Matthes (1963)
<u>L. niloticus</u>	16.9	Algae and detritus - bottom feeder	Matthes (1963)
<u>L. pangusia</u>	1.9768-13.6369	Sand particles, detritus & diatoms - bottom feeder	Present author
<u>L. rohita</u>	12.0 1.40-19.0 4.94-10.94 4.13-11.55	Vegetable matter - Column feeder Phytoplankton - column feeder Mud & vegetable debris and animalcules Herbivorous	Das & Moitra (1958) Sinha & Moitra (1975) Kamal (1967) Das & Srivastava (1979)
<u>L. variegatus</u>	16.95	Algae and detritus - bottom feeder	Matthes (1963)

cycle in fishes, and various methods have been used. Changes in the appearance and weight of the gonad have often been used to define the spawning season. Gonad staging on a descriptive scale allows a rapid qualitative assessment of the breeding state, and gonad weights give a quantitative record of changes in gonad condition (Crossland, 1977). The measurement of ovarian egg diameters and their frequency distributions at different times of the year is another common method used by various workers such as Clark (1934), Hickling and Rutenberg (1936), June (1953), Shindo and Aoyama (1954), Prabhu (1956), Andreu and dos Santos Pintos (1957), Mc Gregor (1957), James (1967), Baker (1972), Tong and Vooren (1972), Macer (1974) and many others.

Observations on the maturation of L. pangusia and L. dero indicate that the gonads begin to develop from February onwards and mature specimens (Stages IV to VI) were found to be available from late March to August with peak in May and June.

It is well known that gonadosomatic ratio (G.S.R.) increases with the maturation of fish, being maximum during the period of peak maturity and declining abruptly thereafter, when the fish reaches spent stage as also stated by Hickling (1930) and Le Cren, (1951). In the present study, gonadosomatic ratio (G.S.R.) when plotted against body weight indicated that there was no marked tendency for the G.S.R. to change with increased body weight within every maturity stage and since seasonal peaks

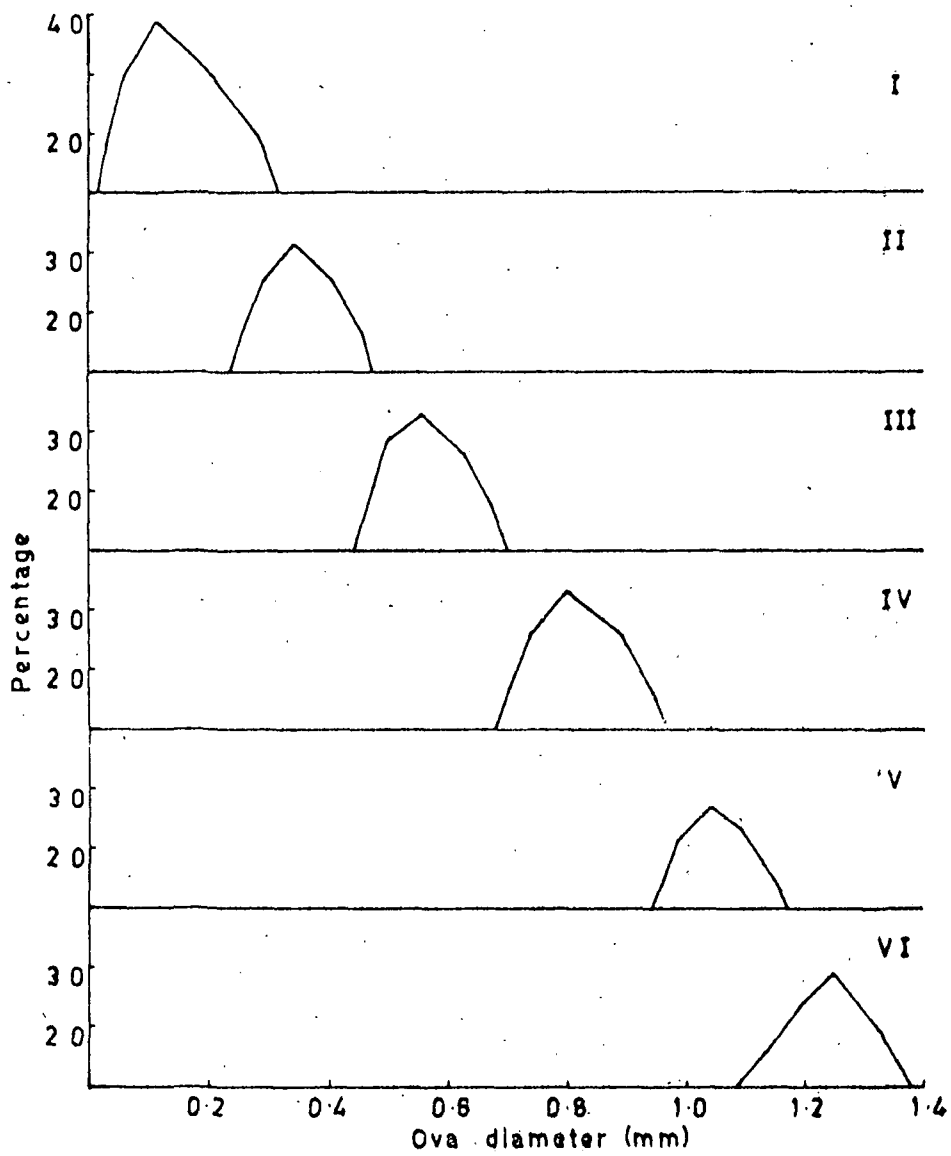


Fig.22. Size-frequency distribution of Intra-ovaria oocytes of Labeo pangusia at different stages of maturation

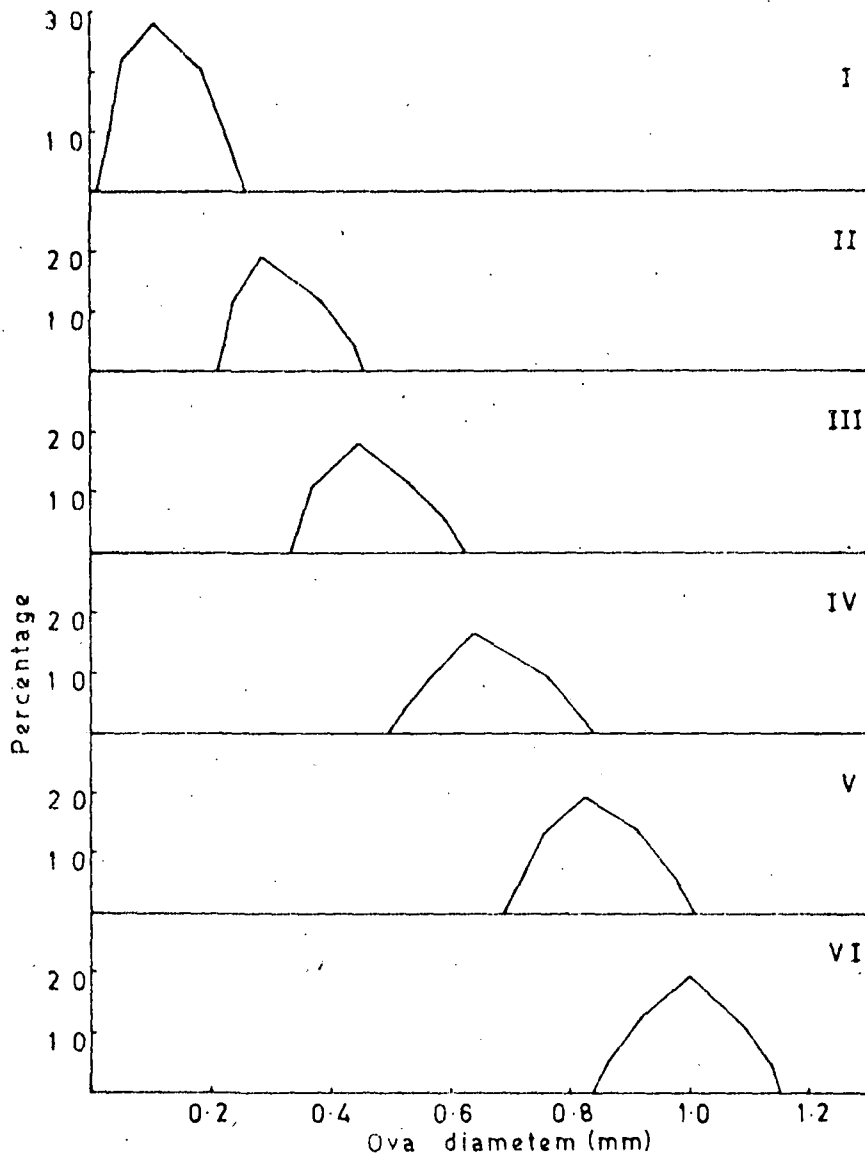


Fig. 23. Size-frequency distribution of intra-ovarian oocytes of Labeo dero at different stages of maturation

in the mean G.S.R. coincided with peaks in the percentage occurrence of mature fish (Stage IV to VI), the G.S.R. can be used as an index of gonadal development. The ovary was used in this study as the major indicator of gonadal changes, as the environmental influences on the sex cycle are reflected with greater dependability on the ovary than in the testes (Harrington, 1959). The G.S.R. is a valid measure because the gonad-body weight ratio tends to be constant at any one season for all sizes of the the same sex and state of maturity (Le Cren, 1951).

In both L. pangusia and L. dero, the G.S.R. was maximum during May - June, when the majority of the fishes were found to be mature. After that the G.S.R. values decreased rapidly indicating the beginning of the spawning season.

Earlier workers have observed that the fluctuations in the condition factor is correlated with the maturity cycle and spawning of fish (Hickling, 1930; Hart, 1946; Menon, 1950; Le Cren, 1951 and Morrow, 1951). This is found to be true in the case of both L. pangusia and L. dero also, as their condition factor was found to be maximum during May - June when majority of the specimens were found to be mature and the values of K-factor were low from July onwards when spawning commenced. Thus during monsoon months, K-factor declined because of the decrease in the G.S.R. values and also due to cessation of feeding. The sharp rise and fall in the K-factor in the females of both the species might be due to the develop-

ping gonad and release of the reproductive products which was more prominent in females than in the males.

Observation on the maturity studies indicated that the ripe individuals of both the species were available from May to August. The G.S.R. was also found to be maximum in May - June and thereafter the ratio declined which is an indication of the spawning of the fishes. The condition (K) factor also showed a similar trend in the spawning season. Moreover, the occurrence of fry and fingerlings (5 - 10 cm size) during the months of September and October also indicate that the spawning must have occurred during June - July.

In L. pangusia and L. dero two groups of ova were encountered in the ripe ovary (Stage VI). The mature ova, however, can be clearly distinguished from the immature stock. The fact that both small and large developing ova appear in the ovary at the same time may indicate that L. pangusia and L. dero spawn in batches, i.e., only a portion of the developing ova are released at any one time during spawning. Alternatively, the smaller developing ova may remain in the ovary after spawning, and gradually become reabsorbed. That the mature oocytes remain in the ovary and are finally absorbed in the body as has also been mentioned for many other teleosts (Walford, 1932; Qasim and Qayyum, 1961; Henderson, 1963; Nikolsky, 1963 and Coombs, 1969) is true in the case with L. pangusia and L. dero as is evident in the present study.

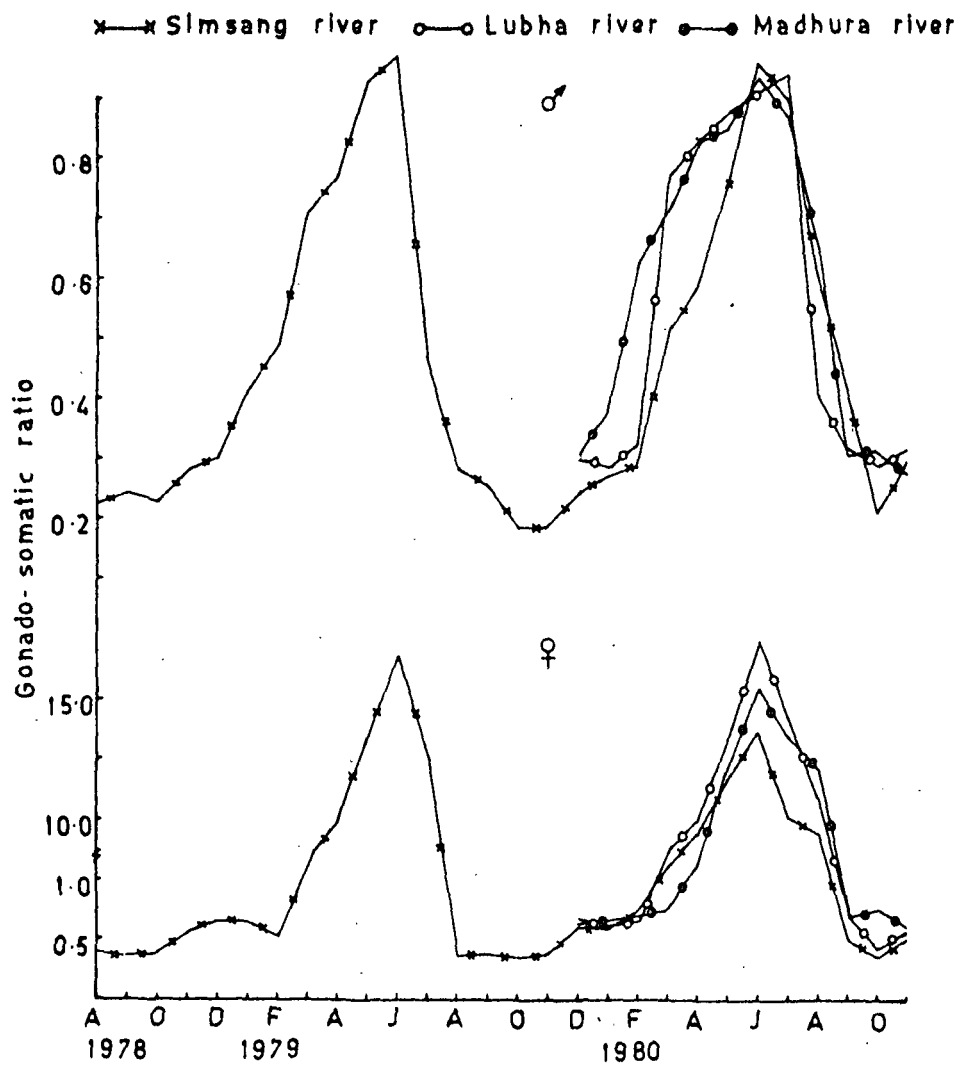


Fig.24. Seasonal variations in the gonado-somatic ratio of Labeo pangusia

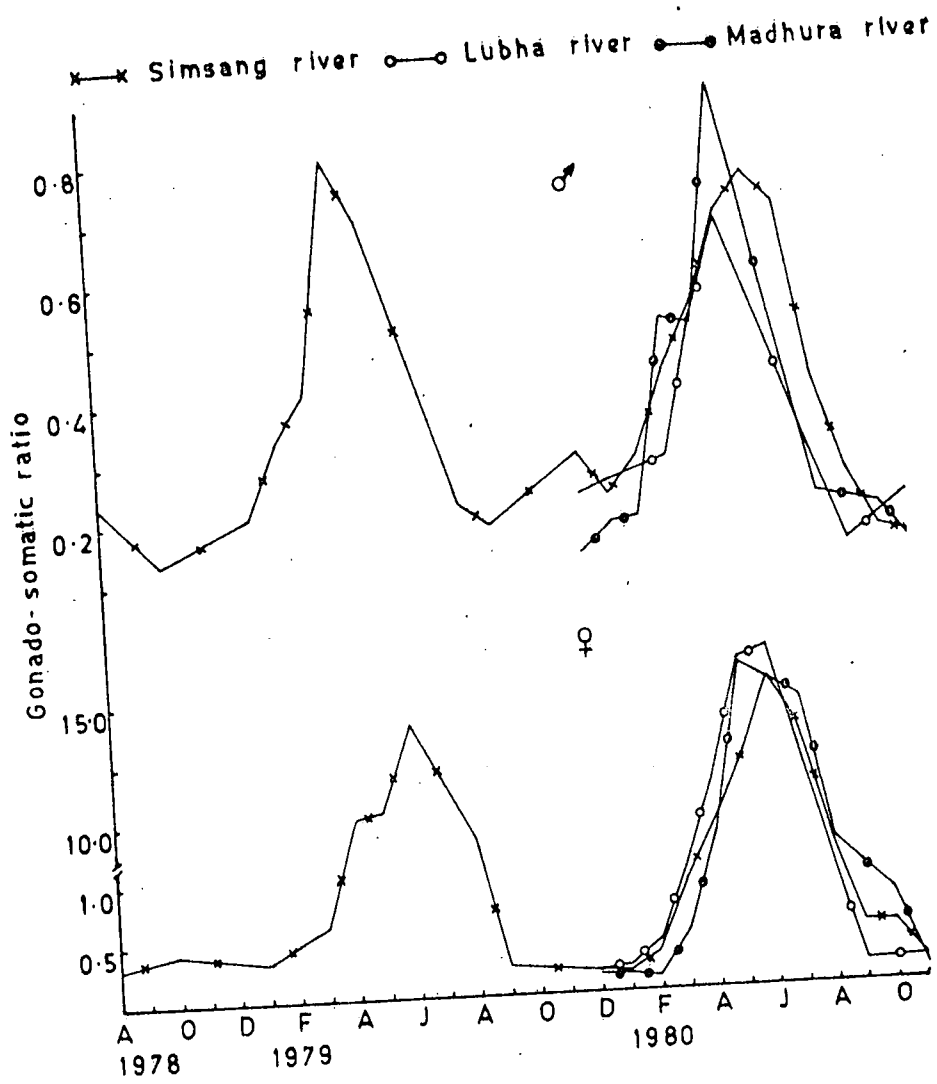


Fig.25. Seasonal variations in the gonado-somatic ratio of Labeo deero

The occurrence of only one batch of maturing ova clearly demarcated from the immature stock is also reported in other carps like Labeo calbasu, L. fimbriatus, L. rohita etc. which also possess a single group of large oocytes (in the mature females) evidently destined to be spawned in a single spawning act. This phenomenon might be true in the case of L. pangasia and L. dero also.

Clark (1934) pointed out that if only one batch is spawned, the ratio between the number of eggs in the maturing group should remain constant and on the other hand, if more than one batch is spawned the ratio generally decreases. In the present study also the ratio was found more or less constant in both the species.

Qasim and Qayyum (1961) divided the Indian fishes into three categories on the basis of their ova diameter frequencies:

(i) In this category are included all those species which possess a single batch of maturing eggs in their ovaries. The spawning in these fishes is adapted to an annual rhythm. The cycle of maturation and depletion of gonads occurs only once a year and synchronises throughout the population with the onset of monsoon rains. In all such forms, the gonads show a regular seasonal change, and at any given time, the state of maturity is almost uniform in all the individuals of the population. (ii) This category includes fishes which have more than one group of maturing oocytes. In such forms, owing to a

succession of spawnings, the breeding cycle of each individual takes an independent course. The breeding season is long and the states of maturity at any given time show a considerable overlapping in the population. (iii) All those species which have oocytes of all sizes ranging from the smallest to largest with no well marked batches. Since the cycle of maturation and spawning becomes a continuous process, the population at all time has a random selection of all stages of maturity.

On the basis of this classification, L. pangusia and L. dero can be grouped into the first category as the spawning of both the species occurs during a short spawning season. The breeding of these two species starts from late May and continues upto August. The peak period of breeding is roughly estimated to be June and July. However, in the present study it has been observed that breeding of L. pangusia and L. dero takes place little earlier than other parts of the country which may be due to the fact that the monsoon rain generally starts earlier in the North-Eastern region than the rest of the parts of India. The early breeding of Indian carps has also been reported from Assam by Parameswaran et al. (1970).

Studies on the maturity cycle also reveal that both the males and females of L. pangusia mature at 25.1- 30 cm length group and the specimens of Madhuma river mature even at 20.1- 25 cm length group. In case of L. dero male specimens were found to mature at 20.1- 25 length group whereas females mature at

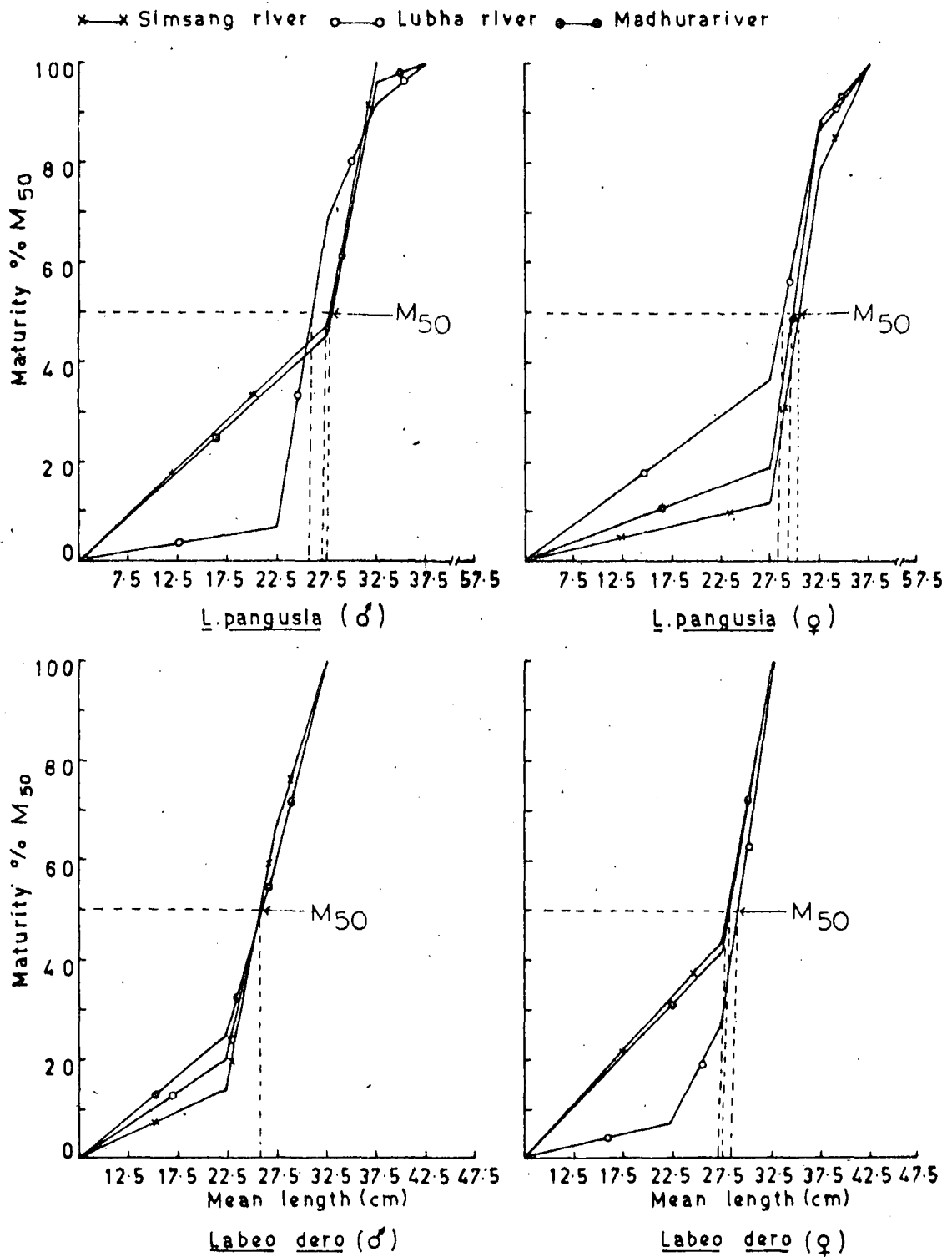


Fig.26 Graph showing length at M₅₀ (50 maturity)

25- 30 cm length group. However, it was observed that males of both the species mature at a shorter length than that of females. It has been observed in the present study that males and females of L. pangusia generally mature at the age of 1⁺ year while L. dero matures mostly in the first year itself like various other carps as reported by Alikunhi (1956), Alikunhi and Rao (1951), Alikunhi et al. (1962) and Selvaraj et al. (1972).

Woodhead (1978) reported that fish become sexually mature for the first time at a size which is a rather constant proportion of their final length; this value is given as close to two thirds of the final body length. According to him maturity would, therefore, appear to be correlated with the growth. Under optimum conditions growth will be rapid and this length attained when the fish is young (Nikolsky, 1963 and 1969).

Alm (1952 and 1959) showed that the onset of first sexual maturity in populations of Perch, Perca fluviatilis depended upon growth and the achievement of certain body size, but at the same time, maturity also depended upon the fish having attained the maximum age. He further observed that in any one age group (year class) those fishes which were first to mature were the largest individuals, with the best rate of growth. Fish with a slower growth rate reached maturity later, but by then they had attained a larger body size than the earlier maturing fish.

According to Woodhead (1978), fecundity may act as a regulatory mechanism by means of which the numerical strength of a population is brought into the line with the food availability of the water body. Generally, an improvement in feeding conditions, either by an increase in food supply, a reduction of the population by fishing, or transference to another body of water results in a greater number of eggs laid during the spawning season. When living conditions deteriorate and growth rate of the fish is reduced, the age at first maturity increases and these results a fall in the fecundity rate.

On the whole, the fecundity of fishes is much higher than that of terrestrial vertebrates. The most fecund fishes are those which have floating pelagic eggs; in second order are those which have adhesive eggs to some submerged substratum. Fishes which protect or hide their eggs usually have a lower fecundity rate (Kryzhanovisky, 1949 and Nikolsky, 1963).

In the present study, the fecundity of L. pangusia and L. dero was found to vary from population to population. The fecundity of L. pangusia was found to range from 1,89, 626 to 8, 14, 897. However, fecundity from Lubha river population, was found higher than the other two populations. The fecundity of L. dero was recorded to be between 80,627 and 2,33,205, but Bhatnagar (1964) observed the fecundity of L. dero from Bhakra reservoir ranged from 1,92,396 to 7,10,934.

Differences occur in the fecundity of fishes of the same length in different populations (Baxter, 1963). Thus for example, the fecundity of Pike in the Aral sea is 8,287 and in the North Caspian 17,587; in the Silver Crucian carp in the Amur, the fecundity is 68,200, and in the lake Urals it is 26,000 as reported by Nikolsky (1963).

A similar differences in the fecundity of Labeo capensis is notable. Mulder (1973) found the fecundity of L. capensis at 35 cm length was only 67,000 from Vaal river, while Baird (1976) observed that fecundity of the same species at the same length was 1,06,000 from Caledon river. Simpson (1951) also observed that there was very great variation in the fecundity of Plaice of the same size which were spawning or caught from the same area.

The fecundity of L. pangusia and L. dero is found to be quite high and is comparable with any other Labeo species. The absolute and relative fecundity of various species of Labeo has been given in Table 35; from which it can be seen that differences occur in the fecundity of the Labeo species living under different ecological conditions.

Several authors emphasized both genetic and environmental factors to explain variations in fecundity within and between populations (Hempel, 1965; Parrish and Seville, 1965; Bagenal, 1966 and Nikolsky, 1969). Among environmental factors, food supply and temperature were often mentioned (Leggett and

Table 35: ABSOLUTE AND RELATIVE FECUNDITY OF SOME LABEO SPECIES

Species	Absolute fecundity	Relative fecundity	Reference
<u>L. bata</u>	3,01,861-5,76,251	212-436	Bhatnagar (1964)
	-	285.5-374.9	Alikunhi (1956)
	10,040-8,70,000	584	Siddiqui <u>et al.</u> (1976a)
<u>L. boga</u>	-	239-596	Alikunhi <u>et al.</u> (1962)
<u>L. boggut</u>	4,738-12,673	-	Selvaraj <u>et al.</u> (1972)
<u>L. calbasu</u>	40,200-5,17,500	-	Rao & Rao (1972)
<u>L. capensis</u>	12,664-1,06,268	-	Baird (1976)
<u>L. dero</u>	91,034-2,33,205	159-264(Simsang)	} Present author
	85,156-2,32,641	152-281(Lubha)	
	80,627-2,32,903	188-277(Madhura)	
	1,92,396-7,10,934	177-570	
<u>L. fimbriatus</u>	1,42,600-5,09,000	-	Bhatnagar (1972)
	64,770-5,25,893	-	Rao (1976)
<u>L. gonius</u>	-	88.13-364.56	Parameswaran <u>et al.</u> (1974)
	9,309-3,45,656	744	Siddiqui <u>et al.</u> (1976b)
<u>L. pangusia</u>	1,89,626-5,40,034	345-414(Simsang)	} Present author
	2,26,788-8,14,897	105-546(Lubha)	
	2,25,471-6,36,900	275-534(Madhura)	
<u>L. rohita</u>	2,25,600-27,94,000	-	Sukumaran (1969)
	6,21,345-35,21,025	319-535	Khan (1972)
	59,650-12,27,500	222-269	Varghese (1973)

Power, 1969; Hodder, 1972 and Messeih, 1976). Bagenal (1967) viewed that while temperature and feeding conditions during the maturation may play a role in determining fecundity, the main factor, will, however, be selection.

According to Nikolsky (1963) the fecundity of fishes, as that of other animals, is an adaptation which ensures the survival of the species under the conditions in which it originated and exists. According to him fecundity of a fish increases where there is a high mortality of fry and fingerlings due to predation or other environmental factors. He also viewed that changes in individual fecundity are regulated by changes in the food supply and also faster growing individuals usually have a higher fecundity than slower growing ones of the same size. The species responds to changes in the environment by changes in its fecundity. Thus, in the present study, the comparatively higher fecundity observed in the Lubha river population may be due to faster growth rate in this population.

Kesteven (1942) pointed out that the gonad maintains a relationship with the remainder of the body of the organisms and since the average size of maturing or mature ova are constant in general, the number of eggs being a number of units of weights will show an exponential with the length in the same way as does the length of the entire organism.

In both L. pangusia and L. dero, the fecundity was found to increase as the fishes grew in length. On plotting

fecundity values against body length, a straight line relationship was found in both the species. The exponent 'b' was found to be ranging between 1.5132 to 2.2074 in L. pangusia and 2.8554 to 4.5699 in L. dero from different populations. According to Bagenal (1967) the value of the exponent 'b' has been found to range from 2.34 to 5.28 for different species, the most usual values are a little above 3. Thus it may be concluded that the fecundity of L. dero increases at a rate almost equal to or substantially higher than the third power of the length of the body.

Different relationships have been found to exist between length and fecundity in different species of fishes. Fecundity is related to the length of the fish by a factor closer to cube as has been reported by many authors like Raitt (1938) in haddock, Hickling (1940) in herring, Simpson (1951) in Plaice, Bhatnagar (1964) in Labeo dero, Rao and Rao (1972) in L. calbasu, Khan (1972) in L. rohita, Bhatnagar (1972) in L. fimbriatus, Varghese (1973) in L. rohita and Parameswaran et al. (1974) in L. goni while Franz (1910a, b), Kisselewitch (1923) and Clark (1934) have observed that fecundity in the fishes they studied increased in proportion to square of length.

According to Simpson (1951) fecundity is directly proportional to body weight. In the present study the log-log relationship between fecundity and body weight was found linear

in both L. pangusia and L. dero. In the older specimens of L. pangusia and L. dero, the fecundity values congregate below the regression line, showing that their fecundity in relation to body weight is low, compared to smaller specimens. The fecundity of L. pangusia was found to be increased with the weight of the fish and at the rates between 0.5206 and 0.6991 power of the weight and in L. dero the fecundity was found to be increased at the rates between 0.9825 and 1.2517 power of the weight.

The existence of straight line relationship between fecundity and weight of fish has been reported by several workers (Bagenal, 1957a, Sarojini, 1957; Pillay, 1958; Kändler, 1959; Baxter, 1959; Bridger, 1961; Gupta, 1968 and Varghese, 1961; 1973 and 1976). Yuen (1955) found that the relationship between fecundity and weight to be curvilinear which indicates that fecundity is more dependent on weight rather than length as have been reported by Smith (1947) and Manooch (1976).

Many authors gave their results in the form of relative fecundity (Anokhina, 1963; Kändler and Dutt, 1958; Määr, 1949; Toots, 1951; Alikunhi, 1956; Shatunovskii, 1964; Bhatnagar, 1964; Khan, 1972; Varghese, 1973; Parameswaran et al., 1974). This method of expressing the results assumes the relation between fecundity and weight as linear (Bagenal, 1957a, Pitt, 1964). In the present study, relative fecundity of L. pangusia was found to be decreased as the fish grew. In L. dero, the

relative fecundity did not fluctuate markedly among different size groups from all the population studied which coincided with the observation made by Bagenal (1973). However, Bhatnagar (1964) observed that relative fecundity was higher in the older size groups of L. dero, but reverse was found by him in L. bata. Le Cren (1951) and Raitt (1968) reported that relative fecundity in any species might change markedly due to changes in the condition of the species. Zotin (1961) related the egg size to the relative fecundity. Many workers (Scott, 1962; Hester, 1964; Bagenal, 1969; Wootton, 1973) correlated relative fecundity with the food availability.

Fecundity was found to increase with increasing ovary weight in both the species. However, the fecundity per gram ovary weight gradually decreases inspite of the fact that weight of the ovary increases as the fishes grow in size and weight. Bhatnagar (1964) found that the number of eggs per gram ovary weight was higher in large size groups of L. dero but in the case of L. bata he observed that fecundity per gram ovary weight gradually decreased as the fish grew in size. According to Bagenal (1963), in most of the fish, the number of eggs does not change significantly as the season progress, but the gonad weight increases due to increase in water content or organic matter derived from food, or organic matter inferred from somatic tissues. The log-log relationship between fecundity and ovary weight supports the view of Bagenal (1967) that decreases in relative fecundity of heavier ovaries are correlated with increase egg size. Lack (1948) and Williams (1966) attributed

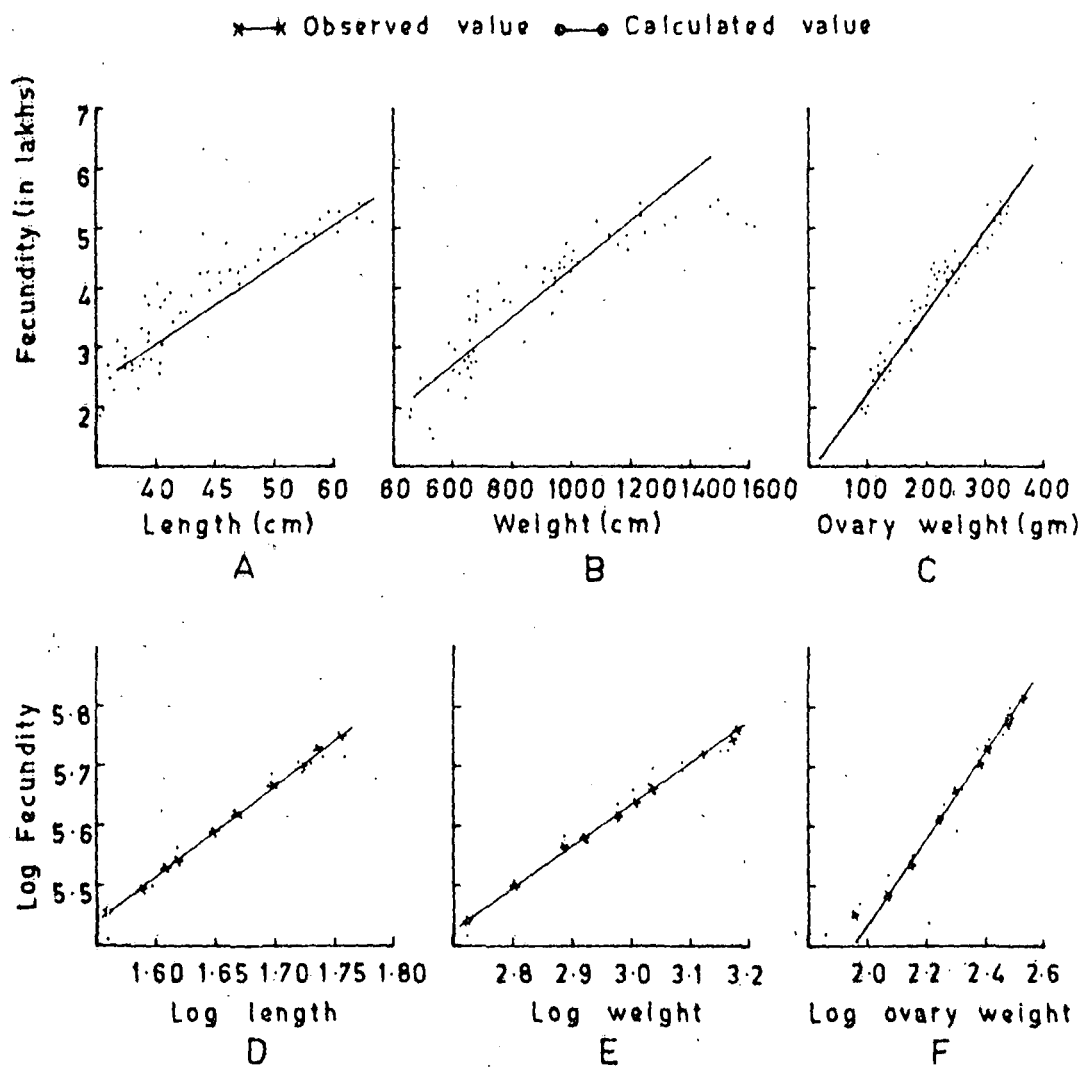


Fig.27. Relationship between fecundity and (A) length, (B) weight, and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight, and (F) ovary weight of Labeo pangusia from Simsang river

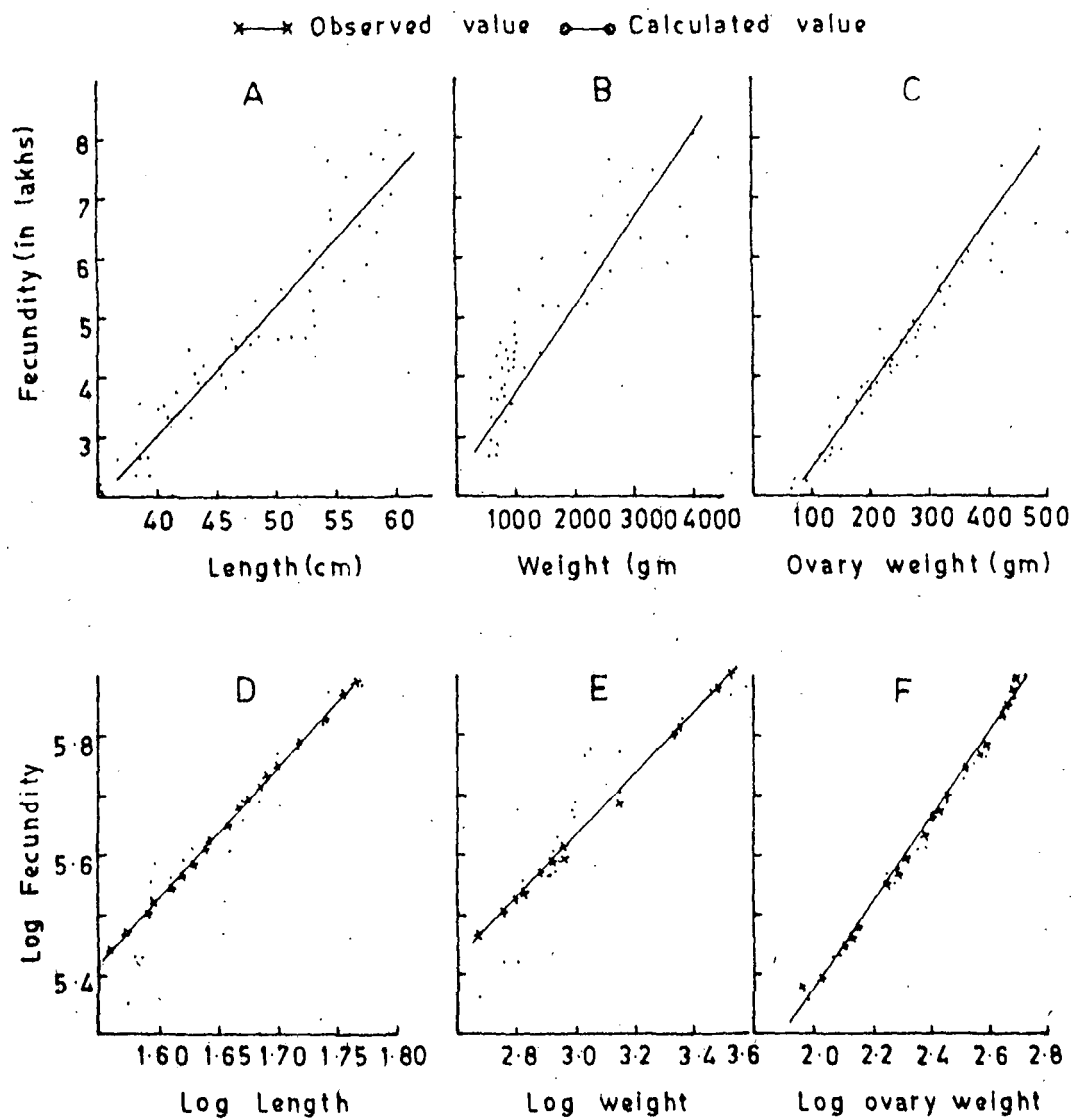


Fig.20. Relationship between fecundity and (A) length, (B) weight, and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight, and (F) ovary weight of Labeo pangusia from Lubhā river

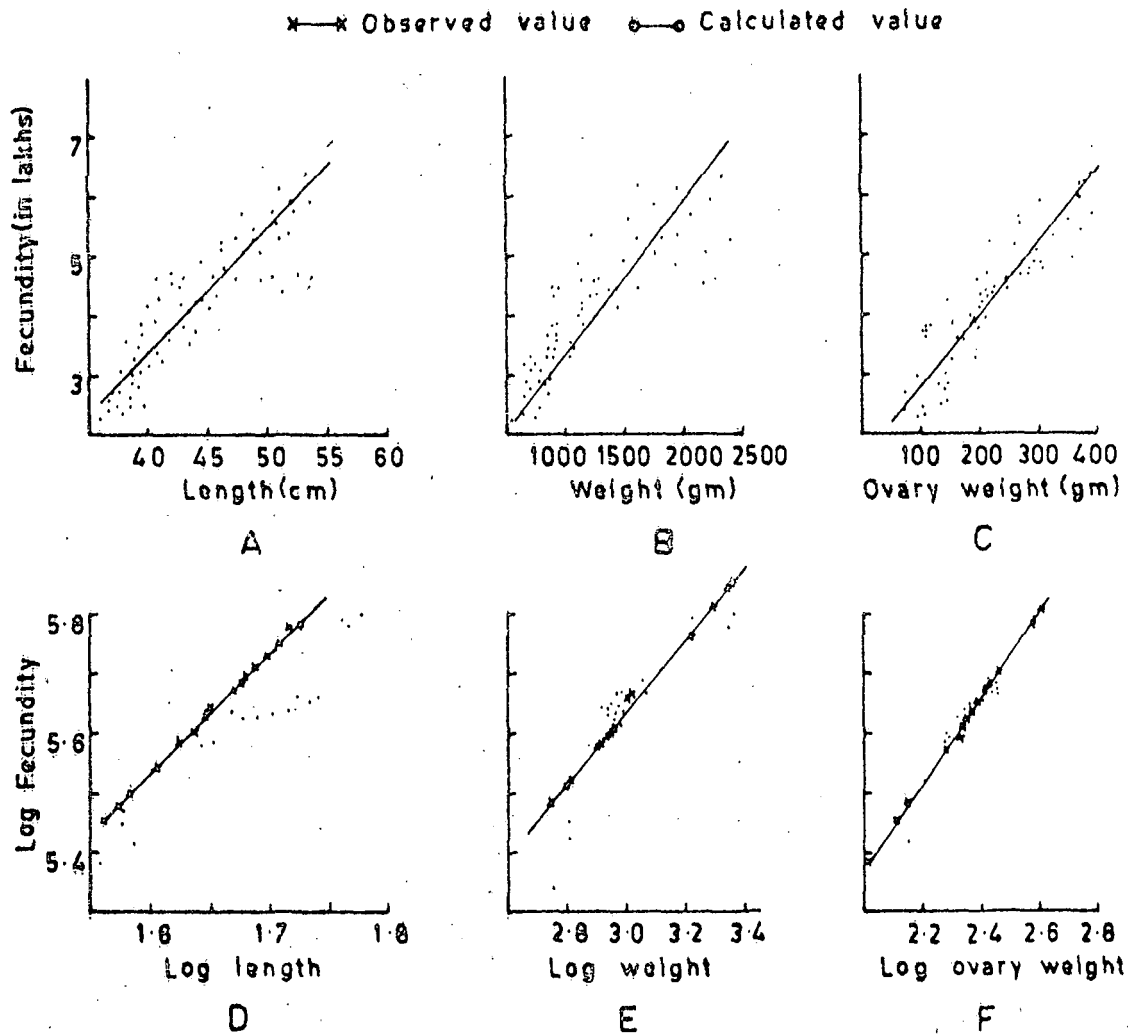


Fig. 29. Relationship between fecundity and (A) length, (B) weight, and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight, and (F) ovary weight of Labeo pangusia from Madhura river

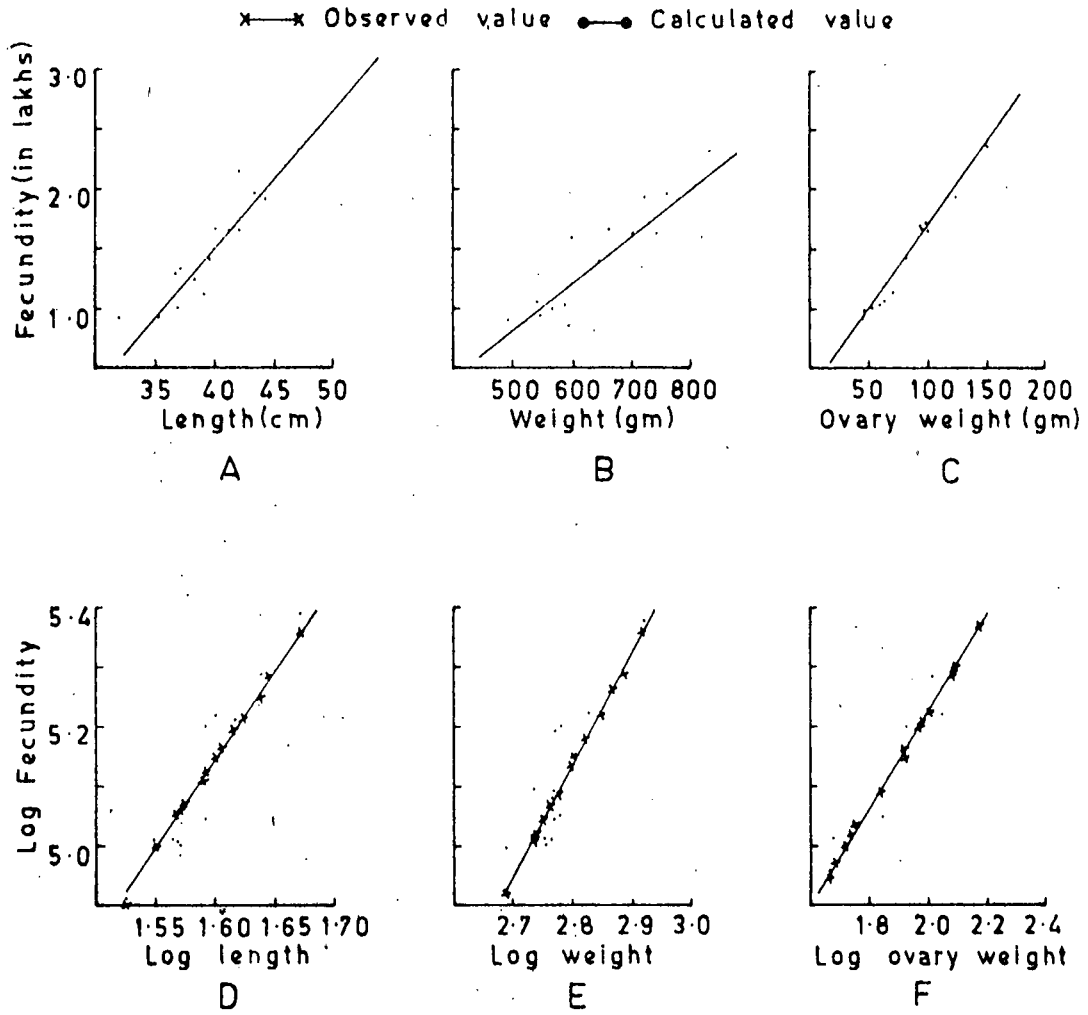


Fig.30. Relationship between fecundity and (A) length, (B) weight, and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight, and (F) ovary weight of Labeo dero from Simsang river

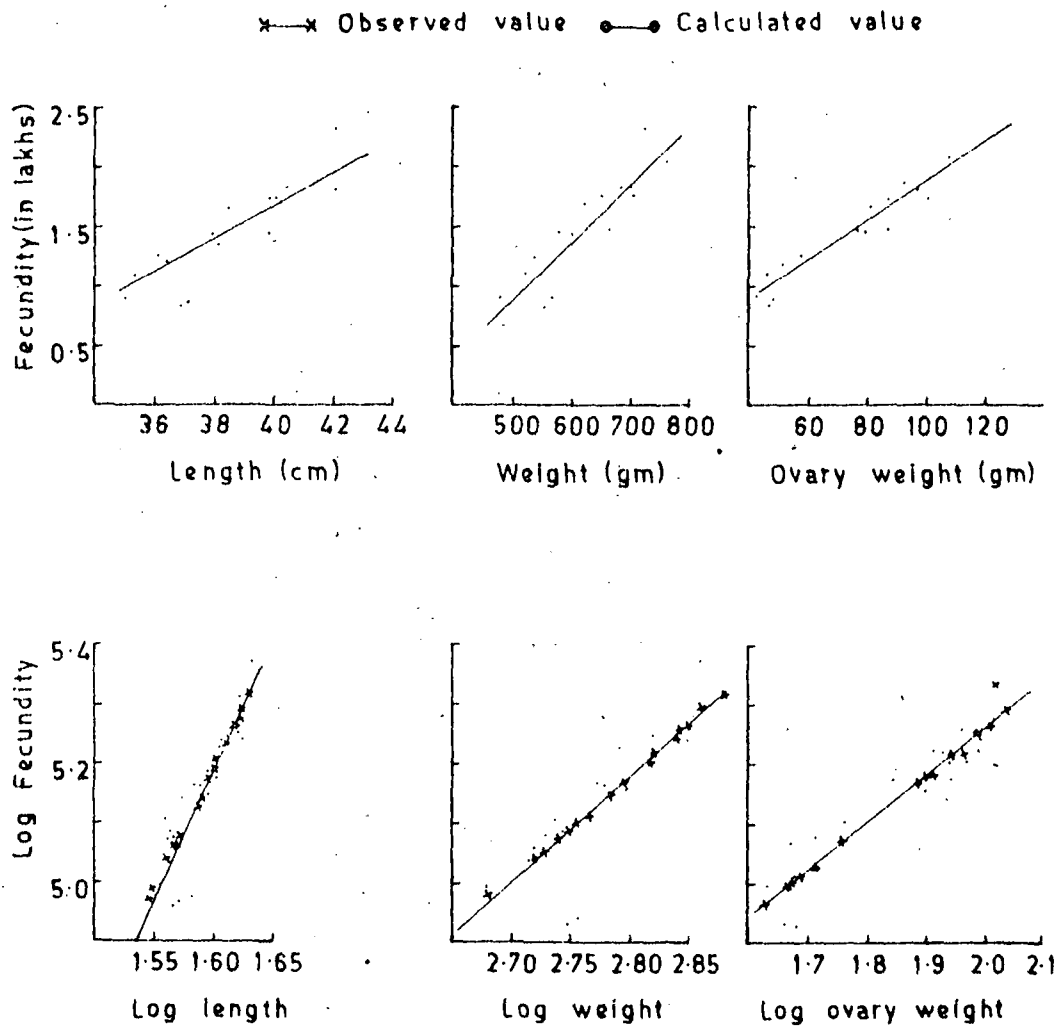


Fig. 31. Relationship between fecundity and (A) length, (B) weight, and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight, and (F) ovary weight of Labeo deero from Lubha river

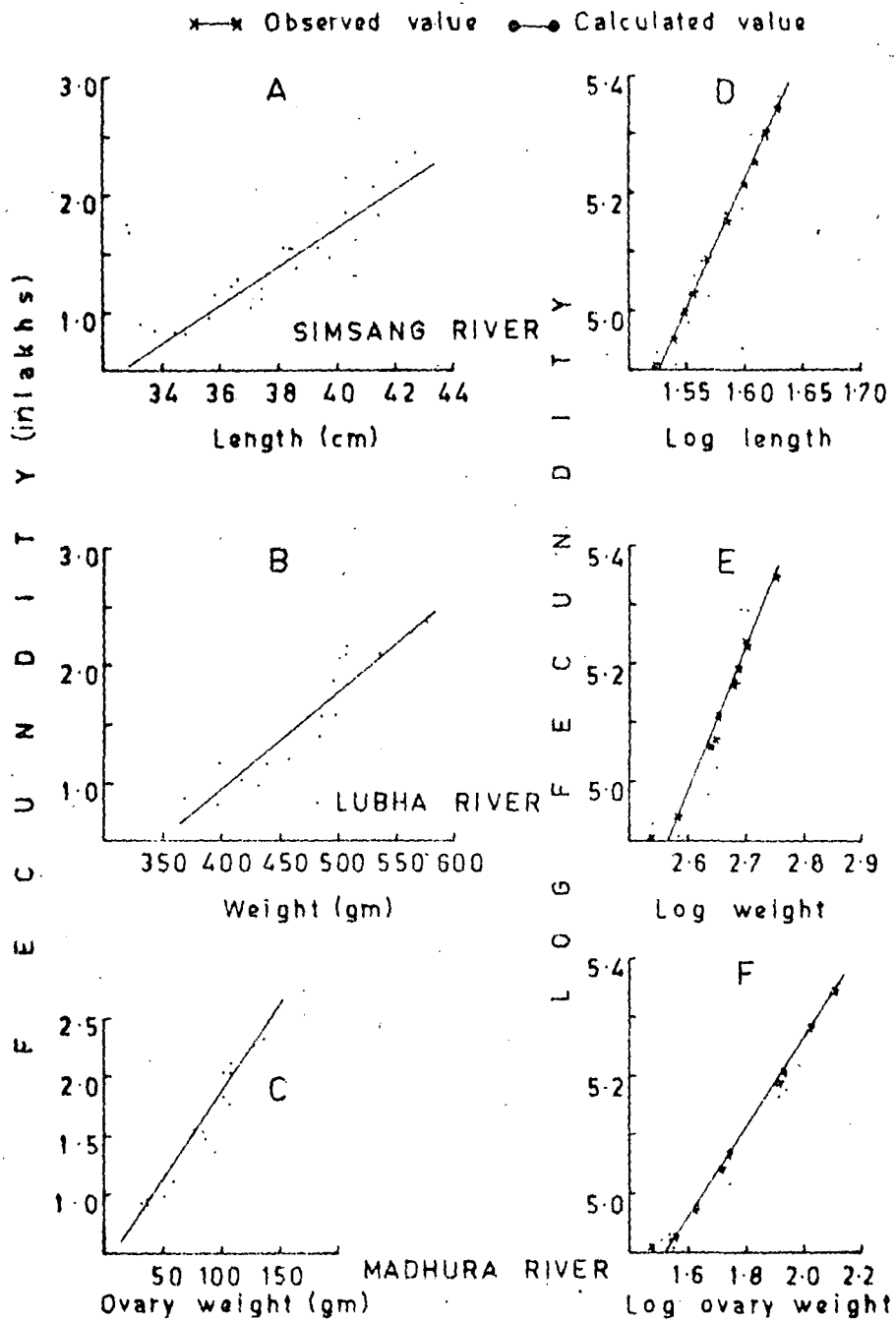


Fig. 32. Relationship between fecundity and (A) length, (B) weight, and (C) ovary weight and log-log relationship between fecundity and (D) length, (E) weight, and (C) ovary weight of *Labeo dero* from Madhura river

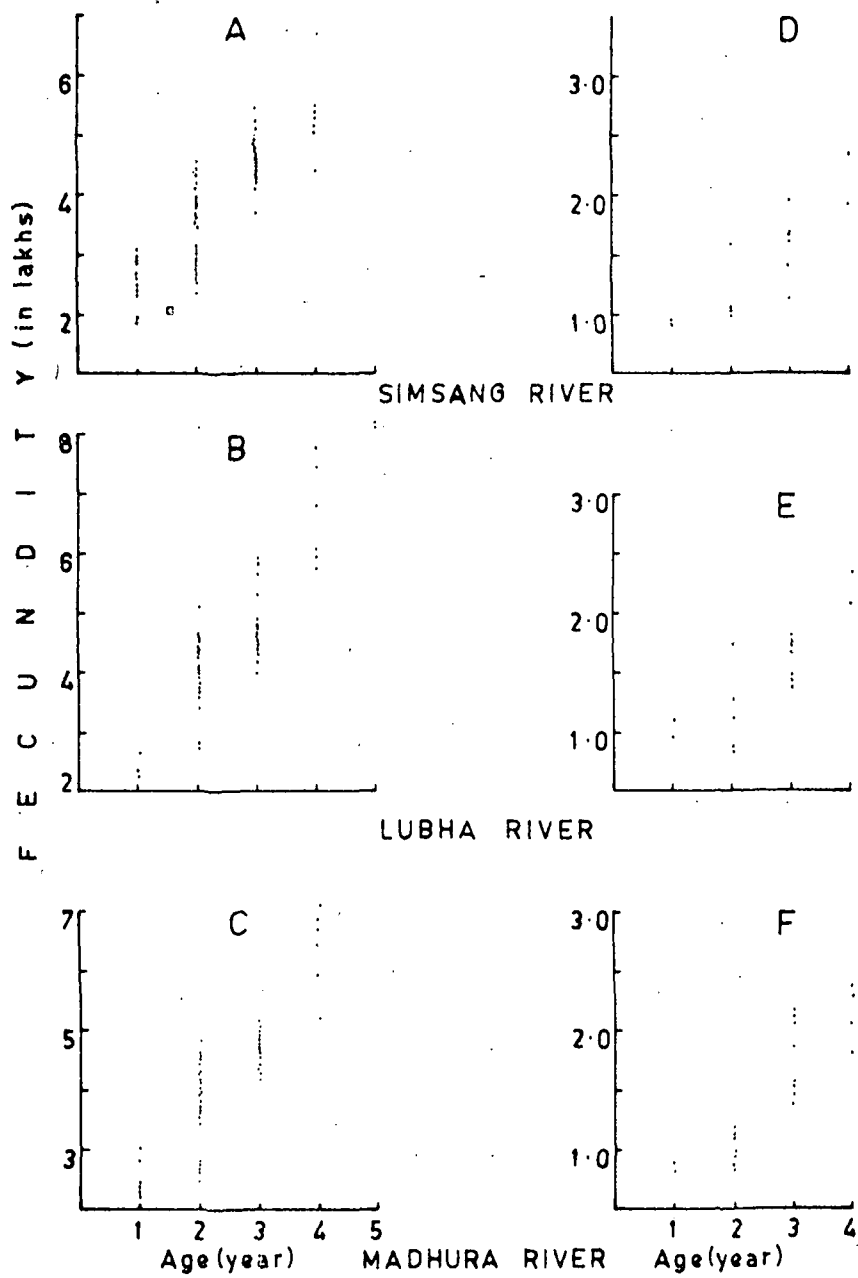


Fig. 33. Relationship between fecundity and age of *L. pangusia* (A,B & C) and *L. dero* (D,E & F)

it to the limited capacity of females to gather, metabolize and store food for egg production. In such circumstances any increase in egg size will be counteracted by a decrease in egg number. Svärdson (1949) proposed that increases in egg size (and associated decreases in fecundity) are common in fish populations because the bigger eggs, or resultant offspring, have better chances of survival than the small eggs and resultant offspring of fish with increased fecundity.

In the present study, the fecundity of L. pangusia and L. dero was found to increase with increasing ages. De Silva (1973b) and Wilkinson and Jones (1977) also found that age significantly influenced the fecundity of sprat and dace respectively. Conversely, Simpson (1951) and Bagenal (1957b) found that age, by itself, had no effect on fecundity.

AGE AND GROWTH

The principle of age determination in fishes depends on the "annual" growth marks that are formed in certain skeletal parts of the fish, like the scales, otoliths and bones. These growth marks are really the growth checks formed in skeletal parts as a result of fluctuations in the growth of the fish. The growth of a fish, normally, is not uniform ~~either~~ throughout the year of its life. ~~Again,~~ the fish grows fast during a certain part of the year and slower or even ceases to grow during other part of the year. This fluctuating periodicity of fast and slow growth of the fish expresses itself annually on the

skeletal parts of the fish as a periodic structure of fast growing (i.e. wide) and slow growing (i.e. narrow) zones. European and American ichthyologists have more or less established that these rhythms of growth are seasonal and that there is very close relation between the periodic structure of the skeletal parts and the growth of the fish (Menon, 1954).

Validity of the scale method for determining age and growth of L. pangusia and L. dero is based on the following facts of evidences :

The scales of Labeo bata, L. calbasu, L. fimbriatus, L. goniis and L. rohita show celar zonations which have been used for studying the age and growth of these fishes by various authors such as Chatterjee et al. (1979), Rao and Rao (1972), Rao (1976), Bhatnagar (1979), Gupta and Jhingran (1974), Khandkar and Haque (1970), Khan and Siddiqui (1973b) etc. These authors have also attempted to establish the annual nature of these rings and provided some evidence in its support. Labeo pangusia and L. dero are closely related to these species and hence, their scales are expected to bear similar annular rings.

According to Van Oosten (1929), the scale in order to be of use in age determination must bear (i) a relation of proportionality with the linear dimension of the fish; (ii) the scale number must remain fairly constant; and (iii) that the annulus must be formed yearly and at the same approximate time of the year. The scale of L. pangusia and L. dero fulfils these conditions.

Body and scale relationship is another method to confirm the validity of scales. In order to ascertain the relationship between body and scale length, the individual measurements obtained were plotted graphically (Fig. 34). The regression equation applied for the regression of body over scale length further confirm the validity of the scales.

In both L. pangusia and L. dero, annuli were added systematically as fish grew, thus furnishing preliminary evidence about the validity of markings being truly annual. With the growth of the fishes a decrease between the distance of adjacent annuli occurred, which is another evidence of the validity of scales as indices of age determination and progressively slow growth rate.

The validity of scales of L. pangusia and L. dero as age indicators is established by correlation of lengths as different ages derived from scales.

For many years the difference of opinion amongst the various workers has been centered on the causative factors of check formation in the skeletal parts of the fishes.

Several workers have suggested a number of factors like temperature (Fulton, 1904; Dahl, 1909; Lea, 1911; Cutler, 1918; Lee, 1920; Thompson, 1926; Graham, 1929a, b; Van Somern, 1950; Johnels, 1952; Hølden, 1955; Bishai and Gideiri, 1965; Balon, 1971; Hopson, 1972; Tweddle, 1975 and Kato, 1977), seasonal

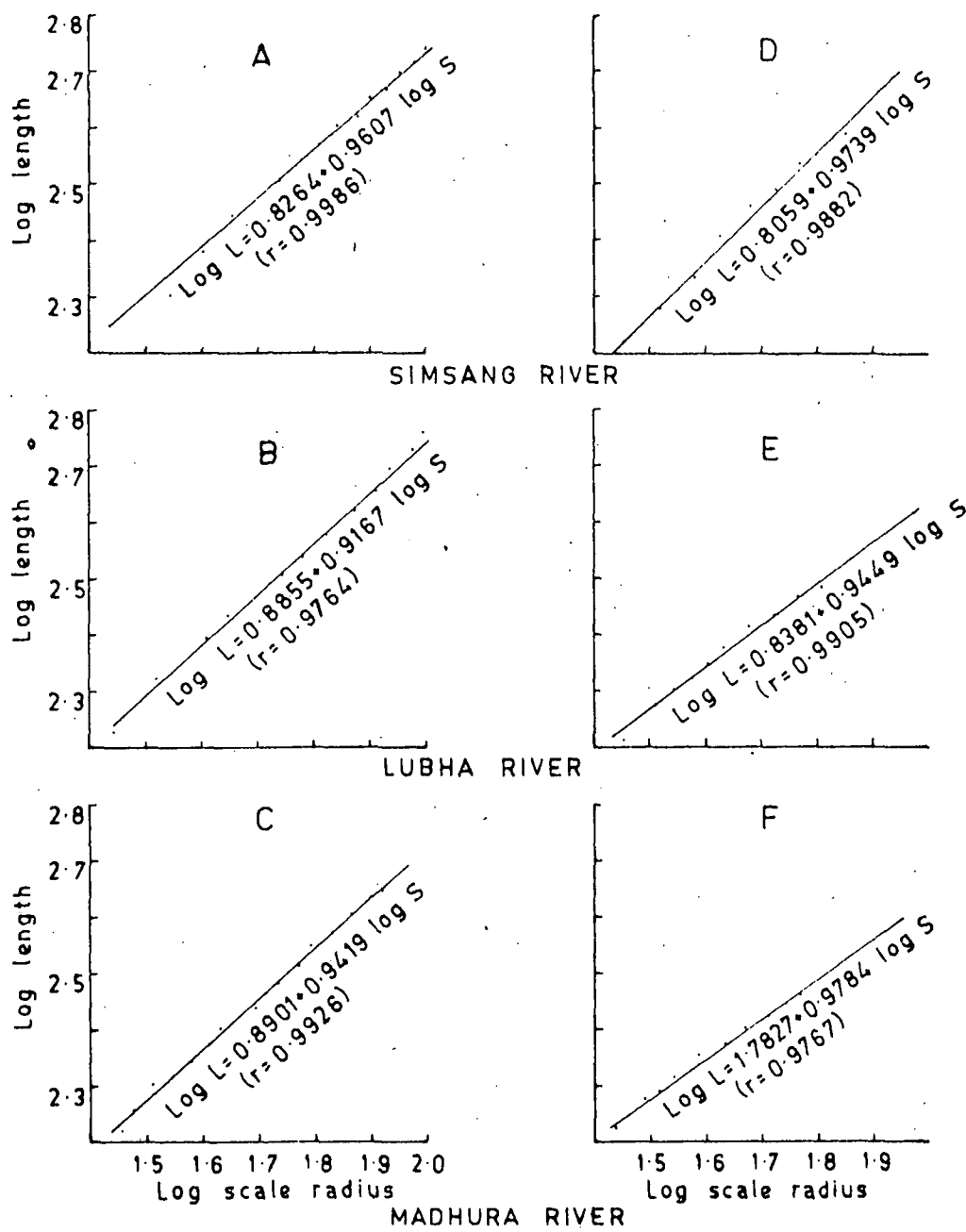


Fig.34. Log-log relationship between scale radius and total length of *L. pangusia* (A,B & C) and *L. dero* (D,E & F).

variation in feeding intensity (Thomson, 1904; Hardy, 1924; Kesteven, 1942; Nair, 1949; Bhimachar and George, 1952; Daget, 1952; Pillay, 1953; Qasim, 1957; Radhakrishnan, 1957; Jhingran, 1959; Natarajan and Jhingran, 1963; De Bont, 1967; Lakshmanan et al., 1971; Khan and Siddiqui, 1973b; Rangaswamy, 1973; and Chatterjee et al., 1979), period of starvation concurred with the spawning act (Hardy, 1924; Hickling, 1933; Fage and Veillet, 1938; Chacko and Krishnamurthi, 1950; Menon, 1950; Garrod, 1959; Major and Craddock, 1962; Lowe-McConnel, 1963; Natarajan and Jhingran, 1963; Jhingran, 1971; Bilton, 1974 and Payne, 1976), low water level and high turbidity (Hora and Nair, 1940; Johnels, 1952 and Olatunde, 1979), annual physiological changes in the internal environment (Hickling, 1933; Brown, 1946; Molander, 1947; Menon, 1950; Swift, 1955; Hoar, 1957; Simkiss, 1974; and Payne, 1976), affecting the formation of annual zones on the skeletal parts of the fish.

It has been observed in the present study that in the first year, ring is formed in both the species, L. pangusia and L. dero sometimes between May to July when intensity of feeding was found very low, whereas in other months even in December and January a moderate feeding was observed and formation of marginal rings in the scales of the fishes was very rarely encountered. In the second or subsequent year classes, the ring formation was found to occur during March to August, which are the maturing and spawning months of both the species. As stated earlier, during the spawning period gonads enlarge

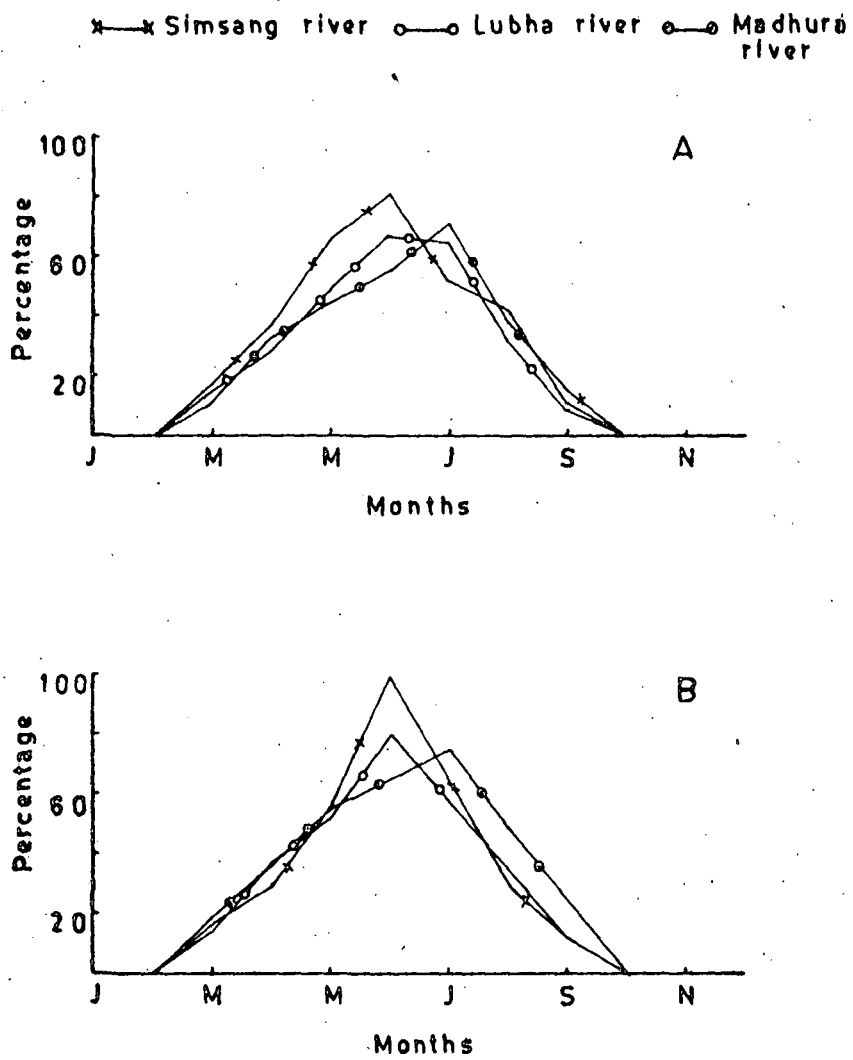


Fig.35. Percentag of scales with marginal rings in Labeo pangusia (A) and Labeo dero (B)

enormously and most of the growth potential is directed towards gonad building. The space for the gut is also reduced due to enlargement of the gonads and resulting the low rate of feeding.

A certain degree of size overlapping was found in both L. pangusia and L. dero. This might be due to the wide range of sizes among fishes of the same year class as also suggested by Qasim (1957) and Frost and Kipling (1967). This overlapping is partly due to the fact that spawning of all individuals did not take place at the same time. The spawning season of L. pangusia and L. dero lasts for two to three months. Therefore, some fishes hatch earlier than others and stand to gain a good start of life. Size of the fish supposed to be another most important factor which affects the growth of the population (Brown, 1946). Larger fishes have been found to grow comparatively faster, because they prove to be more efficient in competition and able to attain more food than the smaller ones. Such phenomenon has also been observed by Chatterjee et al. (1979) in L. bata.

A comparison of the growth rate in various age groups of L. pangusia and L. dero shows that the growth in length was rapid in the first three or four years. Thereafter, the increment in length ceases but the growth in weight increases rapidly. The growth in length has been observed very rapid in the first year itself for both the species. In L. pangusia, the increment in length was found to be about 25 cm in the first year, but to attain 55 cm in length the fish needs another 5

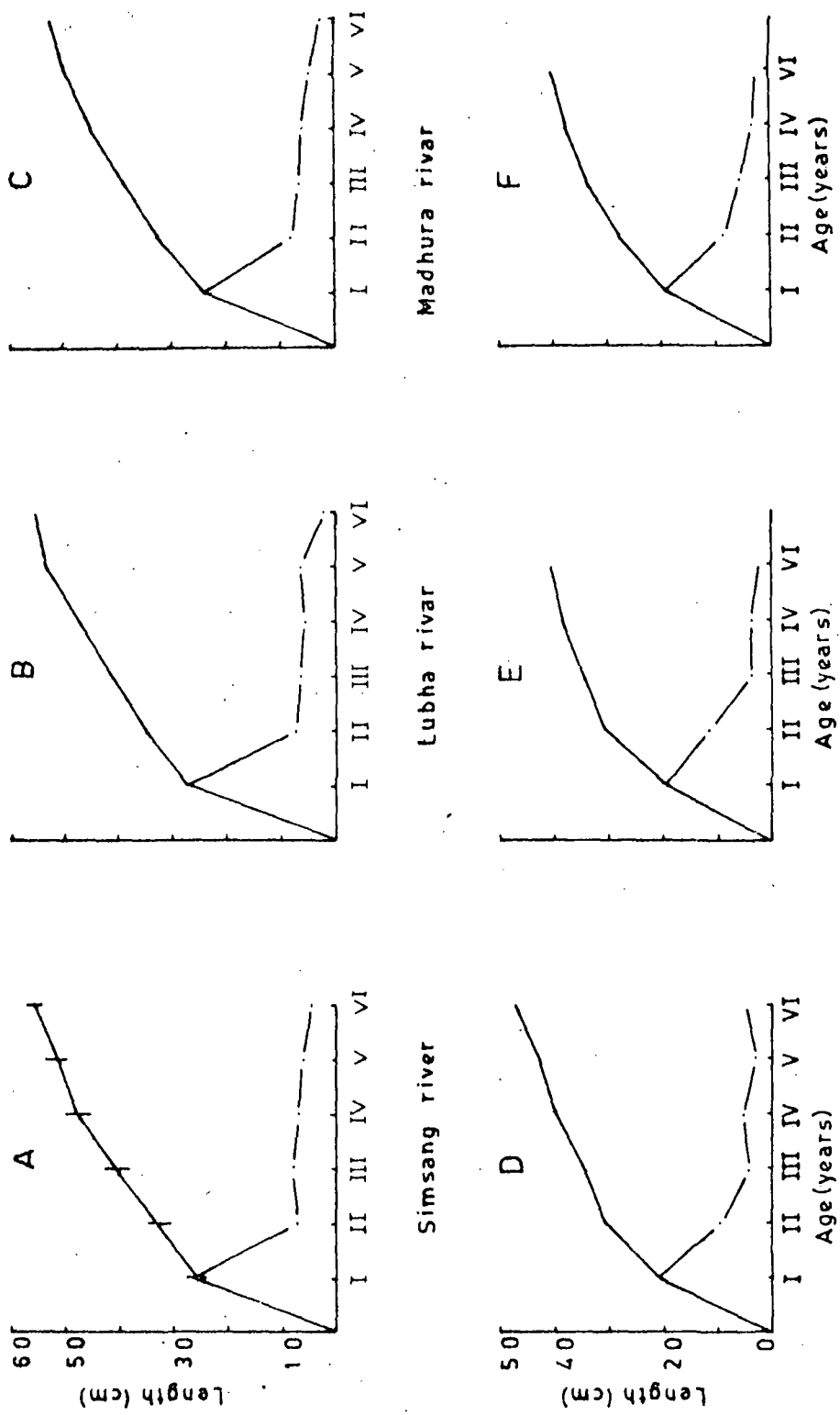


Fig.36. The growth curve of Labeo pangusia (A,B,C) and Labeo dero (D,E,F). The upper curve represent the average length and lower curve represents the specific growth

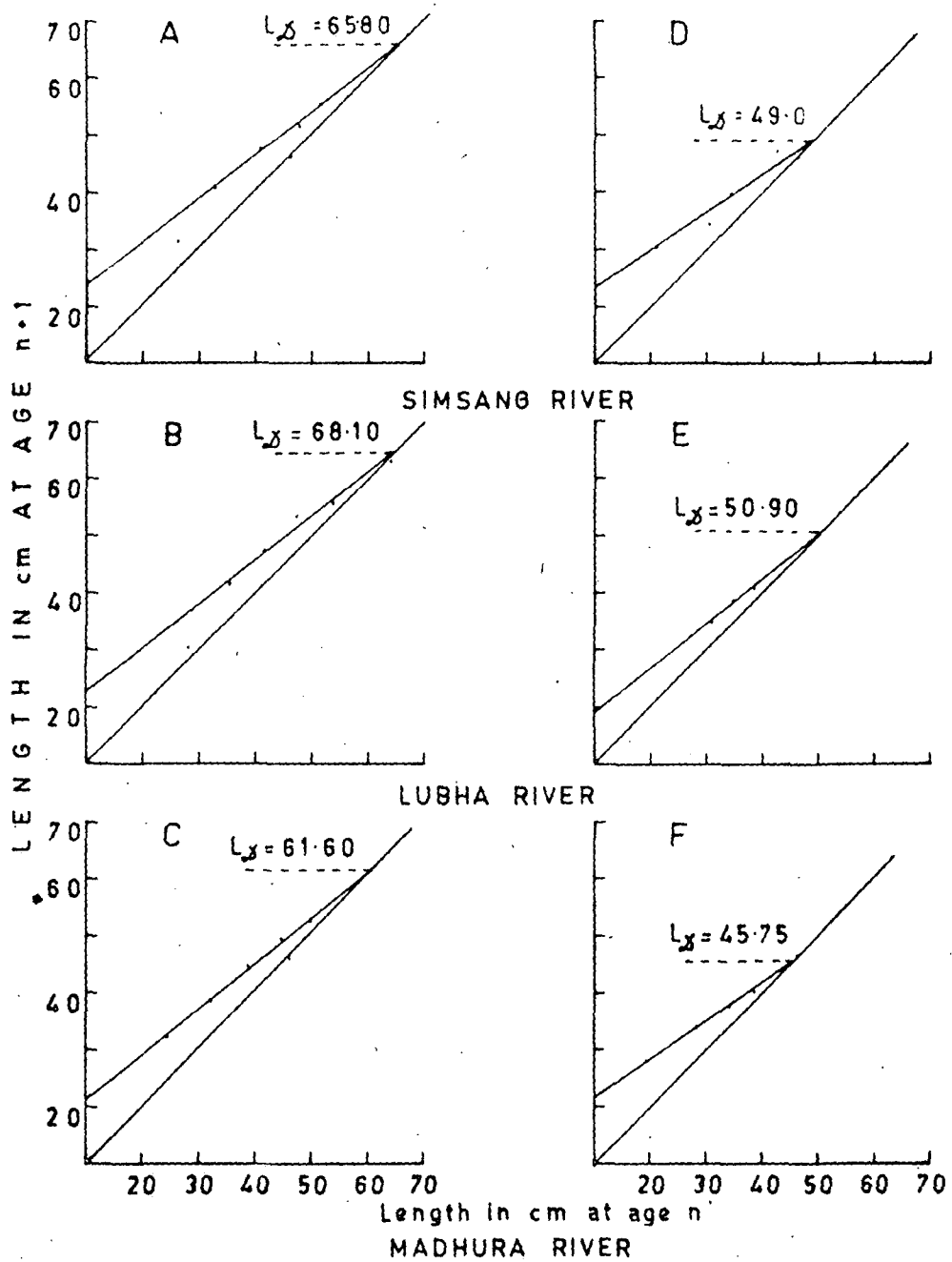


Fig. 37. Graph showing the maximum expected length (L_x) of *Labeo pangusia* (A, B & C) and *Labeo dero* (D, E & F) in particular population

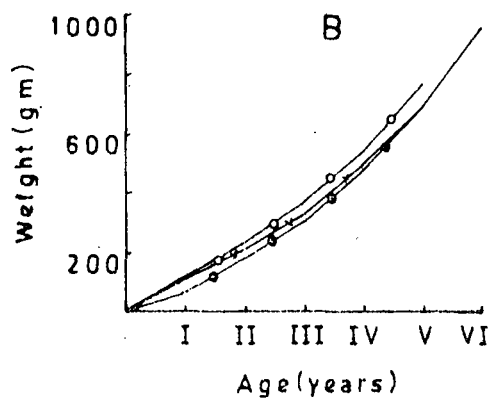
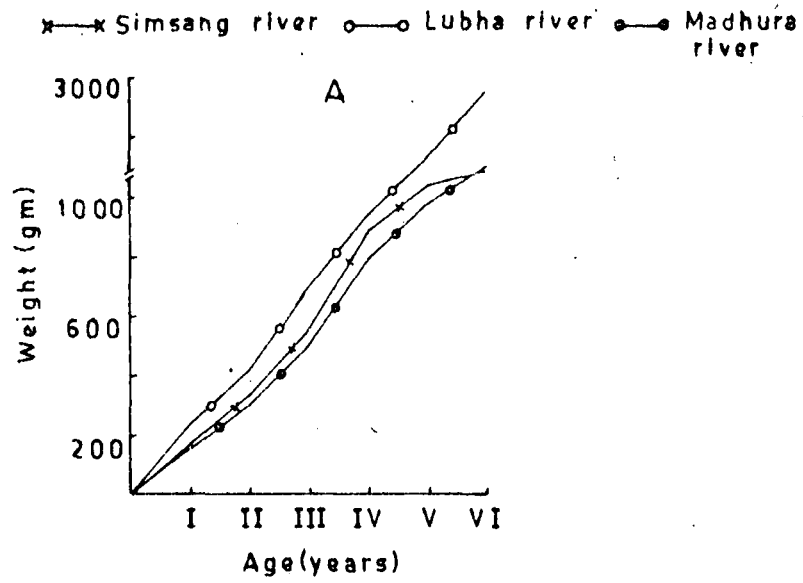


Fig. 38. Weight attained at different ages by Labeo pangusia (A) and Labeo dero (B)

years. Similarly, L. dero grows about 20 cm in length after completion of the first year and about 40 cm in length after completion of the fifth year.

The slower growth rate after the first year may be due to attainment of maturity and it is a well known fact that most of the growth potential is used in gonad building, rather than for dimensional growth. According to Nikolsky (1963), after the attainment of maturity the main part of the food consumed by fish is used not for linear growth but mainly for the ripening of the gonads and the fat accumulation for overwintering. During the period of old age, linear growth particularly ceases; the value of the growth characteristic is sharply reduced; most of the food is used for maintenance and only occasionally for fat accumulation particularly in overwintering fishes.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Keeping in view, the basic necessity to have a knowledge on the biology of Labeo pangusia and L. dero indigenous to the highlands of North-Eastern India, coupled with their great economic importance and because of the fast gaining popularity of culturing these fishes, the present investigation has been undertaken. The thesis entitled "Studies on some aspects of the biology of Labeo pangusia (Ham.) and Labeo dero (Ham.) from the North-Eastern India", embodies the results obtained during the studies on the biology of these fishes; a summary and conclusion of which are presented below :

MORPHOMETRIC AND MERISTIC CHARACTERS

The result indicates that there exists an intraspecific difference in the regression equations in various morphometric characters of L. pangusia and L. dero which may be attributed to diverse ecological conditions prevalent in the three different river systems. The various meristic counts of L. pangusia and L. dero made during the present study did not show marked intraspecific differences.

It can be concluded from the results that there exists an inter- and intraspecific difference as well as sexual dimorphism, at least in some of the morphometric characters, viz., pectoral fin height, body depth, number of lateral line scales, etc.

The results of the biometric characters for L. pangusia reveal that eye diameter becomes smaller in relation to head length. The similar trend has also been recorded in case of L. dero. The growth of the head length in relation to total length is isometric in L. pangusia whereas it is allometric in the case of L. dero. Again, the body depth exhibits allometric growth in L. pangusia whereas in case of L. dero the same show an isometric growth. The standard length in relation to total length was found to be allometric in both the species.

POPULATION STRUCTURE

Young specimens of L. pangusia and L. dero, particularly fishes belonging to '0' and 'I' year age groups were found to be dominating in the present collections. Scarcity of the older size groups of L. pangusia and L. dero in the present collection may be due to wanton fishing of larger individuals in the previous years.

The sex-ratio (male:female) in L. pangusia was found to be 1:1.2514, 1:1.4232 and 1:1.3569 in Simsang, Lubha and Madhura river populations respectively. The sex-ratio in L. dero was observed to be 1:1.8182, 1:2.0333 and 1:2.5333 from Simsang, Lubha and Madhura rivers respectively. A possible explanation for the general abundance of females is that the females are generally heavier than the males particularly during maturing and breeding season (March to August). This heaviness of the body perhaps makes the females sluggish and less agile than the

males resulting in their capture more easily. Differential mortality may also be a cause of differences in sex-ratios in L. pangusia and L. dero.

LENGTH-WEIGHT RELATIONSHIP

It is evident from the results obtained on length-weight relationship that there exists intra-specific variation in the exponential or 'b' value in both the species studied. It is also evident that exponential values in L. pangusia and L. dero differ seasonally, in different life stages (juvenile and adult) and also in different sexes. The general equation of the length-weight relationship of the two species was found to be :

$$\begin{aligned} \text{L. pangusia} &: \text{LogW} = -2.0220 + 3.0066 \log L \\ &r = 0.9724 \end{aligned}$$

$$\begin{aligned} \text{L. dero} &: \text{LogW} = -1.9409 + 2.9030 \log L \\ &r = 0.9827 \end{aligned}$$

The 'b' value in the length-weight relationship of L. pangusia was found to be nearly '3' indicating isometric pattern of growth whereas in L. dero the growth is allometric as the 'b' value was found to be less than '3'. However, the exponential value in these species approximates the cube law, hence, they can be considered as an 'ideal' fish as per the recommendation of Allen (1938).

CONDITION FACTOR

It has been observed that there are seasonal fluctuations in the 'K' values in L. pangusia and L. dero and such variations can be attributed to different factors such as food availability and gonadal maturity. The results of condition factor indicates that the 'K' value is higher in smaller fishes than the bigger ones in both the species.

The present study supports the view of Wheatherly (1972) that even among the members sampled in a same date from the same population, there may be considerable variation in 'K' values with length. It is further concluded that condition factor is mainly influenced by the maturation of gonads and food present in the alimentary canal.

FOOD AND FEEDING HABITS

The results on the food and feeding habits of L. pangusia and L. dero indicate that the basic food of these two species are detritus and diatoms. However, Chlorophyceae and Myxophyceae can be regarded as secondary food of these two species. The diet of the young and adult specimens of the two species is almost similar, the difference being only in magnitude. It was observed in the present study that the quantity of detritus and sand particles increased with the increase in length of the fishes. In both the species the R.L.G. value has been found to be very high and is quite

comparable with other detritus feeding fishes. Presence of ventral mouth, high R.L.G., values and occurrence of large quantities of detritus and sand particles confirm that both the species browse in the river bottom and have bottom feeding habit.

The G.S.I. values indicate that the feeding intensity is very high during March - April and again in August - September. The low feeding intensity during peak breeding season (June and July) might have been compelled by the completely developed gonads permitting limited space in the abdominal cavity. This is further supported by the results indicating the increase in feeding intensity after the spawning season.

It has also been observed that the feeding rate is higher among young individuals than of the older individuals. This may be due to the fact that metabolic activities are generally higher in young individuals.

MATURITY AND SPAWNING

The result on maturity indicates that both the males and the females mature at the same time of the year i.e. May to August, the peak breeding period being June and July. The occurrence of ripe specimens (Stage IV to VI) during April to June, high G.S.R. and K-values are indications of the maturity. It has further been noticed that seasonal peaks in the G.S.R. values coincided with the peaks in the percentage of occurrence.

of matured individuals. Studies on M_{50} (50% maturity) reveals that 50% of the males and females of L. pangusia mature at 25.4 - 30.0 cm group. The males of L. dero attain 50% maturity at 20.4 - 25.0 cm group while females at 25.4 - 30.0 cm group.

The fecundity of L. pangusia was found to be ranging from 1,89,626 to 5,40,034 in the specimens from Simsang river, 2,26,788 to 8,14,897 in the specimens from Lubha river and 2,25,471 to 6,36,900 in the specimens from Madhura river. The fecundity of L. dero was observed to be ranging from 91,034 to 2,33,205 in the individuals from Simsang river, from 85,156 to 2,32,641 in the specimens from Lubha river and from 80,627 to 2,32,903 in the individuals from Madhura river. Further, the logarithmic relationships between fecundity and the different body parameters were found to be linear in both the species. The relative fecundity of L. pangusia was found to range from 105 to 546 while in L. dero the range was found to be between 152 and 281.

The fecundity estimate suggests that both the species are highly fecund like other species of the genus Labeo. The fecundity of L. pangusia was found to increase at a rate almost square of the total length of the fish whereas in L. dero the fecundity was observed to increase at a rate almost equal to or substantially higher than the third power of the length of the body.

The fecundity of L. pangusia was found to have linear relationship to body weight, at a power almost equal to unity

and in L. dero also the fecundity was found to be increased proportional to fish weight.

The logarithmic relationship between fecundity and ovary weight of L. pangusia and L. dero from different river systems was also found to be linear. The high coefficient of correlation (r) also proved that the fecundity and ovary weight were very closely correlated.

Fecundity continued to increase with age while growth in length became quite slow. This explains maximum fecundity in L. pangusia and L. dero of the oldest age group.

The high fecundity of L. pangusia and L. dero might be due to heavy destruction of eggs and fries by predators or other factors. Variation in the fecundity from one population to other is regulated by food availability. Moreover, it is also observed in the present study that faster growing individuals have a higher fecundity than slower growing ones of the same size.

AGE AND GROWTH

Scales of L. pangusia and L. dero were observed to exhibit readable growth checks and were found to serve as reliable indices of age. It is shown that the checks were formed annually mostly during May to July and the probable causative factors for their deposition was interpreted to be the retarda-

tion in feeding intensity during these months.

The relationship between the total length and the radius of the scale in both the species was ascertained to be linear in the logarithmic form. Based on this relationship a formula for back calculation of lengths at different ages has been derived. The growth in length attained during first year of their life was found to be maximum in both the species. However, the increment in weight was observed to be faster from 3rd/4th year onwards. The slower growth rate after the first year may be due to attainment of maturity and it is well known fact that most of the growth potential is used for gonad building rather than for dimensional growth. During the period of old age, linear growth practically ceases, and the food consumed at that time is used for the ripening of the gonads and occasionally for fat accumulation particularly in overwintering fishes.

The ultimate or asymptotic length (L_{∞}) of L. pangusia was found to be 65.80 cm, 68.10 cm and 61.60 cm in the individuals from Simsang, Lubha and Madhura rivers respectively. The ultimate length of L. dero was calculated to be 49.0 cm, 50.90 cm and 45.75 cm in the specimens from Simsang, Lubha and Madhura rivers respectively.

In the present study it is observed that growth rate of L. pangusia from Lubha river is higher than those from the Simsang and Madhura rivers which may be due to better food availability in the Lubha river.

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APPENDIX

AUTHOR'S LIST OF PUBLICATIONS

(A): Papers presented at Congress(es)/Seminar(s) :

1. Biswas, S.P. and S.A.K. Nasar. 1980. Length-weight relationship of Puntius clavatus (McClelland) from Simsang River (Meghalaya). Proc. 67th Ind. Sc. Cong. Part III (Abstr): 197.
2. Biswas, S.P. and S.A.K. Nasar. 1981. Studies on the gut length in relation to feeding habits of five hill stream fishes from Assam. Proc. 68th Ind. Sc. Cong. Part III (Abstr.): 16-17.
3. Biswas, S.P. and S.A.K. Nasar. 1982. Fecundity of Puntius clavatus (McClelland). Proc. 69th Ind. Sc. Cong. Part III (Abstr.): 78.
4. Biswas, S.P., S.A.K. Nasar and K. Chatterjee. 1982. Intra-specific comparisons in the morphometric and meristic characters of Labeo pungusia from the North-Eastern India. Presented in the Third All-India Ichthyological Seminar (Gauhati University), 26th to 29th July 1982.

(B): Papers communicated:

1. Biswas, S.P. and S.A.K. Nasar. On the length-weight relationship of Puntius clavatus (McClelland) from Simsang river, Meghalaya.
2. Biswas, S.P. and H.L. Sarkar. Fishes of Manipur.