AN INVESTIGATION ON SOME ASPECTS OF THE BIOLOGY OF MAHSEERS 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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MARCH, 1982

Thesis

A B S T R A C T

There is a paucity of information on the biology of indigenous fishes in the highlands of the North-Eastern Hill Regions of the country. Such a knowledge, is of utmost importance not only from the academic view point, but also in its utility in increasing technological efficiencies of the fishery entreprenuers for evolving judicious management measures. Keeping in view, the basic necessity to have a knowledge on the biology of fishes and hence, on a virtual absence of such informations, a study has been undertaken to elucidate on the Biology of Mahseers (Cypriniformes: Cyprinidae) viz., *Acrossocheilus hexagonolepis* (McClelland), *Tor tor* (Hamilton) and *Tor putitora* (Hamilton) from the highlands of Meghalaya (India).

The study pertains to the specimens of these fishes, collected during the period from August 1978 to July 1980 mainly from Simsang River situated at an altitude of 500 feet in Garo Hills (27°40'N latitude and 91°28'E longitude), India.

The results obtained during the present study has been presented in the thesis entitled "An investigation on some aspects of the biology of Mahseers from the North-Eastern India." The dissertation containing 148 pages, with 38 Tables and 41 Figures, has been divided into 5 chapters. The first chapter deals with an introduction to the biological

studies of fishes, followed by a short review of the available literature on the biology of Mahseers. This is further followed by the taxonomical status, diagnostic characters, synonyms and vernacular names of the species. In the second chapter the materials and methods adopted for the present study have been presented. This is further followed by the third chapter, dealing with the results obtained on morphometric and meristic characters, length/mass relationship, condition factor, maturity and spawning, fecundity and food and feeding habits of these fishes. The fourth chapter contains the disucssion on the results obtained during the present study. In the fifth and final chapter, a summary and conclusion of the entire study have been presented, which is followed by list of literature cited in the dissertation.

The following are the important results obtained during the present investigations and embodied in the thesis:

1) An intra-specific variation has been observed in various morphometric characters viz., head depth, eye diameter and rostral-barbel length of *A. hexagonolepis*. These characters were found to be higher in the specimens from the Pagladia River population, whereas the characters viz., snout length, gape and number of lateral line scales, were found to be significantly higher in the specimens from the Simsang River. Considerable differences in various morphometric parameters between *T. tor* and *T. putitora* have also been observed in the present study.

2) The length-weight regression and parabolic equations for *A. hexagonolepis*, *T. tor* and *T. putitora* are derived to be as follows:

A. hexagonolepis:

$$\text{Log } W = -\ 5.1971 + 3.0640 \text{ Log Tl}$$
$$W = 0.000001005\ L^{3.0640}$$

T. tor:

$$\text{Log } W = -\ 5.1252 + 3.0284 \text{ Log Tl}$$
$$W = 0.000007479\ L^{3.0284}$$

T. putitora:

$$\text{Log } W = -\ 4.8308 + 2.8863 \text{ Log Tl}$$
$$W = 0.00001476\ L^{2.8863}$$

The regression equations of *A. hexagonolepis* and *T. tor* during different seasons viz., summer, monsoon and winter have been found to be:

A. hexagonolepis:

Summer	$\text{Log } W = -\ 5.2230 + 3.0392 \text{ Log Tl}$
Monsoon	$\text{Log } W = -\ 3.6863 + 2.9132 \text{ Log Tl}$
Winter	$\text{Log } W = -\ 4.9479 + 2.9840 \text{ Log Tl}$

T. tor:

Summer	$\text{Log } W = -\ 4.9846 + 2.9993 \text{ Log Tl}$
Monsoon	$\text{Log } W = -\ 4.9686 + 2.9793 \text{ Log Tl}$
Winter	$\text{Log } W = -\ 5.1252 + 3.0284 \text{ Log Tl}$

3) Condition factor (K) varied from 0.695 to 1.180 in *A. hexagonolepis*, 0.802 to 1.060 in *T. tor* and 0.776 to 0.845 in *T. putitora*. Variations in the condition factor have been attributed to be different factors such as environmental condition, food availability and gonadal maturity.

4) Maturity studies, indicated that *A. hexagonolepis* has a prolonged spawning season, extending from March/April to October/November.

5) It has been found that the males of *A. hexagonolepis* were immature below 91 mm in total length, whereas the females were found to be immature below 201 mm in total length. The 50% maturity (M_{50}) in males of the species were recorded at 191-250 mm length group, whereas the same has been recorded for females at 211-220 mm length group.

6) The values of Gonado-somatic index indicated the spawning season of the species from March/April to October/November, supporting the inference drawn from the studies concerning spawning season. It is also indicated that there is a tendency for the Gn.S.I. to increase with increase in length.

7) It has been recorded in the present study that the fecundity of *A. hexagonolepis* ranges from 533 in the specimen measuring 196.00 mm and 74.4 gm in total length and total weight respectively to 11660 in the specimen measuring 442.0 mm and 1000.00 gm in total length and total weight respectively.

The regression equations between fecundity and various parameters, derived are as follows:-

(i) Fecundity Vs. total length:

$$\text{Log } F = -2.0725 + 0.5278 \text{ Log } Tl \quad (r = 0.4506)$$

(ii) Fecundity Vs. total weight:

$$\text{Log } F = -2.3040 + 2.3226 \text{ Log } W \quad (r = 0.6293)$$

(iii) Fecundity Vs. ovary weight:

$$\text{Log } F = -2.9282 + 0.4720 \text{ Log } O.W. \quad (r = 0.8417)$$

(iv) Ovary weight Vs. total length:

$$\text{Log } O.W. = -1.1675 + 0.6565 \text{ Log } Tl \quad (r = 0.6568).$$

8) The results of the food and feeding habits of *A. hexagonolepis* and *T. tor* indicate that the basic food are algal and vegetable matters. However, animal matters were also encountered, hence can be regarded as secondary food of these species. In the case of *T. putitora*, vegetable matter, algae and insect can be regarded as primary food.

The high values of G.S.I. (3.960 - 8.131) recorded for *A. hexagonolepis* reflects towards the voracious feeding nature of the species. The percentage of vegetable matter was found to increase with the increase in length in all the three species, which indicate the change in the diet preference with the increase in length.

It has also been observed that R.L.G. values of all the three species studied, increase with the increase in length. The average R.L.G. values were found to be 2.4, 2.1

and 1.3 in *A. hexagonolepis*, *T. tor* and *T. putitora* respectively. Hence, the results obtained with the food and feeding habits of the fishes reveal that the Mahseers of this region are purely omnivorous.

The present study further suggest that the Mahseers can be considered as a culturable species particularly in the North-Eastern Region and can further be included into "Lab. to Land" programme.

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I certify that the thesis entitled " An Investigation on some aspects of the Biology of Mahseers from the North-Eastern India" , submitted by Mr Mrinal Dasgupta for the Degree of DOCTOR OF PHILOSOPHY of the North - Eastern Hill University , Shillong (India) embodies the record of original investigations carried out under my 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.

Dated: Shillong;

The 15th March, 1982

(S. A. K. NASAR)

Supervisor

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PREFACE

P R E F A C E

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 in the 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 bergeoning 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 life-processes of fish.

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 deficiences. Moreover, it is well known that the tribals of the hilly areas in Meghalaya (Khasis, Jaintia's 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 inidgenous 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, on a virtual absence of scientific knowledge on these aspects, paritcularly of Mahseers prompted to undertake the present investigations. It is, therefore, earnestly hoped that the information embodied in this dissertation, apart from its academic value, it would have application and relevance to the socio-economic development of these areas of the country by evolving suitable pisciculture techniques.

The study pertains to the specimens of Mahseers (Acrossocheilus hexagonolepis; Tor tor and T. putitora) collected during the period from August 1978 to July 1980 mainly from Simsang River situated in Garo Hills (Meghalaya) India. The results obtained during the present study are presented in this thesis entitled "An investigation on the biology of Mahseers from the North-Eastern India." The investigations were carried out at the Fish Ecology Laboratory, Department of Zoology of the North-Eastern Hill University, Shillong, under the supervision and guidance of Dr. S.A.K. Nasar, Ph.D., F.A.Z., F.Z.S. (Lond.).

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The work was carried out under the tenure of Research Fellowships awarded to me by the Indian Council of Agricultural Research, Hindustan Lever Research Foundation and Council of Scientific and Industrial Research, which are hereby thankfully acknowledged.

Dated: Shillong
The 15th March, 1982

(MRINAL DASGUPTA)

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INTRODUCTION

INTRODUCTION

The brilliant colours, bizarre shapes and curious habits of tropical fishes are well known, and throughout the tropics, 'freshwater fishes are of immense importance as a food source for human beings.' The demand for such protein is rising exponentially with the rapid growth in human population.

Although the study of biological processes is of fundamental importance for man's continued existence and well being, such studies from the tropics are still in their infancy and theories about tropical communities are mainly based on few hard data, many of them culled from the behaviours of bird and insect populations. However, fishes have been investigated more than any other group of vertebrates in the tropics, but unfortunately most of the results have been published in specialized or technical reports, which is not readily available to general biologists.

Tropical fish communities are noted for its high diversity. The history and geography of the area dictate the basic stocks of fish which gain access to it (Lowe-McConnell, 1975). The fishes manage to persist in a particular geographical region which depends on the suitability of ecological conditions for all stages of life history, since fishes are very mobile creatures, searching out different habitats to suit the particular requirements of the eggs, the young fish, juveniles or adults. Their social requirements too, change as many fishes living in shoals when young, but in pairs or solitarily when adults. Thus, the composition of the fish communities, the group of interacting population within a particular habitat, may be changing continually (Lowe-McConnell, 1975).

In certain places, communities of fish are very stable throughout the year and from year to year and probably long periods of time, while in other places community membership is changing radically all the time, often with seasonal regularity. Some fish species are "eurytopic", that is to say that they can withstand a great range of environmental conditions such as changing temperatures or salinity, or they can eat diverse type of food while other species are "stenotopic", tolerating only a very narrow range of environmental conditions.

According to Holt (1967), assessment of world production is needed in the next three decades and that inland waters where control can be exercised over the factors governing production will have to bear the brunt of this increasing demand. There is, thus, an urgent need to understand the factors involved in 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 proetin 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 fisheries management is always to obtain the maximum sustained yield of fish from a water body, this involves removing fishes equivalent to the amount of fish produced each year. For developing fishery, it is necessary to understand their populations 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 on natural fish communities. In India, generally the important culturable fishes are the Indian major carps, such as Catla catla, Labeo rohita, and Cirrhina mrigala and the exotic carps viz., Cyprinus carpio, Ctenopharyngodon idellus and Hypothalmichthys molitrix. Apart from these, there exists a wide variety of game fishes gaining fillip in country as far as culture is concerned. Fishes known as game fishes are generally have some qualities such as rapid growth, capacity to fight to the last when caught by the anglers. Trout is well known among the Europeans to have all the sport qualities and during the British rule in India, the British Civil servants introduced trout in Kashmir and Ootakamund, the summer resorts of the Englishmen. Mahseers (Tor tor, T. putitora), Chocolate Mahseer (Acrossocheilus hexagonolepis), and Carnatic carp are our indigenous culturable sport fishes. According to Thomas (1877), the Mahseer shows more sport because of its size than a Salmon. Thomas (1897) and MacDonald (1948) narrated regarding the sport and fighting nature of Mahseer among other sport fish and the use of rod to take them, in their famous works "The Rod in India" and "Circumventing the Mahseer and other sporting fishes" respectively.

Various opinions have been expressed about the etymology of the term "Mahseer". According to Lacy and Cretin (1905) its derivation from "maha-sir", meaning big head may be an attempt to impart a meaning to the name. The derivation from "maha-sher" meaning big tiger is fanciful. The third derivation is from "mussulah" or "mahasalka" meaning big scaled. Jhingran (1975) stated that the fourth derivation is from "matsya", a Sanskrit word standing for fish used in Vedas, perhaps implying the fish among fishes. The Mahseer is regarded as a sacred fish by the Hindus and it is probable that the Barhmins called it "Mahasia" meaning the fish _par excellence_. However, Hora (1939) was of the opinion that Mahseer is a colloquial form of "mahasirasha" or "mahasiras", the bigness referring to the front part of the fish and not merely to its head or snout. Mahaseer is generally found in its largest sizes in mountainous streams and rivers (Hora, 1939), Hamilton (1822) put mahseers under the genus _Cyprinus_ and recognised three species thereof, namely _Cyprinus putitora_, _C. tor_ and _C. mosal_. Later on various workers classified Mahseer under various genus, i.e. _Barbus_ Cuvier, _Labeobarbus_ Rüppel, _Barbodes_ Bleeker, and _Tor_ Gray. The Copper Mahseer (_Acrossocheilus hexagonolepis_) belong to a different genus altogether, has likewise been placed diversely. McClelland (1839), however, placed this genus under _Barbus_ but later it came to be assigned under the genus _Lissocheilus_ finally to be put under _Acrossocheilus_ (Oshima, 1919).

According to the latest taxonomic report by Mennon (1974), the commonly found Mahseers in India are i) _Tor putitora_, ii) _Tor tor_, iii) _Tor mosal_, iv) _Tor khudree_,

v) Tor mussulah, vi) Tor neilli, vii) Tor progeneius and viii) Acrossocheilus hexagonolepis.

It is a well known fact that the knowledge on fish biology particularly on morphemetry, length-weight relationship, condition 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.

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 Giront and Spain (1977), the concepts of size and shape are fundamental to the analysis of variation in living organisms. According to Le Cren (1951) 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, fecundity in relation to length and weight of fish 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 rate 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 succesful aquaculture programme. The knowledge of the number of eggs produced by fishes is of great value in pisciculture, as it would determine the amount of rearing facilties 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 problems (Bagenal, 1978).

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 an organism's niche (Schoener, 1974). Investigations of the feeding ecology of a species can produce insight into how the organims has evolved ecologically to meet this 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, 1973), 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 behavriour, since it can be utilized for exploiting natural fish food.

The National Commission on Agriculture (1976), in its report on "Fisheries" mentioned that there has been a general decline in the Mahseer fishery due to indiscriminate fishing of brood fish and juveniles and adverse effects of river valley projects and recommended an extensive survey and detailed ecological and biological investigations.

However, as mentioned earlier our knowledge on the biology of other indigenous fishes are much more advanced than those of Mahseers and only in recent years, it has proliferated rapidly, but even then the information on the general biology of Mahseers, is fragmentary and the most part widely scattered in literature. However, there is a considerable amount of works from other parts of the country (Ahmed, 1948; Desai, 1979; Kulkarni, 1971; Chaturvedi, 1976; Das and Pathani, 1978; Kukarni and Ogale, 1978), but our knowledge on similar aspects particularly from the North-Eastern parts of the country, is very meagre except for few works by Nasar and Dasgupta (1979) and Dasgupta and Nasar (1981).

Keeping in view, the basic necessity to have a knowledge on the general biology of the Mahseers indigenous to the highlands of the North-Eastern India, a study has been undertaken on some aspects of the biology viz., Morphometry, length-weight relationship, condition factor, reproduction and food and feeding habits of the Mahseers commonly available in the region.

The study pertains to the specimens of three species of Mahseers viz., *Acrossocheilus hexagonolepis*, *Tor tor* and *T. putitora* collected during the period from August 1978 to July 1980, mainly from Simsang River in Garo Hills, Meghalaya.

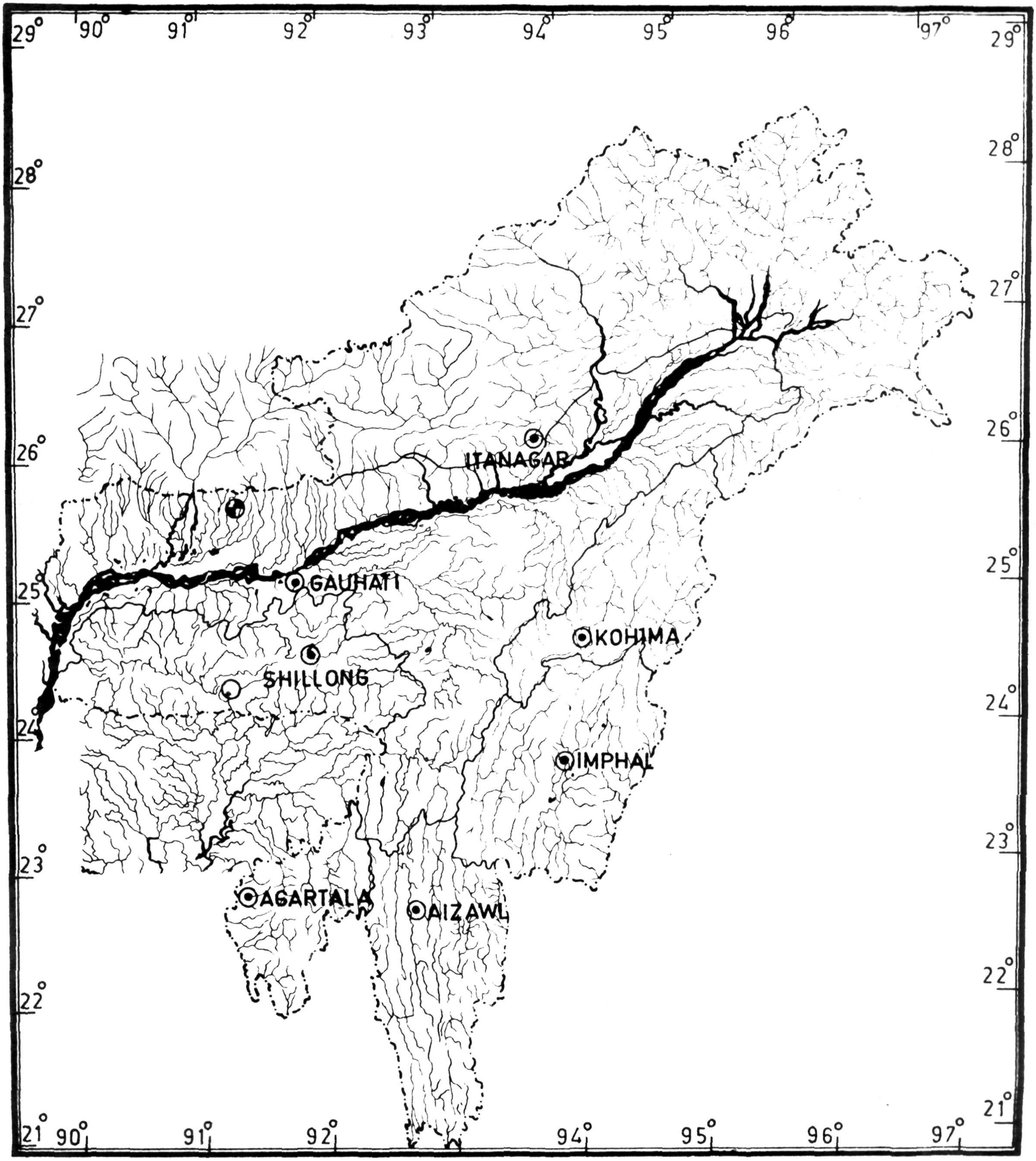


Fig. 1. Drainage map of North-Eastern India showing study sites.
◕ River Pagladia ○ River Simsang

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Knowledge of the occurrence of fish in India dates back to three millenium B.C. (Hora, 1956), According to Nath (1966) fish remains with cut marks, indicative of their use as food, have been obtained from excavations at Mohenjo-daro 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 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 Auslandiche Fische was published in 1785. Later Lacepede wrote Historie des Poissons (1798-1803). Russell (1803) described 200 species from Vizakhaptnam. Then appeared Hamilton's (1822) pioneering work "Fishes of Ganges" which contains a description of 269 species of fish from the Ganges and its tributaries. Cuvier and Valencienne's "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), Gunther (1859-1870).

There is, 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, 1944, 1951b, 1955), which are being continued by many zealous workers notably, Shaw and Shebbeare (1937), Misra (1959); Menon (1951).

Aspects on the Systematics such as morphometry and meristic characters, colouration, key to identification, size attained and habit and habitats of Mahseer have been dealt by Hamilton (1822); Sykes (1839, 1841); Day (1878, 1889); Evans (1926); Spence and Prater (1933); Khan (1934); Mukherji and Hora (1936); Shaw and Shebbeare (1937); Hora (1936, 1939, 1940a, b, c, 1941 a, b, 1942, 1943 a, b); Hora and Misra (1938); Coringdon (1939); Hora and Nair (1943); Raj (1969). Sport and fighting qualities of Mahseer have been described in details by Thomas (1897) and MacDonald (1948).

A few reports are available on the survey of Mahseer fishery and its conservational aspects. Hora and Nair (1944) reported on the pollution of streams and conservation of fisheries with special reference to Mahseers. Raj (1945) discussed about the decline of Mahseer fisheries of the Kumaon Lakes and recommended a possible remedy. Sehgal et al. (1971) made observations on fisheries of Kangra Valley and adjacent areas with special reference to Mahseers. Sehgal (1972) in his article "The cold water fisheries development in India for sport and profit" discussed about Mahseer fishery. Karamchandani (1972) in his article discussed the sporting quality, distribution and fishery of Mahseer.

Joshi et al. (1974) discussed about the fishery resources of the hill streams with special reference to Mahseer and other commercially important species. Pathani (1977) discussed the problem of Kumaun Mahseer - T. tor and T. putitora. Kulkarni (1978) discussed about the present status of Mahseer and its artificial propagation.

Recently, Dasgupta and Nasar (1981) made morphological comparisons between two populations of A. hexagonolepis from two different river systems of the North-Eastern India.

Pardhasaradhi and Alfred (1980) reported an additional caudal fin in the chocolate Mahseer, Acrossocheilus hexagonolepis.

With regard to studies on anatomical and histological aspects, Lal (1963) studied the urinogenital organs of the Mahseer Tor putitora. Lal (1968) studied the anatomy and histology of the alimentary canal of T. putitora. Rai (1967) studied the cyclic changes in the ovaries of Tor (=Barbus) tor. Qureshi et al. (1978) reported on the heterotropic thyroid follicles in the adrenocortical tissue of T. tor.

Very little attention has been paid to the parasitological aspects of Mahseer except that of Nasar and Dasgupta (1979) who reported on the occurrence of Ichthyopthiriasis in Acrossocheilus hexagonolepis and Rautela et al. (1979) who studied the ecological aspects of nematode infection in freshwater fishes including Mahseer (T. tor and T. putitora).

With regards to biochemical aspects, Sharma and Shimlot (1971) dealt with the chemical composition of Mahseer (T. khudree) from Jaisomond Lake, Udaipur, along with other fishes.

With regard to the cytology and genetics of Mahseer practically no work has been done so far, except the report by Khudabuksh (1980) on the high number of chromosomes in the hill stream cyprinid T. putitora.

A few reports are available on the developmental aspects of Mahseer. Ahmed (1948) made observations on the early development of the Copper Mahseer, Barbus (=Lissocheilus) hexagonolepis. David (1953) studied the early stages of Mahanadi Mahseer. Kulkarni (1971) made observations on the eggs and fry of Deccan Mahseer, T. khudree. The early larval stages of T. putitora has been reported by Desai (1972). Recently Kulkarni (1980) described the eggs and early development of Tor Mahseer and compared it with T. khudree. A new method of transport of Mahseer eggs by air in moist cotton wool has been developed by Kulkarni and Ogale (1979).

Comparatively a good deal of works have been done on the reproductive biology of Mahseer than the other biological aspects. Nevil (1915) reported on the breeding habits of the Mahseer (Barbus tor). Khan (1924) studied the breeding habits of some fresh water fishes of Panjab including Mahseer. Khan (1939) and Bhatti (1939) studied the sex organs of Mahseer (T. putitora) in relation to spawning. Langdle Smith (1944) reported on the breeding habits of Katli Barbus (=Lissochilus) hexagonolepis. Ahmed (1948) studied the spawning habits of the copper Mahseer Barbus (=Lissochilus) hexagonolepis. Qasim and Qayyam (1961) determined the spawning frequencies and breeding seasons of some fishes with special reference to those occurring in the plains of Northern India including Mahseers. Kulkarni (1971) studied the spawning habits of Deccan Mahseer T. khudree. David (1973) studied the maturity and fecundity and larval development of T. tor. Tripathi (1978) described a method of artificial breeding of T. putitora. Pathani and Das (1979) were also successful in induced breeding of T. putitora by mammalian and fish pituitary hormone injection. Recently, Pathani (1981) has studied the fecundity of Mahseer, T. putitora.

With regard to the food and feeding habits, Desai (1970) studied the aspect in T. tor from the river Narbada. Das and Pathani (1978) studied the adaptation of the alimentary tract to the feeding habit and somatic weight in the Kumaun Mahseer, T. putitora. Recently, Biswas and Nasar (1981) made a survey of the gut length in relation to food and feeding habits of five hill stream fishes including Mahseer (A. hexagonolepis and T. tor) from Assam.

Studies on the age and growth of Mahseer have been neglected so far. However, recently Pathani (1979) discussed the otolith as age indicator in the Mahseer, T. putitora from

Bhimtal Lake, Kumaun.

The foregoing review of literature reveals that though a good deal of works have been done on the biology of Mahseers, there are still several points with regards to the general biology of this group, particularly *A. hexagonolepis* which requires elucidation. However, available information on such aspects in other species of Mahseer is of very general and preliminary nature. Moreover, there is practically no information available on the general biology of Mahseers from the North-Eastern highlands of India. Therefore, it has been felt desirable to conduct an investigation on the biology of Mahseers (*A. hexagonolepis*, *T. tor* and *T. putitora*) from the Garo Hills of the North-Eastern India.

TAXONOMIC STATUS OF THE FISHES (after Berg, 1940)

Phylum	-	Vertebrata
Sub-phylum	-	Craniata
Super-class	-	Gnathostomata
Series	-	Pisces
Class	-	Teleostomi
Sub-class	-	Actinopterygii
Order	-	Cypriniformes
Sub-order	-	Cypriniodei
Family	-	Cyprinidae
Genus	-	i) *Acrossocheilus* Oshima, 1919
		ii) *Tor* Gray, 1834
Species	-	i) *Acrossocheilus hexagonolepis* (McClelland, 1834)
		ii) *Tor tor* (Hamilton, 1822)
		iii) *Tor putitora* (Hamilton, 1822).

DIAGNOSTIC CHARACTERS OF THE SPECIES

i) Acrossocheilus hexagonolepis:

D. 4/9; P. 13-16; V. 8-9; A. 3/5; C. 19; Ll. 23-28; Ltr. 4/3.

Acrossocheilus hexagonolepis has a graceful form in which both the dorsal and ventral profiles are more or less equally arched. The head is relatively shorter and rounded in front. The length of the head is contained from 4.7 to 5.1 times in the total length and from 3.3 to 4.1 times in the standard length. The height of the head at the occiput is considerably greater than width. The most conspicuous features of the head is the possession of several rows of horny tubercles on the sides, in front of, and below the eyes. The number and arrangement of tubercles vary in different individuals, and when the tubercles are rubbed off or fall away, series of open pores are present instead. The eyes are lateral in position and are of moderate size; they are relatively larger in young specimens and situated mainly in the anterior half of the head; the diameter of the eye is contained from 3.4 to 6.7 times in the length of the head; and according to the size of the specimen, it may be greater or smaller than the length of the snout or the inter-orbital width. The mouth is of moderate size, horizontal and sub-terminal, it is slightly overhung by the snout. The lips are thick, continuously round the angles of the mouth, but the labial groove is widely interrupted in the middle. The posterior lip is not produced into a flap in the middle.

The lower jaw is covered by a sharp, horny covering which enables the fish to rasp off encrusting organic matter from rocks. The barbels are longer than the diameter of the eye. The pharyngeal teeth (5.3. 2/2. 3.5) are relatively shorter but more massive than those of the type - Tor.

Depth of the body is somewhat greater or less than the length of the head; the depth of the body is contained from 3.5 to 4.8 times in the total length and from 3.0 to 3.7 times the length without the caudal. The caudal peduncle is well formed but narrow; its least height is contained from 1.3 to 1.7 times in its length. The scales are large and well-set; the lepidosis varies considerably even in specimens from the same locality. The number of scales along the lateral line may vary from 23 to 28, of predorsal scales from 8 to 11, and of the transverse series between the lateral line and the base of the ventral fin from 2½ to 3½. There is a scaly appendage in the axil of each pelvic fin.

The dorsal fin commences opposite to or slightly in advance of the pelvices, its commencement in half-grown specimens is generally slightly nearer to the top of the snout than to the base of the caudal fin. The position of the dorsal varies with the size of the individuals.

The size and strength of the dorsal spine is also variable and it has been found that the specimens from streams running through lime rocks have better developed spines. The pectoral fin is low and pointed; in young specimens, it may extend to the pelvic fin, but in somewhat grown up individuals the two fins are separated by a considerable distance. The pelvic fins are sharp and do not extend to the anal fin which later may or may not reach the base of the caudal fin. The cau al fin is deeply forked with both the lobes pointed.

Colouration varies considerably according to the nature of the water inhabited by the fish. The colour is olive green or black; each scale above the lateral line are copper coloured at the end deepening to bronge-green at the base. Below the lateral line the scales are pale grey fading to pure white on the belly. Fins are deep-grey coloured paling towards their margins. Iris bright coppery red.

ii) Tor tor:

D. 4/8; P. 17-18; V. 9; A. 3/5; C. 19; Ll. 25-27; Ltr. 4/2.

The Tor Mahseer is more stoutly built than the Putitor Mahseer and, it is compressed with the ventral profile more prominently arched than the dorsal. The head is proportionately smaller than that of the Putitor Mahseer and is sharpish anteriorly; with the exception of very young specimens, it is always shorter than the greatest depth of the body. The length of the head is contained in the standard length from 3.4 times in the young specimens to about 3.8 times in older individuals. The depth of the body is almost equal to the length of the head in young examples upto about 100 mm in total length but in older specimens the head is invariably shorter than the depth of the body; the length of the head is contained from 1.0 to 1.2 times in the depth of the body. The depth of the body is contained from 3.2 to 3.5 times in the standard length. The eyes are situated nearer to the tip of the snout than to the hind border of operculum and are provided with circular pupils. The eyes were proportionately larger in smaller individuals, the diameter of the eye is contained from 1.4 to 2.1 times in the length of the snout and from 1.7 to 2.4 in the inter-orbital distance. The least height of the caudal peduncle is contained from 1.2 to 1.4 times in its length. The mouth is small; its gape does not extend to below the eyes; it is horizontal with the opening obliquely directed upwards. The lips are fleshy and continuous at the angles of the mouth; the posterior lip is invariably produced into a median lobe and the post-labial groove is continuous. The condition of the lips varies considerably in different specimens irrespective of sex. The lips are thick and fleshy but not produced forward; the lower lip is slightly retroverted in the middle. There are two pairs of well-developed barbels; the maxillary are slightly longer than the rostral but are shorter than the diameter of the eye. The body is covered with large scales; there are 25 - 27 scales in a longitudinal series along the lateral line and 2½ rows between the lateral line and the base of the pelvic fin. The general lepidosis is not very different from that for the Putitor Mahaeer. There is a well developed scally appendage in the axil of each pelvic fin.

The dorsal fin commences opposite to or slightly in advance of the pelvics, and its position in relation to the tip of the snout and the base of the caudal fin varies with the size of the specimens, the last spine is strong and bony, and is invariably shorter than the depth of the body below it. The pectoral fins are low, slightly shorter or longer than the head, and are also sharp and do not extend to the anal opening. The caudal fin is deeply forked with both the lobes sharply pointed.

The colour of the lateral surface is somewhat goldish green, whereas ventral surface is silvery. The fins have no spots, but the dorsal ones are dotted. The eyes are silvery in colour with some dots above. The belly are of a reddish colour.

The head is variegated with patches of light orange above the gill opening. The lips and barbels are of a light yellowish colour. The dorsal fins are reddish buff while the pectorals, pelvics and anal fins are of deep orange colour.

iii) Tor putitora:

D. 4/8; P. 17-18; V. 1/8; A. 3/5; C. 19; Ll. 25-28; Ltr. 4/2.

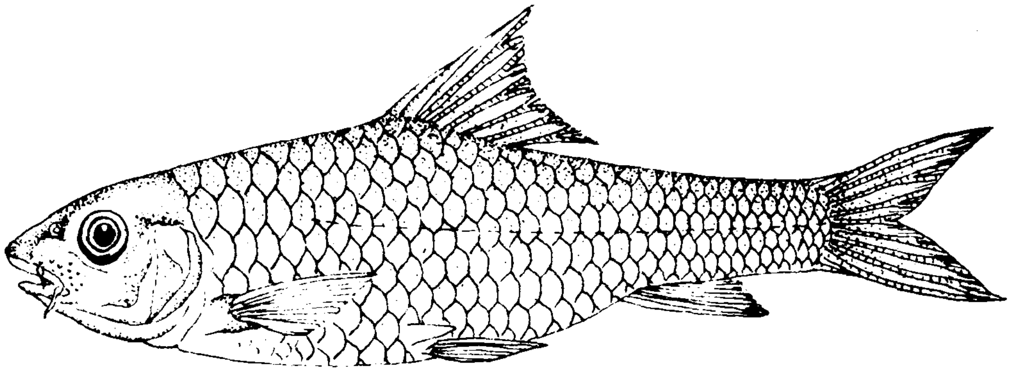
The Putitor Mahseer is generally oblong somewhat compressed, streamlined trout like fish in which both the profiles are gently and gracefully arched. The head is broadly pointed anteriorly and behind the anal fin the tail becomes considerably narrow. The length of the head is always considerably greater than the depth of the body, it is contained from 3.0 to 3.4 times in the standard length; the head is relatively longer in younger specimens. The depth of body is relatively greater in young individuals, it is contained from 1.1 to 1.4 times in the length of the head. The eyes are far forward and are provided with circular pupils; they are proportionally larger in the smaller individuals; the diameter of the eye is contained from 2.5 to 4.7 times in the length of the head.

The mouth is small, its gape does not extend to below the eyes; it is horizontal with the opening obliquely directed upwards. The lips are fleshy and continuous at the angles of the mouth; the posterior lip is produced into a median lobe and the post-labial groove is continuous. The condition of the lips varies greatly in individuals of different sizes and in those collected from different localities. There are two pairs of barbels which are more or less of equal length and are almost as long as the diameter of the eye.

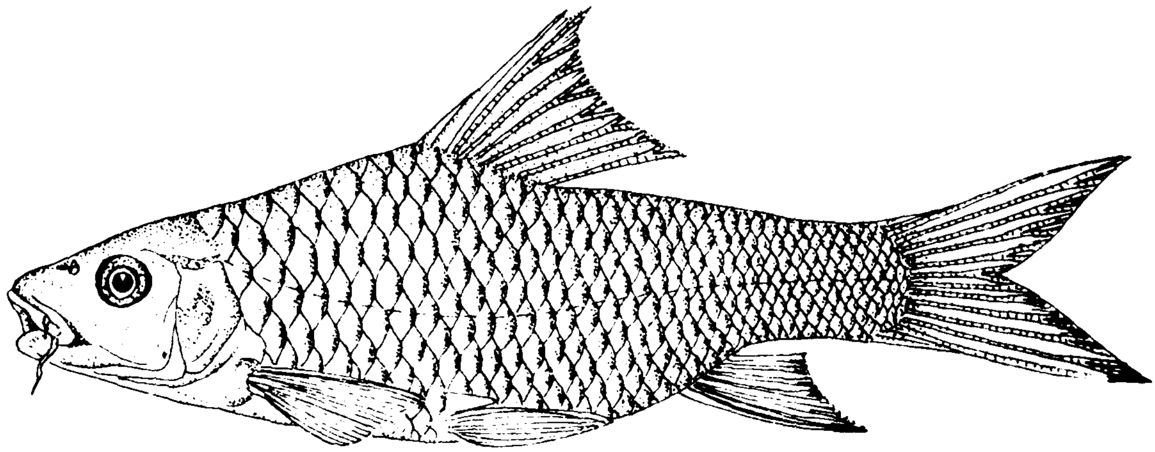
The body is covered with large scales; there are 25 to 28 scales in a longitudinal series along the lateral line; 2½ rows between the lateral line and the base of the pelvic fin; 4½ rows between the lateral and the base of the dorsal fin and 12 round the caudal peduncle. There is a well developed scaly appendage in the axil of the pelvic fin.

The commencement of the dorsal fin is opposite to that of the pelvics, and is almost midway between the tip of the snout and the base of the caudal fin. The last spine is very strong and bony, it is generally shorter than the depth of the body below it, but in some individuals it is equal to the body height. The pectoral fins are low, considerably shorter than the head and sharp above. The pelvic fins do not reach the anal opening. The anal fin does not extend to the base of the caudal fin. The caudal fin is sharply divided, with the lower lobe somewhat more pointed.

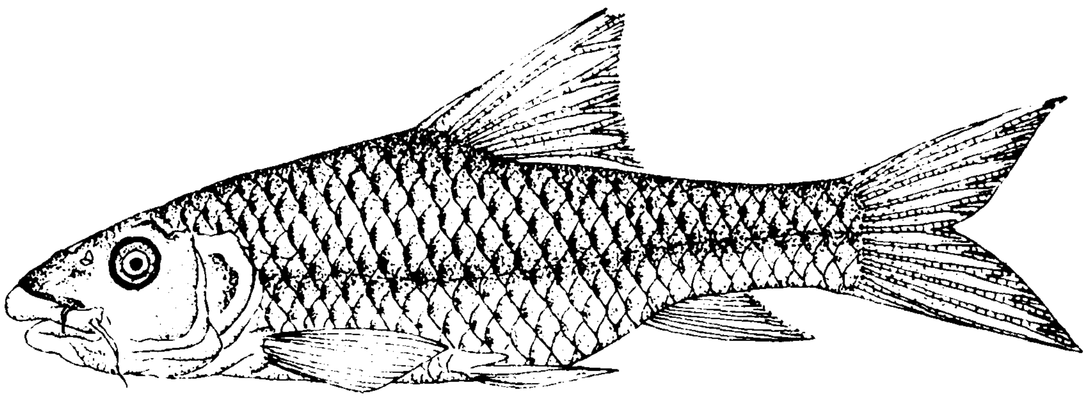
The colours vary considerably according to the nature of the water inhabited by the fish. The back is reddish sap green and along the sides above the lateral line there is a broad band with a purplish shadow throughout. Below the lateral line the body is light orange which fade into silvery white on the belly. The head below the level of the eyes is light buff yellow which is replaced ventrally by a light neutral tint. The iris is light green while the pupil is dark blue. The scales in the upper half of the body are marked anteriorly by reddish sap green colour while in the centre they are brilliantly orange coloured, their posterior edges are of peacock green in colour with shades of light and deep sap green anteriorly. The pectoral, pelvic, anal and caudal fins are peacock green in colour; the distal tip of the anal is marked with a patch of reddish orange, while the posterior border of the caudal fin is marked with reddish green. The tubes on the lateral line are greenish silvery.



Acrossocheilus hexagonolepis (McClelland)



Tor tor (Hamilton)



Tor putitora (Hamilton)

Fig. 2. Diagramatic representation of the three species of Mahseer.

SYNONYMS AND GEOGRAPHICAL DISTRIBUTION

i) *Acrossocheilus hexagonolepis* (McClelland):

1839 *Barbus hexagonolepis* McClelland, *Asiat. Res.*, 19, pp. 270, 271, 336, pl. 41, fig. 3; type locality: Upper Assam.

1878 *Barbus hexagonolepis* Day, *Fish. India*, p. 564, pl. 137, fig. 4.

1889 *Barbus hexagonolepis* Day, *Faun. Brit. Ind. Fish.*, 1, p. 305.

1913 *Barbus hexagonolepis* Chaudhuri, *Rec. Indian Mus.*, 8, p. 249; type locality: Abor Hills, Assam.

1935 *Barbus hexagonolepis* Hora and Mukerji, *Rec. Indian Mus.*, 37, p. 389; type locality: Naga-Hills, Assam.

1936 *Barbus hexagonolepis* Hora, *Rec. Indian Mus.*, 38, p. 318; type locality: Naga-Hills, Assam.

1937 *Barbus hexagonolepis* Hora, *Rec. Indian Mus.*, 39, p. 331.

1949 *Barbus hexagonolepis* Menon, *Rec. Indian Mus.*, 47, p. 233; type locality: Kakha nullah and Tamur river near Tribeni, E. Nepal.

1960 *Barbus hexagonolepis* De Witt, *Stansford Ichth. Bull.*, 7(4), p. 72; type locality: Nepal.

1940 *Barbus (Lissocheilus) hexagonolepis* Hora, *J. Bombay nat. Hist. Soc.*, 42(1), p. 78 text-figs. 1-4, pl.; Revision.

1940 Barbus (Lissocheilus) hexagonolepis Hora and Gupta, J. Asiat. Soc. Beng., (3) 6, p. 79; type locality: Kalimpong Duars and Siliguri Terai.

1878 Barbus dukai Day, Fish. India, p. 564, pl. 143. Fig. 3.

1889 Barbus dukai Day, Faun. Brit. Ind. Fish., 1, p. 306.

1937 Barbus (Lissocheilus) dukai Shaw and Shebbeare, J. Asiat. Soc. Beng., 3, p. 37, pl. 5, Fig. 6, text-fig. 3; type-locality: rivers and clear streams in the foot-hills, Terai and Duars, N. Bengal.

1913 Barbus hexastichus Chaudhuri, (nec. McClelland), Rec. Indian Mus., 8, p. 249; type locality: Abor Hills, Assam.

1921 Barbus hexastichus Hora, Rec. Indian Mus., 22, p. 186; type locality: Naga-Hills and Manipur Valley.

1924 Barbus hexastichus Hora, Rec. Indian Mus., 26, p. 27; type locality: Garo-Hills, Assam.

1974 Acrossocheilus hexagonolepis Menon, A check-list of fishes of the Himalayan and the Indo-Gangetic Plains. Special publication No. 1, CIFRI, Barrackpore, West Bengal, India.

Distribution: Eastern Himalayas and Assam, Burma, Thailand, Malaya and Sumatra (Menon, 1974).

ii) Tor tor (Hamilton):

1822 Cyprinus tor Hamilton, Fish. Ganges, pp. 305, 388; type-locality: R. Mahananda.

1834 Cyprinus tor Gray, Ill. Ind. Zool., 2, pl. 93, fig. 1 (from Hamilton's Ms. drawings).

1822 Cyprinus mosal Hamilton, Fish. Ganges, pp. 306, 388; type-locality: R. Kosi.

1830-32 Cyprinus mosal Gray, Ill. Ind. Zool., pl. 39, fig. 1 (from Hamilton's Ms. drawings).

1839 Barbus megalepis McClelland, Asiat. Res., 19, pp. 271, 337; type-locality: Northern parts of Bengal.

1834 Tor hamiltonii Gray, Ill. Ind. Zool., 2. pl. 36, fig. 1.

1842 Barbus mosal Valenciennes (in C. & V.) Hist. Nat. Poiss., 16, p. 200.

1853 Barbus mosal Bleeker, Verch. Bat. Gen., 25, p. 60.

1870 Barbus mosal Day, Proc. Zool. Soc. Lond., p. 372.

1868 Barbus mosal Gunther (in part), Cat. Fish. Brit. Mus., 7, p. 130.

1839 Barbus hexastichus McClelland, Asiat. Res., 19, 19, pp. 269, 333, pl. 39, fig. 2; type-locality: Great rivers in the plains of India.

1878 Barbus hexastichus Day, Fish. India, p. 565, pl. 136, fig. 4.

1889 Barbus hexastichus Day, Faun. Brit. Ind. Fish., 1, p. 308.

1929 Barbus hexastichus Prasad and Mukerjii, Rec. Indian Mus., 31, p. 200, text-fig. 7.

1921 Barbus hexastichus Hora, Rec. Indian Mus., 22, p. 174; type-locality: Manipur.

1878 Barbus tor Day (in part), Fish. India, p. 564.

1889 Barbus tor Day (in part), Faun. Brit. Ind. Fish., 1, p. 307.

1935 Barbus tor Hora and Mukherji, Rec. Indian Mus., 37, p. 383; type-locality: Naga-Hills.

1936 Barbus tor Hora and Mukherji, Rec. Indian Mus., 38, pp. 134, 139, fig. 1; type-locality: Eastern Doons.

1936 Barbus tor Hora, Rec. Indian Mus., 38, p. 326, figs. 5, 6; type-locality: R. Barak, between Nongba and Kalanoga, Naga-Hills.

1954 Barbus tor Mukherji, J. Bombay nat. Hist. Soc., 41, p. 784, pl. 1 and 11, Met. figs. 1-5; type-locality: Assam.

1941 Barbus (Tor) mosal Hora, J. Bombay nat. Hist. Soc., 41, p. 784, pl. 1 and 11, Met. figs. 1-5; type-locality: Assam.

1941 Barbus (Tor) tor Hora, J. Bombay nat. Hist. Soc., 41, p. 518, pl. 1, 2, 3, text-fig.

1919 Barbus putitora Annandale, Rec. Indian Mus., 16, p. 136, pl. 3, fig. 15.

1954 Tor tor Menon, Rec. Indian Mus., 52, p. 22; type-locality: Manipur State.

1839 *Barbus progeneius* McClelland, *Asiat. Res.* 19, pp. 270, 334, pl. 56, fig. 3; type-locality: Great rivers in the plains of India.

1936 *Barbus progeneius* Hora, *Rec. Indian Mus.*, 38, p. 328, figs. 7-9; type-locality: R. Barak, between Nongba and Kalanaga, Naga-Hills.

1942 *Barbus* (*Tor*) *progeneius* Hora, *J. Bombay nat. Hist. Soc.*, 42, p. 526, pl. and text-figs. 1-3; type-locality: Assam

1941 *Barbus* (*Tor*) *tor* Hora, *J. Bombay nat. Hist. Soc.* 41, p. 518.

1974 *Tor tor* Menon, A check-list of fishes of the Himalayan and the Indo-Gangetic plains. Special publication No. 1, CIFRI, Barrackpore, West Bengal, India.

Distribution: All along the Himalayas and Burma (Menon, 1974).

iii) *Tor putitora* (Hamilton)

1822 *Cyprinus putitora* Hamilton, Fish. Ganges, pp. 303, 388, type-locality: Eastern parts of Bengal.

1838 *Labeobarbus macrolepis* Heckel, *Fisch. Cashmir*, p. 60, pl. 10, Fig. 2; type-locality: Kashmir.

1839 *Barbus macrocephalus* McClelland, *Asiat. Res.*, 19, pp. 270, 335, pl. 55, fig. 2; type-locality: Rapids of the Upper Assam.

1842 *Barbus macrocephalus* Valeniciennes (in C. & V.), 16, p. 201.

1868 Barbus macrocephalus Gunther, Cat. Fish. Brit. Mus., 7, p. 131.

1936 Barbus putitora Hora and Mukherji, Rec. Indian 38, p. 141.

1937 Barbus putitora Shaw and Shebbeare, J. Asiat. Soc. Beng., 3, p. 39, fig. 35.

1939 Barbus putitora Hora, Rec. Indian Mus., 39, p. 44; type-locality: Nepal.

1960 Barbus putitora De Witt, Stanford Ichth. Bull., 7(4), p. 73, type-locality: Phewa Tal, Pokhara, Nepal.

1939 Barbus (Tor) putitora Hora, J. Bombay nat. Hist. Soc., 41(2), p. 272, 2 pls. and 2 figs.

1949 Barbus (Tor) putitora Menon, Rec. Indian Mus., 47, p. 233; type-locality: Kokha nullah, Chhatra, E. Nepal.

1939 Barbus (Tor) putitora Hora, J. Bombay nat. Hist. Soc., 41, 272-85.

1878 Barbus tor Day (in part), Fish. India, p. 564, pl. 136, fig. 5, pl. 140, fig. 1.

1889 Barbus tor Day (in part), Faun. Brit. Ind. Fish., 1, p. 307, fig. 307.

1868 Barbus mosal Gunther (in part), Cat. Fish. Brit. Mus., 7, p. 130.

1954 Tor putitora Menon, Rec. Indian Mus., 52 p. 22; type-locality: Nepal.

1974 Tor putitora Menon, A check-list of fishes of the Himalayan and the Indo-Gangetic plains. Special publication No. 1, CIFRI, Barrackpore, West Bengal, India.

Distribution: All along the Himalayas including Kashmir (Menon, 1974).

VERNACULAR NAMES

i) Acrossocheilus hexagonolepis

Assamese	Boka or Bokar and Boolooah
Bengali	Bhorkol and Buluk
Lepcha	Mirpania
Mechi	Kantasi
Nepali	Katli
Garo	Narong
Khasi	Khasaw

ii) Tor

Assamese	Burapatra, Junga Peetia
Hindi	Naharn
Panjabi	Kukliah
Sindi	Kurreah
Tamil	Kendi, Bom-min
Canarese	Peruval, Harchminu
Malayalam	Meruval
Marathi	Kadehi, Masta
Ceylonese	Kuriah, Lela
Garo	Narem
Khasi	Kha-kulai (Tor tor)
	Kha-lad (T. putitora)

MATERIALS AND METHODS

MATERIALS AND METHODS

MATERIALS:

The materials for the present study pertains to the specimens of *Acrossocheilus hexagonolepis*, *Tor tor* and *Tor putitora* (Fig. 1) collected from River Simsang, situated in the East Garo Hills, Meghalaya (Latitude 25°30'N, Longitude 90°40'E and Altitude 1138 feet above sea level) during the period August 1978 through July 1980. Specimens of *A. hexagonolepis* were also collected from River Pagladia, Assam (Latitude 27.40'N, Longituded 91°28'E, Altitude 500 feet above sea level) during July 1978 (Fig. 2).

METHODS:

Collections were made mostly at fortnightly intervals. Prior to fixing in formalin, total length from the tip of the snout to the tip of the tail were measured to the nearest 0.1 mm. Total weights have also been recorded to the nearest 0.1 gm in a double pan physical balance, whereas for smaller specimens, a chemical balance has been used.

BIOLOGICAL PARAMETERS:

The study is based on the examination of 519 specimens of *Acrossocheilus hexagonolepis* in the size range of 76.5 to 448.0 mm, 256 specimens of *Tor tor* in the size range of 85.0 to 355.0 mm and 78 specimens of *T. putitora* in the size range of 85.0 to 335.0 mm.

The following biological parameters were studied.

a) Morphometric measurements; b) Meristic character; c) Length-weight relationship; d) Condition factor; e) Maturity, spawning cycle and spawning frequency; f) Fecundity; and g) Food and feeding habits.

However, all the above mentioned parameters could not be studied in *T. tor* and *T. putitora* mainly because sexually matured specimens were not available in the catch.

The following methods were adapted for studying the biological parameters selected in the present investigation:

MORPHOMETRIC MEASUREMENTS:

Dividers and measuring board, having graduations in millimeter have been used for various measurements. The following morphometric measurements have been undertaken according to methods described by Lowe - McConnell (1971).

Total length: Total length has been measured from the tip of the snout to the end of the tail fin.

Standard length: It is the greatest length of the fish from the tip of the snout (mouth closed) to the hidden base of the median tail fin rays (where these meet the median hypural plate).

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

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

Snout length: Distance from the tip of the snout to the front margin of the snout.

Eye diameter: Distance from the anterior to the posterior free orbital rim of the eye.

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

Inter-orbital width: The least bony width from orbit to orbit.

Length of upper jaw: Distance from the anterior most point of the premaxillary to the posterior point of the maxillary.

Gape: Distance between the upper and lower jaw with the mouth widely open.

Length of the barbels: The length of the barbels has been measured from the base to the proximal end of the barbels.

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

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

Least height of the body: The shortest vertical distance between the dorsal and the ventral surface of the caudal peduncle.

Length of the caudal peduncle: Oblique distance from the base of the posterior end of the anal fin to the hidden base of the median caudal fin rays (where these meet the median hyperal plate).

<u>Length of the dorsal fin</u>: Distance between the anterior and posterior end of the dorsal fin taken along the base.

<u>Length of free margin of dorsal fin</u>: Distance from the anterior to posterior end of the dorsal fin taken along the free margin.

<u>Height of dorsal fin</u>: Height of the longest fin ray of the dorsal fin.

<u>Height of pectoral fin</u>: Height of the longest fin ray of the pectoral fin.

<u>Height of the ventral fin</u>: Height of the longest fin ray of the ventral fin.

<u>Height of the anal fin</u>: Height of the longest fin ray of the anal fin.

<u>Length of the base of the anal fin</u>: Distance between the anterior and posterior end of the anal fin taken along the base.

<u>Girth</u>: Circumference of the body at its deepest point.

BIOMETRIC INDEX

The number of times each character went into the reference length of the fish was considered as the Biometric Index (Tobor, 1974). The characters taken were: Head length (H.L), Inter-orbital length (I.O.L), Eye-diameter (E.D), Gape (G), and Girth. For each characters a mean index for each 50.0 mm length group has been calculated to see whether it is constant or varying with the increase in total length. Biometric index was calculated for all the three species, viz., A. hexagonolepis, T. tor, and T. putitora.

MERISTIC CHARACTERS:

The following meristic counts were made according to methods as outlined by Lowe-McConnell (1971).

a) Number of rays in the dorsal fin; b) Number of rays in the pectoral fin; c) Number of rays in the ventral fin; d) Number of rays in the anal fin; e) Number of rays in the caudal fin; f) Number of lateral line scales; It represents the number of pored scales on the lateral line. The count was taken from the scale in contact with the shoulder girdle, to the structural caudal base; and g) Number of 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 measurements and counts were made on the left side of the fish. The specimens of all the three species taken up for the present study were grouped into 50.0 mm length groups for convenience sake by pooling the data together, viz., Group I: 50.0 - 100.0 mm, Group II; 101 - 150 mm and so on. However, only 8 groups of

A. hexagonolepis, 5 groups of *T. tor* and 4 groups of *T. putitora* could be made.

The regression method has been applied in various morphometric parameters with the formula:-

$$Y = a + bx$$

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

$$b = \frac{xy - N\bar{x}\bar{y}}{x^2 - N\bar{x}^2}, \quad a = \bar{y} - b\bar{x}$$

where N = total number of length groups, $\bar{x}$ = mean of 'x' and $\bar{y}$ = mean of 'Y'.

All linear measurements were made to the nearest 0.1 mm, then converted to a percentage of the standard length. Mean, range and 'b' values were tabulated and compared.

LENGTH-WEIGHT RELATIONSHIP:

Length-weight relationship in fishes can usually or always be adequately represented by the following equation (LeCren, 1951):

$$W = aL^b;$$

where W = weight of the fish; L = Total length of the fish and 'a' and 'b' are constant. The equations have been transformed into the following logerithmic form:

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

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

The length-weight relationship during the present investigation was studied taking the intact weight of the fish i.e. including gut and gonad and also the eviscerated weight i.e. excluding gut and gonad, into consideration.

The observed average weight was plotted against the observed average length to examine the nature of parabola. On converting the values to logerithms, the exponential relationship has been examined, obtained from 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 into several length groups at 5.0 mm interval. In case of A. hexagonolepis and T. tor, the relationship was calculated for male, female and juvenile separately and also for different seasons, viz., summer (March to June), monsoon (July to October) and winter (November to February). In case of T. putitora the length-weight relationship has been studied irrespective of sex, size or season, because of unavailability of sufficient number of specimens in the collections.

Condition Factor:

Individual variations from general length-weight relationships have been studied under the general name "condition" (Le Cren, 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, this factor has been determined by using the following formula (Hile, 1936).

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

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

Le Cren (1951) reviewed the method and recommended a study of "Relative Condition" (Kn) in preference to the ponderal index or condition factor (K), as in the former, the effect of length and other correlated factors are eliminated and hence the relative condition (Kn) has also been taken into consideration and calculated by the following formula:

$$Kn = \overset{o}{W}/\hat{W}$$

where, $\overset{o}{W}$ = the observed weight and $\hat{W}$ = 'expected' weight for the observed length.

In the present study fluctuations in condition were examined at different length groups of the fish as well as during different months. For this, the mean 'K' and 'Kn' were calculated separately for each 50.0 mm length group as well as for all the length groups combined together during different months.

MATURITY AND SPAWNING

Maturity: The maturity study is based on the examination of 488 specimens of *A. hexagonolepis*. After recording all necessary details, specimens were disected and gonads were carefully taken out from the body cavity. Their maturity stages were determined following the key as outlined by Kesteven (1960) based on the appearance and size of the gonads:

I. Virgin: Very small sexual organs close under the vertibral column. Testes and ovaries transparent, colourless to gray. Eggs invisible to naked eye.

II. Maturing Virgin: Testes and ovaries translucent, grey-red. Length half, or slightly more than half, the length of ventral cavity. Single eggs can be seen with magnifying glass.

III. Developing: Testes and ovaries opaque, reddish with blood capillaries. Occupy about half of ventral cavity. Eggs visible to the naked eye as whitish granules.

IV. Developing: Testes reddish-white. No milt-drops appear under pressure. Ovaries orange reddish. Eggs clearly 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. Spawning/Spent: Not yet fully empty. No opaque eggs left in ovary.

VIII. Spent: Testes and ovaries empty, red. A few eggs in the state of re-absorption.

II. Recovering spent: Testes and ovaries, grey-red. Length half, or slightly more than half, the length of ventral cavity. Single eggs can be seen with magnifying glass.

Spawning: The spawning frequency has been studied according to the following classification described by Hickling and Rotenberg (1936), Walford (1932), and Qasim and Qayyum (1961), which has been classified into the following four types:-

I. Spawning takes place only once a year during a short period of definite duration. In fishes, belonging to this category, the mature ovary contains mature ova distinctly separated from the immature stock.

II. Spawning takes place once a year, but with a longer duration. In species showing this type of spawning, the range in size of mature ova, irrespective of the number of modes representing them, has been found to be nearly half of the total range in size of the entire intra-ovarian eggs.

III. Spawning takes place twice a year. In the ovaries of fishes exhibiting this type of spawning, in addition to the batch in ripe condition, another batch of eggs which has undergone more or less half the process of maturation, becomes apparent.

IV. Spawning extends over a long period, but intermittently. In this category, the different batches of eggs in the ovary are not sharply differentiated from one another, thereby indicating that the passing of one batch of eggs into the next stage is a continuous process.

Ova diameter study:

For ova diameter study, measurements of ova were taken from the 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 sample of over 100 ova was taken from each ovary by separating them out from the tissue. These were arranged in several rows on a glass slide and the diameters of the individual ova were measured with the help of an ocular micrometer. The diameter of ova along whatever axis they lay parallel to the graduations of the micrometer, were measured to ensure random nature of the readings and unbiased values as suggested by Clark (1934).

Gonado-somatic index:

The gonads were weighed to the nearest 0.1 gramme prior to fixing the same in formaline for further studies. Weights of gonads were taken on a chemical balance. In order to study the condition of gonads, Nikolsky (1963) advocated the use of "Coefficient of maturity" also known as maturity index or gonado-somatic index (Gn.S.I) which expresses the weight of gonad as a percentage of total weight and has been calculated according to the following formula (Hodgkiss and Mann, 1978).

$$\text{Gonado-somatic index (Gn.S.I)} = \frac{\text{Gonad Weight} \times 100}{\text{Total Body Weight (gms)}}$$

FECUNDITY:

Ovaries from mature specimens collected just before spawning, only were used for fecundity studies. Altogether 12 formalin preserved ovaries from A. hexagonolepis of known length and weight were studied. Preserved ovaries were taken out and dried off the excess moisture with the help of a blotting paper and then weighed. From each ovary, two sub-samples of about one gram each were taken. The number of ova contained in these samples were counted. The absolute fecundity was calculated by using the formula:

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

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-sample. To test the accuracy of the method, actual counting of total number of ova in two fishes was done and the same was found to stay in close arrangement to the observed values of fecundity.

Apart from absolute fecundity, relative fecundity has also been calculated according to the following formula (Hardisty, 1964).

$$\text{Relative fecundity} = \frac{\text{Total number of eggs in the ovary}}{\text{Body weight}}$$

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

$$\text{Log } Y = \text{Log } a + b \text{ Log } x$$

FOOD AND FEEDING HABITS:

Food and feeding habits of the fish during the present study were studied by examining a total of 247 guts for *A. hexagonolepis*, 166 guts for *T. tor* and 53 guts for *T. putitora*.

Soon after the collection, specimens were dissected and digestive tracts were carefully taken out from the body cavity and preserved in 5% formalin. In the case of smaller specimens, the whole fish was directly preserved but before placing them into preservative they were killed in order to prevent them from regurgitating their stomach contents.

Preserved guts were uncoiled, cleaned of the attached tissues and their weights and lengths were recorded. They were then cut open and the contents were scrapped out into petridish. Weights of emptied guts were also recorded. The scrapped out contents of guts were studied under a compound microscope and identified as far as possible upto generic level except in the cases where the state of digestion rendered it difficult to do so.

For analysing the data, the entire length range of the examined specimens was arbitrarily split into size groups of 50.0 mm class interval to observe whether these demarcated size groups were discrete in their choice of food. The gut contents were also analysed for elucidating seasonal variations in the diet components. The following methods were employed to study the food and feeding habits:

Volumetric method: The volume of individuals of each food items in each gut has been determined by "eye estimation" method (Pillay, 1952). These were summed to enumerate total volume for each kind of food items in the whole sample and then a grand total of volume of all the items was made. The quotient of these gave the percentage representation by volume of each type of food item.

Numerical method: The number of individuals of each food items in each gut has been counted. These were summed to enumerate totals for each kind of food item in the whole sample, and then a grand total of all the item was made.

The quotient of these gave the percentage representation by number of each type of food item (Hynes, 1950).

Gastro-somatic index: The Gastro-somatic index was calculated by the following formula (Bhatnagar and Karamchandani, 1970)

$$G.S.I. = \frac{\text{Gut content weight}}{\text{Body weight}} \times 100$$

Relative length of the gut: The ratio between the gut length and total length (R.L.G.) has been estimated by dividing the gut length by total length of the body (Al-Hussaini, 1949).

Regression method was applied to gut length and body length of the fish and between weight of gut content and length of the fish to describe the relation between them.

RESULTS

RESULTS

MORPHOMETRIC AND MERISTIC COUNTS

MORPHOMETRIC AND MERISTIC COUNTS OF *A. HEXAGONOLEPIS*

MORPHOMETRY:

The results obtained on morphometric measurements of *A. hexegonolepis* from Simsang River and Pagladia River have been presented in Table 1 and summarised below:

Total length: The mean value of total length expressed as percentage of standard length, was found to be 131.23 and 132.38 for the specimens from Simsang and Pagladia Rivers respectively.

Fork length: The mean value of fork length expressed as percentage of standard length was found to be 114.59 and 114.56 for the specimens from Simsang and Pagladia Rivers respectively.

Predorsal length: The mean value of predorsal length expressed as percentage of standard length was found to be 52.01 and 53.17 respectively for Simsang and Pagladia River specimens.

Head length: The mean value of head length expressed as percentage of standard length was found to be 26.45 and 27.50 respectively for Simsang and Pagladia River specimens.

Head depth: The mean value of head depth expressed as percentage of standard length was found to be 18.93 and 20.85 in the individuals from the Simsang and Pagladia

Rivers respectively.

Body depth: The mean value of body depth expressed as percentage of standard length was found to be 29.30 and 30.42 respectively for Simsang and Pagladia River specimens.

Least height of caudal peduncle: The mean value of the least height of caudal peduncle expressed as percentage of standard length was found to be 12.30 and 12.52 respectively for Simsang and Pagladia River specimens.

Length of caudal peduncle: The mean value of the length of caudal peduncle expressed as percentage of standard length was found to be 17.86 and 17.92 respectively for Simsang and Pagladia River specimens.

Dorsal fin length: The mean value of dorsal fin length expressed as percentage of standard length was found to be 16.17 and 15.16 respectively for Simsang and Pagladia River specimens.

Length of free margin of dorsal fin: The mean value of the length of free margin of dorsal fin expressed as percentage of standard length was found to be 18.68 in the individuals from the Simsang River and 21.00 in the specimens from Pagladia River.

Dorsal fin height: The mean value of the dorsal fin height expressed as percentage of standard length was found to be 23.02 and 22.92 respectively for Simsang and Pagladia River specimens.

Pectoral fin height: The mean value of pectoral fin height expressed as percentage of standard length was found to be 21.11 and 20.80 respectively for Simsang and Pagladia River specimens.

Ventral fin height: The mean value of ventral fin height expressed as percentage of standard length was found to be 18.47 and 19.13 respectively for Simsang and Pagladia River specimens.

Anal fin height: The mean value of the anal fin height expressed as percentage of standard length was found to be 19.80 and 19.71 respectively for Simsang and Pagladia River specimens.

Length of Anal fin base: The mean value of the length of anal fin base expressed as percentage of standard length was found to be 8.12 and 8.23 respectively for Simsang and Pagladia River specimens.

Girth: The mean value of girth expressed as percentage of standard length was found to be 74.65 and 75.63 respectively for Simsang and Pagladia River specimens.

Snout length: The mean value of the snout length expressed as percentage of head length was found to be 41.31 and 38.17 respectively for Simsang and Pagladia River specimens.

Eye diameter: The mean value of eye diameter expressed as percentage of head length was found to be 21.21 and 24.13 respectively for Simsang and Pagladia River specimens.

Post-orbital head length: The mean value of the post-orbital head length expressed as percentage of head length was found to be 46.87 and 46.30 respectively for Simsang and Pagladia River specimens.

Inter-orbital distance: The mean value of the inter-orbital distance expressed as percentage of head length was found to be 13.14 and 13.23 respectively for Simsang and Pagladia River specimens.

Length of upper jaw: The mean value of the length of upper jaw expressed as percentage of head length was found to be 29.92 and 29.06 respectively for Simsang and Pagladia River specimens.

Gape: The mean value of the gape expressed as percentage of head length was found to be 36.11 and 32.75 respectively for Simsang and Pagladia River specimens.

Rostral barbel length: The mean value of the rostral barbel length expressed as percentage of head length was found to be 29.09 and 32.51 respectively for Simsang and Pagladia River specimens.

Maxilary barbel length: The mean value of the maxilary barbel length expressed as percentage of head length was found to be 37.57 and 38.91 respectively for Simsang and Pagladia River specimens.

Table 1: Morphometric analysis of *A. hexagonolepis*

Parameters	(Simsang River) % standard length Mean	Range	(Pagladia River) % standard length Mean	Range
Total length	131.23	122.18 - 153.31	132.38	127.38 - 134.74
Fork length	114.59	104.35 - 133.13	114.56	110.19 - 117.03
Predorsal length	52.01	47.43 - 39.35	53.17	49.36 - 66.81
Head length	26.45	24.32 - 30.23	27.50	26.51 - 28.57
Head depth	18.93	15.65 - 20.65	20.85	19.10 - 20.96
Body depth	29.30	26.81 - 33.41	30.42	28.71 - 31.62
Least height of caudal peduncle	12.30	11.41 - 13.76	12.52	11.46 - 13.53
Length of caudal peduncle	17.86	16.26 - 21.13	17.92	16.13 - 19.21
Dorsal fin length	16.17	14.63 - 18.43	15.16	14.64 - 16.14
Length of free margin of dorsal fin	18.68	15.83 - 21.77	21.00	19.06 - 23.14
Dorsal fin height	23.02	18.59 - 25.93	22.92	19.10 - 26.03
Pectoral fin h height	21.11	19.11 - 24.77	20.80	19.21 - 22.28
Ventral fin height	18.47	16.33 - 22.39	19.13	17.51 - 21.83
Anal fin height	19.80	17.61 - 24.26	19.71	17.53 - 22.52
Anal fin base	8.12	6.91 - 9.33	8.23	6.80 - 9.00
Girth	74.65	66.38 - 84.12	75.63	66.85 - 87.31
Parameters	**% Head length Mean**	**Range**	**% Head length Mean**	**Range**
Snout length	41.31	36.95 - 50.30	38.17	35.71 - 41.53
Eye diameter	21.21	18.67 - 41.05	24.13	17.46 - 36.50
Post-orbital head length	46.87	45.86 - 48.46	46.30	43.00 - 47.61
Inter-orbital length	13.14	11.69 - 14.51	13.23	11.81 - 14.62
Length of Upper jaw	29.92	27.39 - 30.80	29.06	26.20 - 33.33
Gape	36.11	34.72 - 43.85	32.75	22.22 - 46.00
Rostral barbel length	29.09	28.33 - 31.55	32.51	28.57 - 39.91
Maxilary barbel length	37.57	30.86 - 42.61	38.91	33.33 - 44.20

MERISTIC COUNTS:

The details of the meristic counts for *A. hexagonolepis* from River Simsang and River Pagladia are presented in Table 2 and summarised below.

Number of dorsal fin rays: The number of dorsal fin rays was found to be constant (4/9) in the specimens collected from both the rivers.

Number of pectoral fin rays: The mean value of the number of pectoral fin rays was found to be 15.01 and 15.83 respectively for Simsang and Pagladia River specimens.

Number of ventral fin rays: The mean value of the number of ventral fin rays was found to be 8.90 and 9.00 (constant) respectively for Simsang and Pagladia River specimens.

Number of anal fin rays: The number of anal fin rays was found to be constant (3/5) in the specimens collected from both the rivers.

Number of caudal fin rays: The number of caudal fin rays was found to be constant (19) in the specimens collected from both the rivers.

Number of lateral line scales: The mean value of the number of lateral line scales was found to be 26.01 and 24.76 respectively for Simsang and Pagladia River specimens.

Number of lateral line transverse scales: The number of lateral line transverse scales was found to be constant

Table 2: Meristic characters of *A. hexagonolepis*

Parameters	Simsang River		Pagladia River	
	Mean	Range	Mean	Range
No. of dorsal fin rays	4/9	4/9 (Const.)	4/9	4/9 (Const.)
No. of pectoral fin rays	15.01	13 - 16	15.83	15 - 16
No. of ventral fin rays	8.90	8 - 9	9.00	9 (Const.)
No. of anal fin rays	3/5	3/5 (Const.)	3/5	3/5 (Const.)
No. of caudal fin rays	19	19 (Const.)	19	19 (Const.)
No. of lateral line scales	26.01	23 - 28	24.76	23 - 27
No. of lateral line transverse scales	4/3	4/9 (Const.)	4/3	4/3 (Const.)

Table 3: Regression equations of morphometric parameters of *A. hexagonolepis* from Simsang River

Parameters	Regression equations	Correlation Coefficient 'r'
Total length (Y) on standard length (X)	Y = 9.0671 + 1.2615 X	0.9857
Fork length (Y) on standard length (X)	Y = 2.5862 + 1.1334 X	0.9881
Predorsal length (Y) on standard length (X)	Y = 3.1468 + 0.5020 X	0.9887
Head length (Y) on standard length (X)	Y = 0.0605 + 0.2645 X	0.9902
Snout length (Y) on standard length (X)	Y =-0.2696 + 0.1108 X	0.9362
Eye diameter (Y) on standard length (X)	Y =-40.9394+ 0.3521 X	0.7287
Interorbital distance (Y) on standard length (X)	Y =-1.8669 + 0.1430 X	0.9900
Gape (Y) on standard length (X)	Y = 4.0964 + 0.0742 X	0.9572
Rostral barbel length (Y) on standard length (X)	Y = 13.3689+ 0.0282 X	0.9990
Head depth (Y) on standard length (X)	Y =-0.6050 + 0.1918 X	0.9739
Body depth (Y) on standard length (X)	Y = 1.2687 + 0.2863 X	0.9898
Length of caudal peduncle (Y) on standard length (X)	Y =-2.8358 + 0.1968 X	0.9817
Dorsal fin length (Y) on standard length (X)	Y = 1.9255 + 0.1506 X	0.9836
Dorsal fin height (Y) on standard length (X)	Y = 7.6677 + 0.1817 X	0.9730
Pectoral fin height (Y) on standard length (X)	Y =-185.9621+1.1810 X	0.9848
Anal fin height (Y) on standard length (X)	Y =-0.9038 + 0.2041 X	0.9791
Anal fin base (Y) on standard length (X)	Y =-0.4286 + 0.0838 X	0.9791
Girth (Y) on standard length (X)	Y = 3.7765 + 0.7244 X	0.9869

Table 4: Regression equations of morphometric parameters of *A. hexagonolepis* from Simsang River and Pagladia River

Parameters	Simsang River		Pagladia River	
	Regression equations	Correlation coefficient	Regression equations	Correlation coefficient
Snout length (Y) on standard length (X)	Y = - 0.2696 + 0.1108 X	0.9362	Y = 0.6199 + 0.1101 X	0.9852
Eye diameter (Y) on standard length (X)	Y = -40.9394 + 0.3521 X	0.7287	Y = -35.7877 + 0.4075 X	0.6311
Gape (Y) on standard length (X)	Y = 4.0964 + 0.0742 X	0.9572	Y = 3.0058 + 0.0693 X	0.7765
Rostral barbel length (Y) on standard length (X)	Y = 13.3689 + 0.0282 X	0.9990	Y = 3.5410 + 0.2392 X	0.9759
Head depth (Y) on standard length (X)	Y = -0.6050 + 0.1918 X	0.9739	Y = 0.1063 + 0.2066 X	0.9852

Table 5: Morphometric parameters having maximum difference between the specimens of **A.** hexagonolepis from Simsang River and Pagladia River

Parameters	S_1 (% Standard length)	Standard deviation	S_2 (% Standard length)	Standard deviation
Head depth	18.93	18.72	20.85	13.55
Snout length	41.32	11.32	38.18	6.57
Eye diameter	21.21	45.95	24.14	41.72
Gape	36.11	7.37	32.76	5.77
Rostral barbel length	29.10	7.17	32.51	4.18
Number of lateral line scales*	26.01	0.41	24.76	0.80

Note : * Statistically significant difference has been observed in this parameter

S_1 System 1 (Simsang River)

S_2 System 2 (Pagladia River).

(4/3) in the specimens collected from both the rivers.

REGRESSION EQUATIONS AND STUDENTS' 'T' TEST:

The regression equations for various morphometric parameters studied for A. hexagonolepis from Simsang River have been presented in Table 3. Regression equations for morphometric parameters having maximum difference between the specimens collected from Simsang and Pagladia Rivers have been presented in Table 4.

Students' 'T' test was applied to the parameters having maximum difference between the specimens collected from Simsang and Pagladia River (Head depth, snout length, eye dimeter, gape, rostral barbel length, and number of lateral line scales). Out of these parameters statistically significant difference (at 5% level) has been observed only in case of number of lateral line scales (Table 5).

MORPHOMETRY AND MERISTIC COUNTS OF T. TOR

MORPHOMETRY:

The details of morphometric measurements of T. tor from Simsang River have been presented in Table 7 and summarised below.

Total length: The mean value of the total length expressed as percentage of standard length was found to be 131.51.

Fork length: The mean value of the fork length expressed as percentage of standard length was found to be 112.39.

Predorsal length: The mean value of predorsal length expressed as percentage of standard length was found to be 53.72.

Head length: The mean value of head length expressed as percentage of standard length was found to be 27.72.

Head depth: The mean value of the head depth expressed as percentage of standard length was found to be 19.61.

Body depth: The mean value of the body depth expressed as percentage of standard length was found to be 30.33.

Least height of caudal peduncle: The mean value of the least height of caudal peduncle expressed as percentage of standard length was found to be 12.37.

Length of caudal peduncle: The mean value of the length of caudal peduncle expressed as percentage of standard length was found to be 16.45.

Dorsal fin length: The mean value of the dorsal fin length expressed as percentage of standard length was found to be 14.64.

Length of free margin of dorsal fin: The mean value of the length of free margin of dorsal fin expressed as percentage of standard length was found to be 18.22.

Dorsal fin height: The mean value of the height of dorsal fin expressed as percentage of standard length was found to be 26.05.

Pectoral fin height: The mean value of the pectoral fin height expressed as percentage of standard length was found to be 21.51.

Ventral fin height: The mean value of the ventral fin height expressed as percentage of standard length was found to be 19.53.

Anal fin height: The mean value of the anal fin height expressed as percentage of standard length was found to be 21.69.

Length of anal fin base: The mean value of the length of the anal fin base expressed as percentage of standard length was found to be 7.68.

Girth: The mean value of the girth expressed as percentage of standard length was found to be 74.31.

Snout length: The mean value of the snout length expressed as percentage of head length was found to be 39.78.

Eye diameter: The mean value of the eye diameter expressed as percentage of head length was found to be 21.31.

Post-orbital head length: The mean value of the post-orbital head length expressed as percentage of head length was found to be 44.17.

Inter-orbital distance: The mean value of the inter-orbital distance expressed as percentage of head length was found to be 47.17.

Table 6: Morphometric analysis of the male and female of the three species

Parameters	*A. hexagonolepis*		*T. tor*		*T. putitora*	
	% Standard length					
	Male	Female	Male	Female	Male	Female
Total length	128.94	127.64	159.83	132.57	132.43	133.23
Fork length	112.79	112.42	113.66	111.79	114.18	115.21
Predorsal length	50.96	51.50	54.46	58.06	54.05	54.80
Head length	26.16	26.11	29.32	26.86	31.75	32.00
Head depth	19.51	20.53	21.31	19.50	19.59	19.79
Body depth	27.94	27.22	30.78	30.19	25.00	25.23
Least height of caudal peduncle	12.00	12.58	13.75	12.26	11.48	11.63
Length of caudal peduncle	17.65	16.90	15.48	16.76	16.21	17.31
Length of dorsal fin	16.29	17.00	15.75	14.91	14.86	15.05
Length of free margin of dorsal fin	17.72	16.79	20.40	16.97	19.59	19.89
Height of dorsal fin	22.51	19.64	28.32	25.27	25.00	25.36
Height of pectoral fin	21.08	19.85	22.31	20.72	20.94	21.25
Height of ventral fin	18.94	17.16	20.03	18.98	19.59	20.11
Height of anal fin	18.94	19.95	21.58	21.15	20.94	20.13
Anal fin base	8.29	7.16	7.92	7.19	7.43	7.53
Girth	71.62	75.88	66.48	66.63	67.56	68.17
	% Head length					
Snout length	38.52	37.70	36.64	39.96	34.04	34.50
Eye diameter	24.45	23.79	24.80	20.37	17.02	17.36
Post-orbital length	46.44	47.17	42.85	45.47	51.06	51.16
Inter-orbital length	47.54	46.57	45.96	47.63	38.29	38.51
Length of upper jaw	28.41	29.43	24.80	26.77	31.91	32.05
Gape	36.88	42.94	35.71	38.77	40.42	40.53
Rostral barbel length	27.04	28.72	30.12	30.90	21.27	21.47
Maxillary barbel length	30.19	34.27	34.47	24.25	34.04	35.32

Table 7: Morphometric analysis of *T. tor* and *T. putitora*

Parameters	(*T. tor*) % Standard length Mean	Range	(*T. putitora*) % Standard length Mean	Range
Total length	131.51	128.37 - 133.29	131.32	129.65 - 137.64
Fork length	112.39	110.72 - 114.02	112.24	111.88 - 115.32
Predorsal length	53.72	53.12 - 54.32	52.89	52.07 - 56.10
Head length	27.72	26.58 - 29.21	31.34	29.03 - 31.99
Head depth	19.61	17.72 - 20.56	18.46	17.73 - 23.36
Body depth	30.33	28.68 - 31.35	25.65	24.52 - 29.01
Least height of caudal peduncle	12.37	11.43 - 13.08	11.18	10.22 - 13.05
Length of caudal peduncle	16.45	15.74 - 18.22	17.44	15.45 - 18.29
Dorsal fin length	14.64	13.50 - 15.61	13.74	13.39 - 15.17
Length of free margine of dorsal fin	18.22	16.03 - 19.22	19.29	17.89 - 21.13
Dorsal fin height	26.05	24.05 - 28.58	24.05	22.83 - 28.57
Pectoral fin height	21.51	21.09 - 22.46	20.24	19.62 - 24.85
Ventral fin height	19.53	18.98 - 20.88	17.83	17.73 - 21.87
Anal fin height	21.69	21.04 - 22.36	21.05	18.92 - 23.36
Anal fin base	7.68	7.17 - 7.88	7.69	6.62 - 8.92
Girth	74.31	70.75 - 76.89	61.87	59.05 - 73.36

Parameters	% Head length Mean	Range	% Head length Mean	Range
Snout length	39.78	37.18 - 40.86	32.24	31.81 - 32.32
Eye diameter	21.31	19.04 - 26.35	19.03	17.95 - 21.95
Post-orbital head length	44.17	41.17 - 45.97	48.61	44.18 - 49.46
Inter-orbital distance	47.17	45.84 - 46.03	36.30	32.11 - 38.18
Length of upper jaw	26.37	25.49 - 27.49	25.59	24.87 - 27.00
Gape	37.80	35.81 - 37.90	31.02	30.79 - 33.20
Rostral barbel length	31.20	31.04 - 33.74	24.62	23.26 - 26.23
Maxillary barbel length	34.06	31.74 - 35.40	25.73	23.42 - 27.48

Length of upper jaw: The mean value of the length of upper jaw expressed as percentage of head length was found to be 26.37.

Gape: The mean value of the gape epressed as percentage of head length was found to be 37.80.

Rostral barbel length: The mean value of the rostral barbel length expressed as percentage of head length was found to be 31.20.

Maxilary barbel length: The mean value of the maxillary barbel length expressed as percentage of head length was found to be 34.06.

MERISTIC COUNTS:

The details of the meristic counts for *T. tor* from River Simsang are presented in Table 8 and summarized below.

Number of dorsal fin rays: The number of dorsal fin rays was found to be constant (4/8).

Number of pectoral fin rays: The mean value of the number of pectoral fin rays was found to be 17.07.

Number of ventral fin rays: The number of ventral fin rays was found to be constant (9).

Number of anal fin rays: The number of anal fin rays was found to be constant (3/5).

Table 8: Meristic characters of *T. tor* and *T. putitora*

Parameters	*T. tor* Mean	*T. tor* Range	*T. putitora* Mean	*T. putitora* Range
No. of dorsal fin rays	4/8	4/8 (Const)	4/8	4/8(Const.)
No. of pectoral fin rays	17.07	17 - 18	17.50	17 - 18
No. of ventral fin rays	9	9 (Const.)	9	9 (Const.)
No. of anal fin rays	3/5	3/5 (Const.)	3/5	3/5(Const.)
No. of caudal fin rays	19	19 (Const.)	19	19 (Const.)
No. of lateral line scales	25.8	25 - 27	27.6	25 - 28
No. of lateral line transverse scales	4/2	4/2 (Const.)	4/2	4/2(Const.)

Number of caudal fin rays: The number of caudal fin rays was found to be constant (19).

Number of lateral line scales: The mean value of the number of lateral line scales was found to be 25.8.

Number of lateral line transverse scales: The number of lateral line transverse scales was found to be constant (4/2).

REGRESSION EQUATIONS:

The regression equations for various morphometric parameters studied for *T. tor* have been presented in Table 9.

MORPHOMETRY AND MERISTIC COUNTS OF *T. PUTITORA*:

MORPHOMETRY:

The details of morphometric measurements of *T. putitora* from Simsang River have been presented in Table 7 and summarised below.

Total length: The mean value of total length expressed as percentage of standard length was found to be 131.32.

Fork length: The mean value of fork length expressed as percentage of standard length was found to be 112.24.

Predorsal length: The mean value of the predorsal length expressed as percentage of standard length was found to be 52.89.

Table 9: Regression equations of morphometric parameters of *T. tor*

Parameters	Regression equation	Correlation coefficient
Total length (Y) on standard length (X)	Y = - 1.7729 + 1.3283 X	0.9996
Fork length (Y) on standard length (X)	Y = 9.5745 + 1.0578 X	0.9983
Predorsal length (Y) on standard length (X)	Y = 1.1029 + 0.5299 X	0.9997
Head length (Y) on standard length (X)	Y = 4.0956 + 0.2502 X	0.9997
Snout length (Y) on standard length (X)	Y = -0.1675 + 0.1103 X	0.9998
Eye diameter (Y) on standard length (X)	Y = 4.1495 + 0.0335 X	0.9990
Inter-orbital distance (Y) on standard length (X)	Y = 1.4395 + 0.1205 X	0.9923
Gape (Y) on standard length (X)	Y = 1.9590 + 0.0922 X	0.9800
Rostral barbel length (Y) on standard length (X)	Y = 0.9323 + 0.0803 X	0.9932
Head depth (Y) on standard length (X)	Y = 9.6250 + 0.1297 X	0.9900
Body depth (Y) or standard length (X)	Y = -2.0831 + 0.3165 X	0.9972
Length of caudal peduncle (Y) on standard length (X)	Y = -1.0792 + 0.1727 X	0.9836
Dorsal fin length (Y) on standard length (X)	Y = 3.3634 + 0.1241 X	0.9941
Dorsal fin height (Y) on standard length (X)	Y = 5.8411 + 0.2215 X	0.9941
Pectoral fin height (Y) on standard length (X)	Y = 1.3756 + 0.2058 X	0.9992
Anal fin height (Y) on standard length (X)	Y = -0.8480 + 0.2220 X	0.9965
Anal fin base (Y) on standard length (X)	Y = 1.3195 + 0.0681 X	0.9867
Girth (Y) on standard length (X)	Y = 0.1177 + 0.7422 X	0.9962

Head length: The mean value of the head length expressed as percentage of standard length was found to be 31.34.

Head depth: The mean value of the head depth expressed as percentage of standard length was found to be 18.46.

Body depth: The mean value of the body depth expressed as percentage of standard length was found to be 25.65.

Least height of caudal peduncle: The mean value of the least height of caudal peduncle expressed as percentage of standard length was found to be 11.18.

Length of caudal peduncle: The mean value of the length of caudal peduncle expressed as percentage of standard length was found to be 17.44.

Dorsal fin length: The mean value of the dorsal fin length expressed as percentage of standard length was found to be 13.74.

Length of free margin of dorsal fin: The mean value of the length of free margin of dorsal fin expressed as percentage of standard length was found to be 19.29.

Dorsal fin height: The mean value of the dorsal fin height expressed as percentage of standard length was found to be 24.05.

Pectoral fin height: The mean value of the pectoral fin height expressed as percentage of standard length was found to be 20.24.

Ventral fin height: The mean value of the ventral fin height expressed as percentage of standard length was found to be 17.83.

Anal fin height: The mean value of the anal fin height expressed as percentage of standard length was found to be 21.05.

Anal fin base: The mean value of the anal fin base expressed as percentage of standard length was found to be 7.69.

Snout length: The mean value of the snout length expressed as percentage of head length was found to be 32.24.

Eye diameter: The mean value of the eye diameter expressed as percentage of head length was found to be 19.30.

Post-orbital head length: The post-orbital head length expressed as percentage of head length was found to be 48.61.

Inter-orbital distance: The mean value of the inter-orbital distance expressed as percentage of the head length was found to be 36.30.

Length of upper jaw: The mean value of the length of upper jaw expressed as percentage of head length was found to be 25.59.

Gape: The mean value of the gape expressed as percentage of head length was found to be 31.02.

Rostral barbel length: The mean value of the rostral barbel length expressed as percentage of head length was found to be 24.62.

Maxilary barbel length: The mean value of the maxilary barbel length expressed as percentage of head length was found to be 25.73.

MERISTIC COUNTS:

The details of the meristic counts of *T. putitora* from River Simsang have been presented in Table 8.

Number of dorsal fin rays: The number of dorsal fin rays was found to be constant (4/8).

Number of pectoral fin rays: The mean value of the number of pectoral fin rays was found to be 17.50.

Number of ventral fin rays: The number of ventral fin rays was found to be constant (9).

Number of anal fin rays: The number of anal fin rays was found to be constant (3/5).

Number of caudal fin rays: The number of caudal fin rays was found to be constant (19).

Number of lateral line scales: The mean value of the number of lateral line scales was found to be 27.6.

Number of lateral line transverse scales: The number of lateral line transverse scales was found to be constant (4/2).

REGRESSION EQUATIONS:

The regression equations for various morphometric para-

Table 10: Regression equations of morphometric parameters of *T. putitora*

Parameters	Regression equation	Correlation coefficient
Total length (Y) on standard length (X)	Y = 7.8493 + 1.2559 X	0.9994
Fork length (Y) on standard length (X)	Y = 35.3946 + 1.4643 X	0.9781
Predorsal length (Y) on standard length (X)	Y = 2.0832 + 0.5278 X	0.9994
Head length (Y) on standard length (X)	Y = 2.5112 + 0.2787 X	0.9983
Snout length (Y) on standard length (X)	Y = -0.9645 + 0.2477 X	0.4033
Eye diameter (Y) on standard length (X)	Y = 2.6924 + 0.0409 X	0.9933
Inter-orbital distance (Y) on standard length (X)	Y = 1.5151 + 0.9935 X	0.9935
Gape (Y) on standard length (X)	Y = 0.8394 + 0.1007 X	0.9351
Rostral barbel length (Y) on standard length (X)	Y = 2.2731 + 0.0615 X	0.9996
Head depth (Y) on standard length (X)	Y = 4.5772 + 0.1622 X	0.9972
Body depth (Y) on standard length (X)	Y = 10.0129 + 0.2134 X	0.9501
Length of caudal peduncle (Y) on standard length (X)	Y = -1.5977 + 0.1825 X	0.9837
Dorsal fin length (Y) on standard length (X)	Y = 1.8418 + 0.1298 X	0.9881
Dorsal fin height (Y) on standard length (X)	Y = 2.6880 + 0.2458 X	0.9976
Pectoral fin height (Y) on standard length (X)	Y = 5.6000 + 0.1678 X	0.9964
Anal fin height (Y) on standard length (X)	Y = 5.3555 + 0.1608 X	0.9933
Anal fin base (Y) on standard length (X)	Y = 2.5068 + 0.0534 X	0.9699
Girth (Y) on standard length (X)	Y = 11.9981 + 0.5794 X	0.9975

meters studied for *T. putitora* have been presented in Table 10.

BIOMETRIC INDEX

Biometric index in *A. hexagonolepis*:

For each character, a mean biometric index for each 50.0 mm length group has been calculated and presented in Table 11. The mean biometric indices for 50.0 mm length groups for the specimens belonging to Simsang and Pagladia Rivers have been presented in Table 12 for comparison.

It is quite clear from Fig. 3 that the growth of head and girth in relation to total length and growth of inter-orbital distance in relation to head length for the size range studied are isometric with minor variations. The growth of eye diameter and gape in relation to head length shows negative allometry with minor variations in the lower length groups.

The growth of snout length and gape in relation to head length is almost similar in the specimens of *A. hexagonolepis* collected from Simsang and Pagladia Rivers with minor variations only in the magnitude. In case of the growth of head length in relation to total length, opposite trends are observed in length groups III (151-200 mm) and VI (301-350 mm). The growth of eye diameter and rostral barbel length in relation to head length shows slightly different trends (Fig. 4).

Biometric index in *T. tor*:

For each character a mean biometric index for each 50 mm length groups has been calculated and presented in Table 13. It is clear from Fig. 5 that the growth of head length and girth in relation to total length and growth of gape in relation to head length is isometric with minor oscillations. The growth of eye diameter in relation to head length shows negative allometry. The growth of inter-orbital distance in relation to head length is allometric and shows wide variations.

Biometric index in *T. putitora*:

For each character a mean biometric index for each 50 mm length groups has been calculated and presented in Table 14. It can be seen from Fig. 6 that the growth of girth in relation to total length is isometric whereas the growth of head length in relation to total length and growth of inter-orbital distance and gape in relation to head length is allometric showing wide variations. The growth of eye diameter in relation to head length shows negative allometry with slight variation in length group IV (201-250 mm).

LENGTH-WEIGHT RELATIONSHIP

Length-weight relationship in *A. hexagonolepis*:

The entire length-weight data of *A. hexagonolepis* were pooled into a single equation which was calculated to be:

Table 11: Mean Biometric indices in different length-groups of *A. hexagonolepis*

Parameters	Gr. I 50 - 100 (mm)	Gr. II 101 - 150 (mm)	Gr. III 151 - 200 (mm)	Gr. IV 201 - 250 (mm)	Gr. V 251 - 300 (mm)	Gr. VI 301 - 350 (mm)	Gr. VII 351 - 400 (mm)	Gr. VIII 401 - 450 (mm)
TL/HL	4.70	5.19	5.02	4.95	4.96	5.06	-	4.70
HL/Sn.L	2.55	2.21	2.71	2.69	2.04	1.99	-	2.41
LL/POL	2.14	2.17	2.19	2.18	2.06	2.16	-	2.41
HL/ED	3.44	3.49	2.44	4.69	5.21	5.36	-	6.71
HL/IOD	2.00	2.12	2.08	1.98	1.98	2.08	-	1.84
HL/G	2.27	2.58	2.60	2.43	2.58	2.88	-	3.48
HL/RBL	3.15	3.43	3.31	3.41	3.53	3.36	-	3.48
HL/MBL	2.66	2.35	1.23	2.93	3.14	3.24	-	3.13
HL/AFB	3.10	2.20	3.52	3.62	3.36	3.24	-	3.36
TL/GIRTH	1.69	1.85	1.73	1.54	1.94	1.89	-	1.70

Table 12: Mean biometric indices in different length groups of *A. hexagonolepis* from Simsang River (S_1) and Pagladia River (S_2)

Parameters	Gr. I 50 - 100 (mm)		Gr. II 101 - 150 (mm)		Gr. III 151 - 100 (mm)		Gr. IV 201 - 250 (mm)		Gr. V 251 - 300 (mm)		Gr. VI 301 - 350 (mm)	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
TL/HL	6.57	6.04	6.68	6.41	6.16	6.39	6.89	8.66	6.70	6.66	7.66	5.98
HL/Sn.L	2.54	2.73	2.21	2.40	2.70	2.54	2.69	2.80	2.68	2.71	1.71	2.52
HL/ED	3.44	2.73	3.48	4.35	2.65	4.78	4.69	4.94	5.20	5.70	5.35	6.09
HL/G	2.26	2.17	2.57	3.10	2.60	3.43	2.43	3.00	2.58	2.37	2.88	4.78
HL/RBL	3.15	2.85	3.43	2.50	3.31	2.70	3.40	3.00	3.52	3.35	3.35	3.72

Note : S_1 System I
S_2 System II

Table 13: Biometric indices in different length-groups of *T. tor*

Parameters	Gr. I 100 - 150 (mm)	Gr. II 151 - 200 (mm)	Gr. III 201 - 250 (mm)	Gr. IV 251 - 300 (mm)	Gr. V 301 - 350 (mm)
TL/HL	4.39	4.72	4.82	4.81	4.95
HL/Sn.L.	2.68	2.56	2.54	2.48	2.42
HL/POL	2.36	2.42	2.20	2.17	2.25
HL/ED	3.79	4.25	4.75	4.96	5.25
HL/IOL	2.18	2.19	2.09	2.03	2.17
HL/G	2.63	2.62	2.50	2.80	2.62
HL/RBL	3.22	3.27	3.17	3.21	3.15
HL/MBL	2.91	2.76	2.82	2.87	3.15
TL/AFB	3.74	3.40	3.78	3.45	3.70
TL/GIRTH	1.70	1.87	1.73	1.73	1.80

Table 14: Biometric indices in different length-groups of *T. putitora*

Parameters	Gr. I 50 - 100 (mm)	Gr. II 101 - 150 (mm)	Gr. III 151 - 200 (mm)	Gr. IV 201 - 250 (mm)	Gr. V 251-300 (mm)	Gr.VI 301 - 350 (mm)
TL/HL	4.30	4.41	6.13	6.92	-	4.24
HL/Sn.L	2.79	2.60	1.89	1.57	-	2.93
HL/POD	2.26	2.41	1.63	1.39	-	1.98
HL/ED	3.91	4.22	1.66	4.50	-	6.07
HL/IOL	2.26	2.39	1.78	1.46	-	2.82
HL/G	2.68	2.95	1.93	1.81	-	3.43
HL/RBL	3.30	3.54	2.76	2.49	-	4.16
TL/MBL	2.98	2.92	2.13	2.21	-	4.16
TL/AEB	3.58	4.04	2.76	2.85	-	4.16
TL/GIRTH	1.88	1.99	1.99	1.99	-	2.12

$$\text{Log } W = - 5.1971 + 3.0640 \text{ Log } Tl$$
$$r = 0.9917$$

where W = Total weight and Tl = Total length. A high degree of positive correlation between length and weight has been indicated by the correlation co-efficient (r). This value is an index of the reliabilities of the observations. The parabolic equation derived is as follows:

$$W = 0.000001005 \; L^{3.0640}$$

The "b" value of 3.0640 indicates that it follows closely the cubic law for isometric growth.

On plotting the observed average weight of the species (A. hexagonolepis) against the observed length, a parabolic curve has been obtained (Fig. 7A). A logerithmic graph prepared with the above data showed a straight line relationship (Fig. 7B).

The various regression equations on length-weight relationship of A. hexagonolepis has been presented in Table 15.

Length-weight relationship in A. hexagonolepis during different seasons:

The length-weight relationship was calculated during the different seasons to see the seasonal impact on the relationship. Three seasons, viz. summer, monsoon, and winter have been taken into consideration. It is evident from the results that the value of regression co-efficient tend to be

Table 15: Length-weight regression equations of the three species

	Logerithmic equations	Correlations coefficient	Parabolic equations
A. hexagonolepis			
Pooled[1]	Log W = -5.1971 + 3.0640 Log Tl	0.9917	$W = 0.000001005\ L^{3.0640}$
Pooled[2]	Log W = -5.1733 + 3.0542 Log Tl	0.9734	$W = 0.000006699\ L^{3.0542}$
Male	Log W = -5.2247 + 3.0883 Log Tl	0.9932	$W = 0.000005957\ L^{3.0883}$
Female	Log W = -5.6144 + 3.2827 Log Tl	0.9600	$W = 0.000002424\ L^{3.2827}$
Juvenile	Log W = -3.9258 + 2.4475 Log Tl	0.9556	$W = 0.0001683\ L^{2.4475}$
T. tor			
Pooled[1]	Log W = -5.1252 + 3.0284 Log Tl	0.9979	$W = 0.000007479\ L^{3.0284}$
Pooled[2]	Log W = -5.1281 + 3.0127 Log Tl	0.9993	$W = 0.000007444\ L^{3.0127}$
Male	Log W = -4.4787 + 2.7525 Log Tl	0.9661	$W = 0.000052125\ L^{2.7525}$
Female	Log W = -4.5492 + 2.7807 Log Tl	0.9889	$W = 0.00002823\ L^{2.7807}$
Juvenile	Log W = -4.7451 + 2.6620 Log Tl	0.9850	$W = 0.000001798\ L^{2.6620}$
T. putitora			
Pooled[1]	Log W = -4.8308 + 2.8863 Log Tl	0.9974	$W = 0.00001476\ L^{2.8863}$
Pooled[2]	Log W = -4.5752 + 2.7673 Log Tl	0.9984	$W = 0.0000265\ L^{2.7673}$

Note: 1 = calculated from total weight

2 = calculated from evicerated weight.

Table 16: Seasonal variations in the length-weight relationship of *A. hexagonolepis* and *T. tor*

Season	Regression equations	Correlation coefficient
	A. hexagonolepis	
Summer	Log W = -5.2230 + 3.0392 Log Tl	0.9593
Monsoon	Log W = -3.6863 + 2.9132 Log Tl	0.9934
Winter	Log W = -4.9479 + 2.9840 Log Tl	0.9953
	T. tor	
Summer	Log W = -4.9846 + 2.9993 Log Tl	0.9661
Monsoon	Log W = -4.9686 + 2.9793 Log Tl	0.9647
Winter	Log W = -5.1252 + 3.0284 Log Tl	0.9935

higher during summer season and lower during monsoon season (Table 16).

Length-weight relationship in male and female of *A. hexagonolepis*:

The length-weight relationship in male is based on the examination of specimens ranging from 99.4 mm to 280.0 mm and that of female from 87.4 mm to 442.0 mm in total length. The regression equation for male was estimated to be:

$$\text{Log } W = -\ 5.2247 + 3.0883 \text{ Log Tl}$$
$$r = 0.9932$$

The regression equation for female was estimated to be:

$$\text{Log } W = -\ 5.6144 + 3.2827 \text{ Log Tl}$$
$$r = \cdot 9600$$

The parabolic equation for male was determined to be:

$$W = 0.000005957\ L^{3.0883}$$

The parabolic equation for female was determined to be:

$$W = 0.000002424\ L^{3.2827}$$

The exponential index (b) for male (3.0883) shows that the male is lighter in weight in relation to its length than the female (b = 3.2827).

Length-weight relationship in juvenile of *A. hexagonolepis*:

The length-weight relationship in juvenile is based on the examination of specimen ranging 87.4 mm to 145.33 mm in total length. The regression equation for juvenile was estimated to be:

$$\text{Log } W = -3.9258 + 2.4475 \text{ Log } Tl$$

$$r = 0.9556$$

The parabolic equation for juvenile was determined to be:

$$W = 0.0001683 \text{ Log}^{2.4475}$$

The exponential index (b) for the juvenile (2.4475) is lower than that of male (3.0883) and female (3.2827). This shows that juvenile is lighter in weight in relation to its length than the male or female.

Length-weight relationship in *A. hexagonolepis* calculated from the eviscerated weight:

The entire total length and eviserated weight data was pooled into a single equation which was calculated to be:

$$\text{Log } W = -5.1733 + 3.0542 \text{ Log } Tl$$

$$r = 0.9734$$

The parabolic equation was determined to be:

$$W = 0.000006699 \; L^{3.0542}$$

The exponential index (b) of 3,054 was found to be slightly lower than that calculated from total weight (3.064).

Length-weight relationship in *T. tor*:

The entire length-weight data of *T. tor* was pooled into a single equation, which was calculated to be:

$$\text{Log } W = -5.1252 + 3.0284 \text{ Log } Tl$$

$$r = 0.9979$$

where W = Total weight and Tl = Total length. A high degree of positive correlation between length and weight has been indicated by the correlation coefficient (r).

The parabolic equation derived is as follows:

$$W = 0.000007479\ L^{3.0284}$$

The 'b' value of 3.0284 indicates that it follows closely the cubic law for isometric growth.

On plotting the observed average weight of the species (T. tor) against the observed length, a parabolic curve has been obtained (Fig. 8A). A logerithmic graph prepared with the above data showed a straight line relationship (Fig. 8B). The various regression equation of T. tor has been presented in Table 15.

Length-weight relationship in T. tor during different seasons:

The length-weight relationship was calculated during the different seasons to see the seasonal impact on the relationship. Three seasons, viz. summer, monsoon and winter have been taken into consideration. It is evident from the results that the value of regression co-efficient tends to be higher during winter and lower during monsoon (Table 16).

Length-weight relationship in male and female of T. tor:

The length-weight relationship in male is based on the examination of specimens ranging from 110.0 mm to 263.0 mm and that of female from 124.0 mm to 312.0 mm in total length. The regression equation for male was estimated to be:

$$\text{Log } W = -\ 4.4787 + 2.7525 \text{ Log Tl}$$

$$r = 0.9661$$

The regression equation for female was estimated to be:

$$\text{Log } W = -\ 4.5492 + 2.7807 \text{ Log Tl}$$

$$r = 0.9889$$

The parabolic equation for male was determined to be:

$$W = 0.000052125\ L^{2.7525}$$

The parabolic equation for female was determined to be:

$$W = 0.00002823\ L^{2.7807}$$

The exponential index (b) for male (2.75) shows that the male is slightly lighter in weight in relation to its length than the female (b = 2.78).

Length-weight relationship in juvenile of *T. tor*:

The length-weight relationship in juvenile is based on the examination of specimens ranging from 108.0 mm to 164.5 mm in total length. The regression equation for juvenile was estimated to be:

$$\text{Log } W = -\ 4.7451 + 2.6620 \text{ Log Tl}$$

$$r = 0.9850$$

The parabolic equation for juvenile was determined to be:

$$W = 0.000001798\ L^{2.6620}$$

The exponential index (b) for the juvenile (2.662) was found to be lower than that of male (2.7525) and female (2.7807). This shows that juvenile is lighter in weight in relation to its length than male and female.

<u>Length-weight relationship in *T. tor* calculated from the eviscerated weight</u>:

The entire total length and eviscerated weight data was pooled into a single equation which was calculated to be:

$$\text{Log } W = -\ 5.1281 + 3.0127 \text{ Log Tl}$$

$$r = 0.9993$$

The parabolic equation was determined to be:

$$W = 0.000007444\ L^{3.0127}$$

The exponential index (b) of 3.012 was found to be slightly lower than that calculated from total weight (3.0284).

The value of correlation co-efficient 'r' was found to be 0.9993, which indicates a high degree of positive correlation between total length and eviscerated weight in *T. tor*.

<u>Length-weight relationship in *T. putitora*</u>:

The entire length-weight data was pooled into a single equation which was calculated to be:

$$\text{Log } W = -\ 4.8308 + 2.8863 \text{ Log Tl}$$

$$r = 0.9974.$$

A high degree of positive correlation between length and weight of *T. putitora* has been indicated by the correlation co-efficient (r).

The parabolic equation was determined to be:

$$W = 0.00001476\ L^{2.8863}$$

The exponential index (b) in *T. putitora* is less than 3.0 which indicates that its growth is allometric. The regression equations for *T. putitora* have been presented in Table 15.

On plotting the observed average weight of the species (*T. putitora*) against the observed length, a parabolic curve has been obtained (Fig. 9A). A logerithmic graph prepared with the above data showed a straight line relationship (Fig. 9B).

Due to lack of adequate number of specimens of *T. putitora*, no attempt could be made to find out the length-weight relationship for different sex, size or season.

Length-weight relationship in *T. putitora* calculated from eviscerated weight:

The entire total length and eviscerated weight data was pooled into a single equation which was calculated to be:

$$\text{Log } W = -\ 4.5752 + 2.7673\ \text{Log } Tl$$

$$r = 0.9984$$

The parabolic equation was determined to be:

$$W = 0.0000265\ L^{2.7673}$$

The exponential index (b) of 2.7673 was found to be slightly lower than that calculated from total weight (2.8863). The 'r' value (0.9984) indicated a high correlation between total length and eviscerated weight in *T. putitora*.

LENGTH-FREQUENCY DISTRIBUTION

To find out the length-frequency distribution, graphs have been prepared by converting the frequencies into percentages and plotting the same against the respective length groups.

Length-frequency distribution of *A. hexagonolepis*:

The length-frequency distribution of *A. hexagonolepis* for the entire period of study (Fig. 10) indicate the presence of one distinct mode at 90-100 mm length group and another minor mode at 240-250 mm length groups.

Length-frequency distribution of *T. tor*:

The length frequency distribution of *T. tor* for the entire period of study (Fig. 11A) indicates the presence of a single distinct mode at 150-160 mm length group.

Length-frequency distribution of *T. putitora*:

The length frequency distribution of *T. putitora* for the entire period of study (Fig. 11B) indicates the presence of a single distinct mode at 130-140 mm length group.

CONDITION FACTOR

Condition factor (K) and relative condition factor (Kn) in *A. hexagonolepis* at different length groups:

The condition factor (K) and relative condition factor (Kn) have been calculated for each 50 mm length groups and presented in Table 17.

The 'K' value shows a fall at length group II (101-150 mm) and thereafter it rises steadily reaching its peak at length group VIII (401-450 mm) (Fig. 12A). The 'Kn' value shows a fall at length group II (101-150 mm), and thereafter maintains the same value showing minor variations (Fig. 12A).

Monthly fluctuations of the condition factor (K) and relative condition factor (Kn) in *A. hexagonolepis*:

Monthwise averages of condition factor 'K' and relative condition factor 'Kn' have been calculated for the entire two year period to elucidate the seasonal fluctuation and presented in Table 18. The average 'K' values show an increasing tendency from the month of January onwards and attain a peak in May (Fig. 12B). The male and female tends to maintain the same trend with minor oscillations (Fig. 13A), whereas the juvenile shows a different pattern of fluctuation (Fig. 13B). It is evident from Fig. 12B that the period of peak is quite long and remains almost from May to November, whereafter the 'K' value drops abruptly. The 'Kn' values followed almost the same pattern as 'K' in its monthly fluctuations (Fig. 12B).

Table 17: Fluctuations in the condition factor in different length groups of the three species

Length-Groups (mm)	Condition factor			Relative Condition factor		
	A. hexagonolepis	*T. tor*	*T. putitora*	*A. hexagonolepis*	*T. tor*	*T. putitora*
50 - 100	0.958	-	0.865	1.055	-	1.002
101 - 150	0.918	0.987	0.883	1.008	1.011	1.002
151 - 200	0.949	0.906	0.838	0.994	1.003	1.019
201 - 250	0.996	0.900	0.775	1.004	1.000	0.990
251 - 300	1.052	0.962	-	0.991	0.985	-
301 - 350	1.082	0.980	0.720	1.013	1.012	0.991
351 - 400	-	-	-	-	-	-
401 - 450	1.150	-	-	0.997	-	-

Table 18: Monthly fluctuations in the condition factor (K) and Relative condition factor (Kn) of *A. hexagonolepis* and *T. tor*.

Months		Condition factor		Relative condition factor	
		A. hexagonolepis	*T. tor*	*A. hexagonolepis*	*T. tor*
1978	Aug.	0.990	0.990	1.051	0.949
	Sept.	1.010	1.060	0.883	1.042
	Oct.	1.057	0.880	1.020	0.992
	Nov.	1.075	0.870	1.200	0.988
	Dec.	1.003	0.860	1.199	0.985
1979	Jan.	0.857	0.883	1.134	1.041
	Feb.	0.850	0.802	0.754	0.970
	Mar.	0.919	0.840	1.089	0.972
	Apr.	0.695	0.932	1.061	1.037
	May	0.962	1.024	1.085	1.101
	June	0.996	1.037	1.089	1.071
	July	1.030	1.050	1.093	1.041
	Aug.	0.870	1.010	0.740	1.052
	Sept.	1.170	1.030	1.115	1.077
	Oct.	1.170	0.823	1.108	1.036
	Nov.	1.180	0.850	1.189	1.002
	Dec.	-	-	-	-
1980	Jan.	1.150	0.807	1.108	0.988
	Feb.	1.150	0.832	1.054	0.987
	Mar.	1.120	0.908	1.037	0.989
	Apr.	0.990	0.911	0.755	1.011
	May	-	-	-	-
	June	0.990	1.010	1.157	1.121
	July	1.020	1.030	1.160	1.132

Condition factor (K) and relative condition factor (Kn) in *T. tor* at different length groups:

The condition factor (K) and relative condition factor (Kn) have been calculated for each 50 mm length groups and presented in Table 17. The average 'K' value (Fig. 14A) showed a slight decrease in length group II (151-200 mm) and III (201-250 mm), whereafter it showed a gradual rise, attaining the maximum value at length group V (301-350 mm). The 'Kn' values (Fig. 14A) showed almost the same pattern as 'K' in its fluctuation with the increase in length of the fish except in length group IV (251-300 mm).

Monthly fluctuations of the condition factor (K) and relative condition factor (Kn) in *T. tor*:

Monthwise averages of condition factor 'K' and relative condition facor 'Kn' have been calculated for the entire two year period to elucidate the seasonal fluctuations and presented in Table 18.

It is evident from Fig. 14B that the peak remains for quite long, almost from May to September whereafter the 'K' values drop abruptly. The 'Kn' values in its seasonal variations showed almost the same pattern of fluctuation as in 'K' with minor oscillations (Fig. 14B).

Condition factor (K) and relative condition factor (Kn) of *T. putitora* at different length groups:

The condition factor 'K' and relative condition factor

Table 19: Seasonal fluctuations in the condition factor, gonado-somatic index and gastro-somatic index of T. putitora

	Condition factor	Relative condition factor	Gonado-somatic index	Gastro-somatic index
1978 Monsoon	0.845	1.203	0.502	2.143
1979 Winter	0.801	1.123	0.373	1.868
Summer	0.776	1.053	0.306	2.955
Monsoon	0.871	1.216	0.871	2.326
1980 Winter	0.842	1.156	0.842	2.084
Summer	0.820	1.132	0.820	2.583

Note : In case of T. putitora the data could not be represented monthly because samples could not be obtained during the months.

'Kn' have been calculated for each 50 mm length groups and represented in Table 17. The 'K' value showed a decreasing trend with the increase in length of the fish (Fig. 15A).

Seasonal fluctuations of the condition factor (K) and relative condition factor in *T. putitora*:

The condition factor 'K' and relative condition factor 'Kn' have been calculated for different seasons (summer, monsoon and winter) for the entire two year period and presented in Table 19. The 'K' factor shows higher values during monsoon and lower values during summer (Fig. 15B). The 'Kn' values also showed the same trend (Fig. 15B).

MATURITY AND SPAWNING IN *A. HEXAGONOLEPIS*

Cycle of maturation:

Percentages of different maturity stages during different months have been calculated and presented in Fig. 16. Ovary condition progressed from stage I (immature) into stage V (gravid) in March. Ovary in stage VI (spawning) was recorded from April onwards till October. This indicates that spawning season of *A. hexagonolepis* generally extends from April to October. However, in few instances, ovaries in stage VII (spawning/spent) condition have also been recorded during April, September, November and December.

Ova-diameter study:

To find out the ova-diameter frequency during different stages of ovarian development of mature *A. hexagonolepis* a graph has been plotted by converting the frequencies into percentages and plotting the same against the respective ova-diameter groups (Fig. 17).

The fully mature ovaries (Stage V) were found to contain ova in various stages of development. The batch of fully matured ova were not clearly demarked from the immature stock. The size of the fully mature ova in stage V ranged from 2.84 - 3.00 mm. The frequency distribution of ova at various stages of development between the immature and mature stock was more or less uniform. The spawning/ spent ovary (Stage VII) contained a second batch of ova progressing maturation.

Gonado-somatic index:

Monthly averages of gonado-somatic index for the entire two year period has been presented in Table 20.

It is clear from Fig. 18B that the Gn.S.I. showed a wide fluctuation. However, its maximum value observed during August in the first year and September in the second year and minimum value was observed during October in the first year and March in the second year.

Plotting the Gn.S.I. values against different length groups (Fig. 18A) indicated that there is a definite tendency for the Gn.S.I. to increase with the increase in total

Table 20: Monthly fluctuations in the gonado-somatic index of *A. hexagonolepis*.

Months	1978	1979	1980
January	-	2.322	0.854
February	-	1.200	1.736
March	-	2.220	0.111
April	-	1.283	1.248
May	-	1.374	-
June	-	1.370	1.608
July	-	1.367	1.405
August	3.332	0.928	-
September	1.430	3.002	-
October	0.447	2.321	-
November	0.800	0.455	-
December	0.843	-	-

Table 21: Fluctuations in the gonado-somatic index in different length-groups of the three species

Length-Groups	*A. hexagonolepis*	*T. tor*	*T. putitora*
50 - 100	1.484	-	0.325
101 - 150	1.718	1.335	0.300
151 - 200	0.904	0.759	0.281
201 - 250	0.659	0.255	0.324
251 - 300	2.171	0.747	-
301 - 350	2.786	0.240	0.089
351 - 400	-	-	-
401 - 450	6.982	-	-

Table 22: Mean length of *A. hexagonolepis* at M_{50} (50% maturity)

Length (mm)	% mature male	% mature female
70 - 80	0	0
81 - 90	0	0
91 - 100	11.11	0
101 - 110	15.78	0
111 - 120	23.52	0
121 - 130	26.66	0
131 - 140	18.18	0
141 - 150	25.00	0
151 - 160	25.00	0
161 - 170	20.00	0
171 - 180	25.00	0
181 - 190	33.33	0
191 - 200	50.00	0
201 - 210	50.00	20.00
211 - 220	0	50.00
221 - 230	0	66.66
231 - 240	66.00	33.00
241 - 250	25.00	75.00
251 - 260	66.00	66.66
261 - 270	0	75.00
281 - 290	100.00	50.00
291 - 300	0	75.00
301 - 310	0	100.00
321 - 330	0	100.00
441 - 450	0	100.00

length. However, this trend is interrupted in length groups III and IV where it shows a decrease (Table 21).

Size at first maturity:

All the female specimens below 201 mm were found to be immature. However, in case of male, maturity first appeared in specimens belonging to length group 91-100 mm. It is evident that 50% maturity in case of male occurs at length group 191-200 mm (Table 22). In case of female specimens 50% maturity first occurs at 211-220 mm length group. All the males were found to be mature at length group 281-290 mm and all the females were found to be mature at length group 301-310 mm.

FECUNDITY

Fecundity of *A. hexagonolepis* varied considerably from individual to individual and ranged from 533 in the specimen measuring 196.0 mm and 74.4 gm in total length and total weight respectively to 11660 in a specimen measuring 442.0 mm and 1000.00 gm in total length and total weight respectively (Table 23 and Fig. 17).

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

Fecundity vs. total length:

The logerithmic relationship between fecundity (F)

Table 23: Fecundity and relative fecundity of ***A. hexagonolepis***

Total length (mm)	Total weight (gm)	Ovary weight (gm)	Fecundity	Relative Fecundity
196.00	74.40	0.85	532.66	7.15
205.00	141.40	2.75	1243.00	8.79
235.00	135.50	12.35	4446.00	32.81
245.00	144.50	5.47	2806.11	19.41
250.00	169.00	14.72	3650.56	21.60
287.00	267.50	5.87	823.10	3.07
295.00	266.00	8.30	1912.28	7.18
330.00	294.50	10.82	2402.04	8.15
340.00	460.00	4.96	1656.64	3.60
350.00	572.00	26.68	7231.09	12.64
360.00	515.00	26.65	5791.80	11.24
442.00	1000.00	69.82	11659.94	11.65

and total length (Tl) has been shown in Fig. 20A. The equation derived is:

$$\text{Log } F = -2.0725 + 0.5278 \text{ Log } Tl \quad (r = 0.4506)$$

The correlation coefficient (r) was found to be 0.4506, which indicates a positive correlation between these two parameters.

Fecundity vs. total weight:

The logerithmic relationship between the fecundity (F) and total weight (W) has been presented in Fig. 20B. The equation derived is as follows:

$$\text{Log } F = -2.3040 + 2.3226 \text{ Log } W \quad (r = 0.6293)$$

The value of correlation coefficient (0.6293) indicates that weight is more closely related to fecundity than length in *A. hexagonolepis*.

Fecundity vs. ovary weight:

The logerithmic relationship between fecundity (F) and ovary weight (O.W.) has been shown in Fig. 21A. The equation derived is:

$$\text{Log } F = 2.9282 + 0.4720 \text{ Log } O.W. \quad (r = 0.8417)$$

The value of correlation coefficient (r) was found to be 0.8417, which indicates a high degree of positive correlation between the two parameters.

Ovary weight vs total length:

The logerithmic relationship between ovary weight (O.W.) and total length (Tl) has been shown in Fig. 21B, and the equation derived is:

$$\text{Log O.W.} = -1.1675 + 0.6565 \text{ Log Tl } (r = 0.6568)$$

The value of correlation coefficient (r) was found to be 0.6568, showing a positive correlation between the two parameters.

FOOD AND FEEDING HABITS

Food and Feeding Habits of *A. hexagonolepis*:

Percentage composition of different items (Fig. 22) in the gut content of *A. hexagonolepis* has been summarized in Table 24. The gut contents of *A. hexagonolepis* can be grouped into 9 broad groups, i.e. i) Algae, ii) Unidentified vegetable matter, iii) Protozoa, iv) Rotifera, v) Nematoda, vi) Crustaceae, vii) Unidentified animal matter and viii) Sand particles.

The present description is based on the numerical percentage of different items. The corresponding percentage volume has been presented in Table 24.

i) Algae: This group formed 35.90% in the gut content and was represented by Chlorophyceae, Chrysophyceae, Euglenophyceae, Cyanophyceae and Rhodophyceae.

Table 24: Percentage of different food items in the gut of the three species

Food items	*A. hexagonolepis*		*T. tor*		*T. putitora*	
	% N	% V	% N	% V	% N	% V
Chlorophyceae	11.43	6.98	17.30	14.52	3.07	0.49
Euglenophyceae	0.58	0.20	-	-	-	-
Chrysophyceae	21.02	9.52	18.40	4.04	16.53	2.55
Cyanophyceae	3.95	0.92	0.46	0.16	-	-
Rhodophyceae	0.04	0.01	-	-	-	-
Unidentified veg. veg. matter	31.92	49.69	31.89	35.00	33.45	39.53
Protozoa	3.34	1.33	0.34	0.19	1.25	0.65
Rotifera	7.01	3.28	-	-	0.38	0.07
Nematoda	2.34	2.21	1.30	1.07	1.53	0.42
Coleoptera	0.94	0.80	0.28	0.42	0.76	1.39
Odonata	3.62	4.17	1.89	8.03	1.53	2.48
Ephemeroptera	0.06	0.80	6.19	10.22	20.38	27.41
Diptera	0.41	0.34	4.61	8.99	7.30	15.11
Cladocera	0.60	0.87	0.20	0.07	0.38	0.76
Copepoda	-	-	0.38	0.97	0.38	0.38
Ostracoda	0.29	0.86	0.76	0.78	-	-
Diaptomus	0.04	0.12	-	-	-	-
Eubranchiopoda	-	-	-	-	0.38	0.19
Hydracarina	-	-	0.45	0.86	0.38	0.76
Melacostraca	11.57	0.22	0.27	0.82	-	-
Gastropoda	-	-	3.67	8.93	0.38	0.76
Unidentified animal matter	1.84	16.36	4.36	1.63	9.99	6.46
Sand particles	0.01	0.12	7.25	3.24	1.92	0.68

Note: N = Number
V = Volume

a) Chlorophyceae: This group was represented by Cosmarium, Mesotaenium, Closterium, Raphidonema, Characium, Tetmemorus, Trochiscia, Gonatozygon, Desmidium, Radiofilum, Excentrosphaera, Hyalotheca, Cladophora, Bulbochaete, Echinosphaerella, Chlorella, Crucigenia, Spirogyra and Cerasterias. Spirogyra was found to be the most common followed by Mesotaenium. Chlorophyceae formed 11.435% in the gut content.

b) Bacillariophyceae: This group of algae was represented by Fragilaria, Navicula, Cymbella, Tabellaria, Achanthes, Gamphoneis, Gamphonema, Pinnularia, Nitzschia, Coscinodiscus, Stauroneis, Melosira, Surirella, Pleurosigma, Amphora, Synedra, Campylodiscus, and Tribonema and in varying percentages. Bacillariophyceae as a whole formed 21.029% of the gut content. Fragilaria was found to be the most abundant, followed by Navicula.

c) Euglenophyceae: This group was represented by Paranema and Euglena and constituted 0.584% of the total gut content.

d) Cyanophyceae: This group of algae was represented by Spirulina, Merismopedia, Oscillatoria, Anabaena, Polycystis, and Aulosira. Among these, Spirulina was the most abundant and the group as a whole made up 2.853% of the gut content.

e) Rhodophyceae: This group was represented only by Audouinella and constituted only 0.045% of the gut content.

ii) Unidentified vegetable matter: This was the most important item next to algae forming 31.922% in the gut content and was represented by macrophytic tissue and decaying vegetable matter, and roots and seed of higher plants. Out of these, macrophyte was the most abundant.

iii) Protozoa: It constituted 3.34% of the gut content.

iv) Rotifera: It constituted 7.017% of the gut content.

v) Namatoda: It constituted 2.343% of the gut content.

vi) Insecta: This group was represented by larvae and adults of Coleoptera, Odnonata, Ephemeroptera, and Diptera in varying percentages and formed 5.042% in the gut content.

vii) Crustacea: This group formed 12.527% of the gut content and was represented by Cladocera, Copepoda, Ostracoda and Melacostraca.

viii) Unidentified animal matter: This item formed 1.844% of the gut content and was represented by semidigested animal matter and invertebrate eggs.

ix) Sand particles: It constituted 0.019% of the gut content.

Food composition of various length-groups of A. hexagonolepis:

The relative importance of different broad items at different length groups of A. hexagonolepis is shown in Fig. 23 and the percentage composition of different items have been presented in Table 25.

Length group-I (50-100 mm): Algae was found to be the most important item in the gut content (41.569) followed by

Table 25: Percentage of different food items in different length-groups of *A. hexagonolepis*

Food items	Gr. I 50-100 mm		Gr. II 101-150 mm		Gr. III 151-200 mm		Gr. IV 201-250 mm		Gr. V 251-300 mm		Gr. VI 301-350 mm		Gr. VII 401-450 mm	
	%N	%V	%N	%V	%N	%V	%N	%V	%N	%V	%N	%V	%N	%V
Chlorophyceae	16.50	9.36	13.06	11.49	8.03	15.64	3.94	4.90	1.64	0.24	4.54	1.61	0.58	2.04
Euglenophyceae	-	-	0.74	0.48	1.25	0.13	0.94	0.43	-	-	-	-	-	-
Chrysophyceae	21.62	8.46	22.64	10.72	21.97	11.97	39.37	15.50	14.00	1.64	18.60	5.15	0.46	6.12
Cyanophyceae	3.44	1.42	0.93	0.61	1.88	0.96	1.75	0.27	2.00	0.24	0.90	0.32	0.69	6.12
Rhodophyceae	-	-	0.16	0.06	-	-	-	-	-	-	-	-	-	-
Unidentified veg. matter	22.95	35.74	24.78	40.87	25.50	32.21	29.72	50.02	54.30	79.62	58.63	82.42	91.75	6.12
Protozoa	1.73	2.49	8.17	2.45	0.68	0.08	-	-	2.00	0.67	-	-	-	-
Rotifera	11.15	7.32	3.70	1.76	8.77	1.46	2.60	1.80	1.00	0.12	2.72	1.29	0.23	4.08
Nematoda	1.92	1.15	1.20	1.01	3.91	4.75	1.88	3.12	3.00	0.61	10.00	3.54	4.64	16.32
Coleoptera	0.52	1.49	1.15	1.64	1.25	0.13	-	-	4.00	0.48	-	-	-	-
Odonata	0.65	2.75	0.60	2.75	1.89	1.26	1.88	5.47	-	-	-	-	-	-
Ephemeroptera	-	-	-	-	-	-	0.62	7.82	-	-	-	-	-	-
Diptera	2.41	0.33	1.82	1.13	-	-	-	-	-	-	-	-	-	-
Cladocera	0.12	0.81	1.83	2.62	0.79	0.15	-	-	1.00	0.36	-	-	-	-
Ostracoda	0.32	0.31	0.32	1.46	0.31	0.06	0.47	1.11	1.00	0.24	-	-	-	-
Copepoda	0.06	0.40	-	-	-	-	-	-	-	-	-	-	-	-
Melacostraca	-	-	-	-	0.21	0.91	-	-	-	-	-	-	-	-
Unidentified animal matter	16.61	26.91	18.50	20.15	23.50	30.21	19.04	10.58	7.00	8.44	4.54	5.64	-	-
Sand particles	-	-	0.33	0.71	-	-	-	-	9.00	6.72	-	-	-	-

Note: N = Number; V = Volume.

unidentified vegetable matter (22.952%). The next in order of preference was unidentified animal matter 16.611%. Others were Rotifera (11.157%), Protozoa (1.734%), Nematoda (1.923%), and Crustacea (0.519%).

Length group-II (101-150 mm): Algae formed 37.512% of the gut content. Unidentified vegetable matter was the next in order of preference in the gut and formed 24.785%. Unidentified animal matter formed 18.5% of the gut content. Others were Protozoa (8.176%), Insecta (3.589%), Rotifera (3.7%), Nematoda (1.2%), Crustacea (2.155%), and Sand particles (0.332%).

Length group-III (151-200 mm): Algae formed 33.149% of the gut content followed by unidentified vegetable matter in order of abundance (25.501%) and unidentified animal matter (23.50%). Other constituents were found to be Rotifera (8.779%), Nematoda (3.913%), Insecta (3.146%), Crustacea (1.329%), and Protozoa (0.681%).

Length group-IV (201-250 mm): Algae constituted 46.025% of the gut content and was the most abundant item in the gut content followed by unidentified vegetable matter (29.722%). Other constituents were Rotifera (2.607%), Insecta (2.514%), Nematoda (1.886%), and Crustacea (0.472%).

Length group-V (251-300 mm): In this group unidentified vegetable matter formed the most important item (54.3%) followed by algae (17.64%). Other constituents were, Sand particles (9.00%), Unidentified animal matter (7.00%), Insecta (4.00%), Nematoda (3.00%), Protozoa (2.00%), Crustacea (2.00%), and Rotifera, (2.727%).

Length-group-VI (301-350 mm): In this group, unidentified vegetable matter formed the most important item in the gut (58.63%), followed by algae (24.054%). Other constituents were Nematoda (10.00%), Unidentified animal matter (4.595%), and Rotifera (2.727%).

Length group-VII (401-450): In this group also unidentified vegetable matter formed very high proportion of the gut content (61.231%). Other constituents were Algae (14.282%), Nematoda (16.326%), and Rotifera (4.08%).

Monthly fluctuations in the gut content of A. hexagonolepis (upto 150 mm in total length):

The percentage number of different broad items in the gut content of *A. hexagonolepis* in the specimens upto 150.0 mm in total length, has been enumerated in Table 26a from which it can be seen that there were considerable variations in the percentages of different items during different months of the year. Algae and unidentified vegetable matter formed the major items throughout the year. The percentage of algae varied from 3.99 (September) to 69.59 (October). Algae was absent during August and January. The percentage of unidentified vegetable matter varied from 5.15 (April) 68.80 (July). Unidentified vegetable matter was absent in the gut content during February. Insect was present through-

Table 26a: Monthly fluctuations in the percentage number of different food items in the gut of *A. hexagonolepis* (upto 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Chlorophyceae	-	1.33	23.65	4.78	1.69	-	1.12	3.97	4.71	3.97	5.23	7.06
Euglenophyceae	-	-	6.08	-	-	-	-	-	13.03	-	-	-
Chrysophyceae	-	-	37.16	36.69	51.80	-	-	15.90	1.43	4.66	6.27	12.35
Cyanophyceae	-	1.33	1.35	0.53	0.49	-	3.03	1.13	-	1.13	1.13	-
Rhodophyceae	-	1.33	1.35	-	-	-	-	-	-	-	-	-
Unidentified veg. matter	52.63	58.33	16.89	21.89	13.31	14.17	-	25.08	5.15	24.08	21.93	68.80
Protozoa	10.52	-	-	1.06	9.72	1.69	3.03	8.29	1.42	8.29	10.31	4.71
Rotifera	15.79	1.33	-	1.60	14.03	6.25	9.09	27.16	4.71	27.16	30.91	1.18
Nematoda	-	32.00	2.02	2.46	-	-	-	1.25	6.84	1.99	3.52	-
Coleoptera	-	5.33	2.02	1.06	-	1.67	25.15	-	-	-	-	-
Odonata	5.26	-	-	-	-	41.66	29.09	-	-	-	-	-
Ephemeroptera	-	-	-	-	-	1.67	3.03	1.13	2.89	1.13	2.36	-
Diptera	-	-	-	-	0.97	-	-	1.99	0.72	1.99	2.81	4.71
Cladocera	-	-	-	2.46	-	1.67	15.15	-	2.74	-	-	-
Ostracoda	-	-	-	-	-	-	-	-	1.58	-	-	1.18
Copepoda	-	-	-	-	-	-	-	-	0.28	-	-	-
Melacostraca	-	-	-	-	-	-	-	-	12.41	-	-	-
Unidentified animal matter	10.52	-	6.76	27.54	8.00	31.25	-	-	-	14.13	15.26	-
Sand particles	5.26	-	2.70	-	-	-	-	14.11	-	-	-	-

Table 26b: Monthly fluctuations in the percentage volume of different food items in the gut of *A. hexagonolepis* (upto 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
1 Chlorophyceae	-	0.08	9.35	3.12	0.60	-	6.03	1.51	43.13	1.51	1.62	0.77
2 Euglenophyceae	-	-	3.60	-	-	-	-	-	6.06	-	-	-
3 Chrysophyceae	-	-	15.10	9.50	18.91	-	-	4.66	0.89	4.63	2.39	2.82
4 Cyanophyceae	-	0.15	0.48	0.10	0.48	-	1.01	3.91	-	3.91	4.73	-
5 Rhodophyceae	-	0.15	0.48	-	-	-	-	-	-	-	-	-
6 Unidentified veg. matter	53.62	65.90	39.57	44.93	38.32	22.20	-	49.34	6.07	46.34	40.21	93.59
7 Protozoa	3.33	-	-	0.10	[illegible]	0.51	4.02	3.63	3.16	3.63	5.72	0.51
8 Rotifera	2.22	1.16	-	2.81	10.58	4.54	3.52	9.99	4.82	9.99	11.36	0.13
9 Nematoda	-	4.62	0.72	2.51	-	-	-	1.26	1.91	1.26	2.32	-
10 Coleoptera	-	23.67	0.72	-	-	0.57	35.25	-	-	-	-	-
11 Odonata	17.51	-	-	-	-	35.71	37.60	-	-	-	-	-
12 Ephemeroptera	-	-	-	-	-	0.26	2.51	7.81	0.64	7.81	8.21	-
13 Diptera	-	-	-	-	0.83	-	-	2.51	5.16	2.51	3.25	1.28
14 Cladocera	-	-	-	5.62	-	0.26	10.05	-	6.16	-	-	-
15 Ostracoda	-	-	-	-	-	-	-	-	2.74	-	-	0.65
16 Copepoda	-	-	-	-	-	-	-	-	2.00	-	-	-
17 Melacostraca	-	-	-	-	-	-	-	-	16.17	-	-	-
18 Unidentified animal matter	22.32	-	18.22	30.19	24.18	35.71	-	-	-	18.43	20.14	-
19 Sand particles	1.85	-	5.28	-	-	-	-	5.43	-	-	-	-

out the year and varied from 0.79% (December) to 57.27% (February). The percentage of Protozoa in the gut content varied from 1.06 (November) to 10.52 (August) and was absent during September and October. Rotifera was present almost throughout the year except during October. Its percentage varied from 1.18 (July) to 15.79 (August). The percentage of Nematoda varied from 1.25 (March) to 32.00 (September). Crustacea was found to be present in the gut content during November, January, February, April and July. Its percentage varied from 1.18 (July to 15.15 (February). Unidentified animal matter varied from 6.76% (October) to 31.25% (January) and was absent during September, February, March, April and July. The percentage of sand particles varied from 2.70 (October) to 14.11 (March) and were recorded only during August, October and March. (The percentage volume of the food items is given in Table 26b).

Monthly variations in the gut content of *A. hexagonolepis* above 150 mm total length):

The percentage number of each item in the gut content of *A. hexagonolepis* above 150 mm during different months of the year has been enumerated in Table 27a from which it can be seen that there were considerable variations in the percentages of different items during different months of the year. Algae and unidentified vegetable matter formed the major items in the gut content. Algae was present almost throughout the year except during October. The percentage of algae varied from 3.99 (September) to 74.01 (April). The

Table 27a: Monthly fluctuations in the percentage number of different food items in the gut of *A. hexagonolepis* (above 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Chlorophyceae	5.26	1.33	-	1.61	-	8.33	7.41	19.35	16.90	6.28	8.23	2.04
Euglenophyceae	-	-	-	-	-	8.33	-	-	-	1.12	2.10	-
Chrysophyceae	10.53	1.33	-	27.74	11.43	35.42	17.78	3.23	57.11	53.70	42.80	3.06
Cyanophyceae	5.26	1.33	-	12.95	2.85	6.25	-	-	-	1.43	1.92	3.06
Unidentified veg. matter	58.10	53.33	41.67	36.57	72.86	-	18.52	45.16	11.27	26.93	29.36	73.13
Protozoa	-	1.33	-	0.75	1.43	-	-	-	-	-	-	-
Rotifera	3.90	32.00	25.00	3.66	1.43	-	18.52	-	1.41	1.63	2.51	2.04
Nematoda	-	-	-	-	1.43	8.33	3.70	6.45	-	3.93	4.22	8.16
Coleoptera	1.20	5.33	-	-	-	0.33	-	-	-	-	-	1.79
Odonata	-	-	8.33	2.40	-	-	-	-	4.23	-	-	-
Ephemeroptera	-	-	-	0.80	-	-	-	-	-	-	-	-
Cladocera	-	-	-	-	-	2.08	1.85	3.23	-	-	-	-
Ostracoda	-	-	-	-	-	2.08	-	-	-	0.56	-	2.04
Melacostraca	10.39	-	-	-	-	-	-	-	4.23	-	3.63	-
Unidentified animal matter	-	-	16.67	6.90	5.71	12.50	7.41	12.90	7.04	5.13	5.22	1.00

Table 27b: Monthly fluctuations in the percentage volume of different food items in the gut of A. hexagonolepis (above 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Chlorophyceae	0.53	0.08	-	0.83	-	88.45	5.71	2.11	18.12	4.64	5.68	1.66
Euglenophyceae	-	-	-	-	-	0.98	-	-	-	0.51	0.89	-
Chrysophyceae	1.06	0.16	-	9.32	1.06	4.17	15.43	0.35	45.31	40.27	30.79	0.23
Cyanophyceae	1.06	0.15	-	1.99	0.39	0.74	-	-	-	0.78	0.85	0.35
Unidentified veg. matter	71.10	69.91	60.68	58.52	93.43	-	37.71	84.36	4.21	46.31	48.40	94.70
Protozoa	-	0.16	-	0.10	0.10	-	-	-	-	-	-	-
Rotifera	12.21	4.62	2.91	8.01	0.19	-	14.86	-	0.81	0.91	1.29	0.12
Nematoda	-	23.67	-	-	0.97	1.23	5.71	7.03	-	1.43	1.70	2.32
Coleoptera	5.05	-	-	-	-	0.98	-	-	-	-	-	0.62
Odonata	-	-	2.43	5.10	-	-	-	-	6.47	-	-	-
Ephemeroptera	-	-	-	7.28	-	-	-	-	-	-	-	-
Cladocera	-	-	-	-	-	0.74	14.20	0.35	-	-	-	-
Ostracoda	-	-	-	-	-	0.49	-	-	-	0.26	-	0.58
Melacostraca	50.00	-	-	-	-	-	-	-	6.47	-	4.39	-
Unidentified animal matter	-	-	19.42	5.60	1.74	1.47	11.43	4.39	8.61	4.64	6.01	4.62

percentage of unidentified vegetable matter varied from 11.27 (April) to 78.13 (July). Unlike the specimens below 150 mm, the specimens above 150 mm in total length did not have insect in their gut contents during all the months. However, when present the percentage of insect varied from 0.33 (January) to 8.33 (October). Protozoa was present only during September, November, and December and its percentage varied from 0.75 (November) to 1.43 (December). The percentage of Rotifera varied from 1.41 (April) to 32.0 (September). It was absent during January and March. The percentage of Nematoda varied from 1.43 (December) to 8.33 (January). Crustacea was present in the gut content for the period January to July and its percentage varied from 0.56 (May) to 4.23 (April). Unidentified animal matter was present in the gut content throughout the year except during September and its percentage varied from 1.00 (July) to 16.67 (October). Sand particle was not encountered in the gut content. The variation of the gut content of A. hexagonolepis as a whole during different seasons has been presented in Fig. 24. (The percentage volume of the food items is given in Table 27b).

Feeding intensity:

The gastro-somatic index (G.S.I.) or in other words, Feeding intensity at different length groups of A. hexagonolepis has been presented in Table 28 and monthly fluctuations of G.S.I. have been presented in Table 29.

Feeding intensity in different length groups of A. hexagonolepis: It can be observed from Fig. 25A that there is no definite trend in feeding intensity, however, there is a wide

Table 28: Fluctuations in the gastro-somatic index in different length-groups of the three species.

Length-groups (mm)	*A. hexagonolepis*	*T. tor*	*T. putitora*
50 - 100	8.131	-	7.417
101 - 150	3.960	3.010	2.236
151 - 200	8.083	2.868	1.920
201 - 250	5.309	2.814	1.196
251 - 300	7.307	3.252	-
301 - 350	7.128	1.233	0.628
351 - 400	-	-	-
401 - 450	6.112	-	-

Table 29: Monthly fluctuations in the gastro-somatic index of *A. hexagonolepis* and *T. tor*

Months		*A. hexagonolepis*	*T. tor*
1978	Aug.	2.985	1.358
	Sept.	6.007	2.964
	Oct.	6.652	1.272
	Nov.	5.345	1.674
	Dec.	4.654	1.071
1979	Jan.	1.609	1.038
	Feb.	1.024	2.188
	Mar.	2.269	2.088
	Apr.	2.952	3.290
	May	5.453	4.501
	Jun.	5.540	4.038
	Jul.	6.628	4.575
	Aug.	1.191	2.213
	Sept.	6.167	2.120
	Oct.	6.850	1.120
	Nov.	7.285	1.361
	Dec.	-	-
1980	Jan.	6.810	2.236
	Feb.	0.656	2.541
	Mar.	3.283	3.172
	Apr.	5.173	3.421
	May	-	-
	Jun.	3.921	2.128
	Jul.	6.703	2.432

fluctuation. The highest G.S.I. was observed in length group I (50-100 mm) and lowest feeding intensity was observed in length group II (101-150 mm).

Seasonal variations in the feeding intensity of *A. hexagonolepis*:

Monthly gastro somatic index of *A. hexagonolepis* during the entire two year period has been presented in Fig. 25B. It is clear from Fig. 25B that there is a wide fluctuation in the feeding intensity showing sharp rise and fall. However, it was highest during October in the first year and November during the second year and lowest during February in the first year and August during the second year in the present study.

Relation between feeding intensity and condition factor in *A. hexagonolepis*: The data on gastro-somatic index and condition factor of *A. hexagonolepis* during different months during the period of study, has been presented in Table 30 and shown in Fig. 26. It is clear that there exists a positive relationship between feeding intensity and condition factor.

Relationship between gut length and body length in *A. hexagonolepis*: The logerithmic relationship between gut lenght (Y) and total body length (X) has been shown in Fig. 27.

The regression equation between these two parameters has been derived as:

$$\text{Log } Y = - 1.0796 + 1.6515 \text{ Log } X$$

The value of correlation coefficient 'r' was found to be 0.8274 (Table 31).

Relationship between weight of gut content and body length in *A. hexagonolepis*: The logerithmic relationship between weight of gut content (Y) and total body length (X) has been presented in Fig. 28. The regression equation between these two parameters has been derived as:

$$\text{Log } Y = -6.0730 + 2.9135 \text{ Log } X$$

The value of correlation coefficient 'r' was found to be 0.9044 (Table 31).

Relative length of the gut of *A. hexagonolepis*: The variation of the relative length of the gut (R.L.G.) with the total length of the fish has been shown in Fig. 29A. The R.L.G. value shows a gradual increase from 1.87 in length group I (50-100 mm) to 3.14 in length group VIII (401-450 mm). It has been observed that there exists a positive relationship between gut length and the percentage of vegetable matter in the gut (Table 32) whereas a negative relationship exists between gut length and the percentage of animal matter in the gut.(Fig. 29A).

Food and feeding habits of *T. tor*: Percentage composition of different food items in the gut of *T. tor* has been summarized in Table 24. The following description of the results is based on the numerical percentage of different items (Fig. 22). The corresponding percentage volume is tabulated in

Table 30: Monthly fluctuations of the condition factors, gonado-somatic index and gastro-somatic index of *A. hexagonolepis*

Months		K. factor	Gonado-somatic index	Gastro-somatic index
1978	Aug.	0.990	3.332	2.985
	Sept.	1.010	1.430	6.007
	Oct.	1.057	0.447	6.652
	Nov.	1.075	0.800	5.345
	Dec.	1.003	0.843	4.654
1979	Jan.	0.857	2.322	1.609
	Feb.	0.850	1.200	1.024
	Mar.	0.919	2.220	2.269
	Apr.	0.695	1.283	2.952
	May	0.962	1.374	5.453
	Jun.	0.996	1.370	5.540
	Jul.	1.036	1.367	6.628
	Aug.	0.870	0.928	1.191
	Sept.	1.170	3.002	6.167
	Oct.	1.170	2.321	6.850
	Nov.	1.180	0.455	7.285
	Dec.	-	-	-
1980	Jan.	1.150	0.854	6.810
	Feb.	1.150	1.736	6.656
	Mar.	1.120	0.111	8.283
	Apr.	0.990	1.248	5.173
	May	-	-	-
	Jun.	0.990	1.608	3.921
	Jul.	1.020	1.408	6.703

Table 31: Regression equations of gut length (Y) on total length (X), and weight of gut content (Y) on total length (X) of the three species

Species	Regression equations of gut length on total length	Correlation co-efficient 'r'
A. hexagonolepis	Log Y = -1.0796 + 1.6515 Log X	0.8274
T. tor	Log Y = -0.5021 + 1.3516 Log X	0.9724
T. putitora	Log Y = -4.6029 + 2.7892 Log X	0.9985
	Weight of gut content on total length :	
A. hexagonolepis	Log Y = -6.0730 + 2.9136 Log X	0.9044
T. tor	Log Y = -4.8757 + 2.2355 Log X	0.7247
T. putitora	Log Y = -3.9865 + 1.7119 Log X	0.7494

Table 24.

From the results, the gut contents of *T. tor* can be grouped into 10 broad groups, viz., i) Algae, ii) Unidentified vegetable matter, iii) Protozoa, iv) Nematoda, v) Insecta, vi) Crustacea, vii) Hydracarina, viii) Gastropoda, ix) Unidentified animal matter and x) Sand particles.

i) **Algae:**

This group formed 35.88% in the gut content and was represented by Chlorophyceae, Bacillariophyceae and Cyanophyceae.

a) Chlorophyceae: This group was represented by *Spirogyra*, *Hyalotheca*, *Ulothrix*, *Closterium* and *Pleurodiscus*. *Spirogyra* was the most abundant genera. Chlorophyceae formed 17.31% of the gut content.

b) Bacillariophyceae: This group of algae was represented by *Navicula*, *Fragilaria*, *Cymbella*, *Pinnularia*, *Surirella*, *Amphora* *Tabellaria*, *Achanthes*, *Gamphonema*, *Gamphoneis*, *Diatoma*, *Pleurosigma* and *Surirella* in varying percentages. And the group as a whole formed 18.102% of the gut content. *Navicula* was found to be most abundant followed by *Fragilaria*.

c) Cyanophyceae: This group of algae formed 0.47% of the gut content and was represented by *Spirulina*, and *Oscillatoria*.

ii) Unidentified vegetable matter:

This was the most important item in the gut content next to algae, forming 31.89% in the gut content and was represented by macrophytes, decaying vegetable matter, seeds and spores.

iii) Protozoa:

It formed 0.34% of the gut content.

iv) Nematoda:

It formed 1.31% of the gut content.

v) Insecta:

This group was represented by larvae and adult of Coleoptera, Odonata, Ephemeroptera and Diptera in varying percentages and formed 12.99% of the total gut content. Among insects, larvae of Ephemeroptera were found to be the most abundant, followed by larvae of Diptera.

vi) Crustacea:

This group was represented by Cladocera, Copepoda and and formed 1.65% of the gut content.

vii) Hydracarina:

It formed 0.45% of the gut content.

viii) Gastropoda:

It formed 3.68% of the gut content.

ix) Unidentified animal matter:

This was represented by semi-digested animal matter and invertebrate eggs and formed 4.36% of the gut content.

x) Sand particles:

It formed 7.35% of the gut content.

Gut contents of *T. tor* in different length groups:

The relative importance of the broad items in the gut contents of *T. tor* in different length groups has been shown in Fig. 30 and the percentage composition of different items has been presented in Table 33.

Length group I (101-150 mm): Algae was the most prefered item and comprised 38.27% of the gut content followed by unidentified vegetable matter (20.58%). Insect was the next important food item (17.68%) and was represented mainly by larval forms. Other items encountered were Crustacea (3.25%), Hydracarina (0.72%), Gastropoda (3.25%), Unidentified animal matter (3.25%) and Sand particles (5.839%).

Length group II (151-200 mm): In this group unidentified vegetable matter was the most abundant food item (37.93%). Algae was the second most prefered item (24.15%). Insects formed 21.55% of the gut content represented by larval forms. Other items were Nematoda (3.45%), Crustacea (1.72%), Hydracarina (0.86%), Gastropoda (5.17%), Unidentified animal matter (0.86%) and Sand particles (4.31%).

Table 32: Percentage of vegetable and animal matter in the gut of the three species and relative length of their gut.

Length group (mm)	*A. hexagonolepis*			*T. tor*			*T. putitora*		
	V.M.	A.M.	R.L.G.	V.M.	A.M.	R.L.G.	V.M.	A.M.	R.L.G.
50 - 100	55.99	44.01	1.87	-	-	-	25.95	70.15	1.25
101 - 150	64.26	35.74	1.89	39.06	58.46	1.74	49.43	50.64	1.73
151 - 200	61.26	38.74	2.39	39.89	58.22	1.98	46.39	52.25	1.73
201 - 250	70.13	29.87	2.45	53.38	41.67	2.09	77.83	22.17	2.56
251 - 300	81.76	18.24	2.62	93.73	6.28	2.01	-	-	-
301 - 350	89.52	10.48	2.77	93.95	6.09	2.88	-	-	1.19
351 - 400	-	-	-	-	-	-	-	-	-
401 - 450	93.49	6.51	3.14	-	-	-	-	-	-

Note: V.M = Vegetable matter (%); A.M. = Animal matter (%)
R.L.G. = Relative length of gut.

Table 33: Percentage of different food items in different length groups of *T. tor*.

Food items	101 - 150 (mm)		151 - 200 (mm)		201 - 250 (mm)		251 - 300 (mm)		301 - 350 (mm)	
	%N	%V	%N	%V	%N	%V	%N	%V	%N	%V
Chlorophyceae	11.55	5.27	8.20	0.91	19.77	8.16	73.35	55.48	81.03	63.46
Chrysophyceae	26.35	4.28	15.95	2.07	30.22	4.30	6.01	0.91	-	-
Cyanophyceae	0.36	0.09	-	-	0.27	0.16	5.25	0.51	-	-
Unidentified veg. matter	20.59	29.43	37.93	36.91	22.76	40.76	14.10	36.81	15.36	30.49
Protozoa	0.72	0.45	-	-	-	-	-	-	-	-
Nematoda	1.08	0.68	3.45	3.76	1.24	1.09	0.85	2.23	0.25	2.03
Coleoptera	-	-	1.72	2.27	0.27	1.25	-	-	-	-
Odonata	1.80	2.03	2.59	11.35	1.36	4.68	-	-	-	-
Ephemeroptera	10.83	20.21	6.03	6.81	5.42	12.16	-	-	-	-
Diptera	5.05	11.48	11.21	16.64	3.52	8.88	0.25	1.01	-	-
Cladocera	-	-	0.86	0.76	-	-	-	-	0.25	1.01
Copepoda	1.81	4.50	-	-	0.27	0.16	-	-	-	-
Ostracoda	1.08	1.35	0.86	0.38	0.27	0.16	-	-	-	-
Hydracarina	0.72	1.80	0.86	0.76	0.27	0.16	-	-	3.10	3.04
Melacostraca	0.36	2.25	-	-	-	-	-	-	-	-
Gastropoda	3.25	11.16	5.17	15.13	3.25	11.53	-	-	-	-
Unidentified animal matter	3.25	2.57	0.86	0.38	1.08	1.56	0.25	3.04	-	-
Sand particles	5.84	2.48	4.31	1.89	10.03	5.02	-	-	-	-

Note : N = Number; V = Volume.

Length group III (201-250 mm): Algae was found to be the most prefered food item (50.25%) in the total gut content followed by unidentified vegetable matter (22.76%). Insects formed 10.57% of the gut content and was represented by both larval and adult forms. Other items found were Nematoda, 1.24%; Crustacea (0.54%), Hydracarina (0.27%), Gastropoda (3.25%), Unidentified animal matter (1.08%), and Sand particles (10.03%).

Length group IV (251-300 mm): Algae formed 84.61% of the gut content. The next important item was found to be unidentified vegetable matter (14.10%). Other items recorded were Nematoda (0.851%), Insecta (0.251%), and Unidentified animal matter (0.251%).

Length group V (301-350 mm): Algae formed 81.03% of the gut content. Other items were Unidentified vegetable matter (15.36%), Nematoda (0.25%), Insecta (0.25%) and Crustacea (3.10%).

Seasonal variations in the gut contents of *T. tor* (upto 150.0 mm total length):

The percentage number of different items in the gut content of *T. tor* (upto 150.0 mm total length) during different months has been enumerated in Table 34a from which it can be seen that there are considerable variations in the diet composition during different months. The algae and unidentified vegetable matter were found to be the most

Table 34a: Monthly fluctuations in the percentage number of different food items in the gut of *T. tor* (upto 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Chlorophyceae	-	1.08	1.89	-	1.67	3.76	19.20	25.00	32.47	24.00	20.27	-
Chrysophyceae	-	1.08	-	27.11	20.00	23.65	26.40	31.25	12.99	26.47	6.76	-
Cyanophyceae	-	-	-	-	-	-	-	-	-	-	40.54	0.25
Unidentified veg. matter	69.44	63.40	62.79	49.15	25.01	16.13	13.24	5.00	19.48	21.54	-	80.00
Protozoa	-	2.15	-	-	-	-	-	-	-	-	-	-
Nematoda	-	2.15	1.89	-	1.67	6.51	2.94	-	-	-	-	-
Coleoptera	-	-	-	-	3.33	1.08	-	-	-	-	4.05	-
Odonata	-	1.08	8.89	-	3.33	1.08	2.94	2.50	-	-	2.70	-
Ephemeroptera	4.65	6.50	5.66	16.95	6.67	7.53	14.70	11.24	6.49	7.00	-	-
Diptera	2.33	10.80	12.22	1.69	11.67	4.30	5.88	5.00	5.19	4.00	-	6.25
Cladocera	-	-	-	-	1.66	0.54	-	-	9.09	-	10.81	-
Copepoda	-	-	-	-	-	-	-	-	2.60	5.00	6.76	-
Ostracoda	-	1.08	1.89	-	-	-	-	-	-	3.00	-	-
Hydracarina	-	1.08	1.89	-	-	-	2.94	1.25	1.30	1.00	-	-
Melacostraca	9.30	-	-	-	-	-	1.47	3.75	-	-	-	-
Gastropoda	-	-	-	5.08	16.67	38.71	5.88	6.25	-	-	-	-
Unidentified animal matter	14.28	9.68	1.89	-	-	-	-	1.25	7.80	2.00	8.11	6.25
Sand particles	-	-	-	-	8.33	3.23	4.11	7.50	2.60	6.00	-	7.25

Table 34b: Monthly fluctuations in the percentage volume of different food items in the gut of *T. tor* (upto 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Chlorophyceae	-	0.12	0.18	-	0.26	1.11	3.14	4.27	11.86	14.18	4.13	-
Chrysophyceae	-	0.59	-	8.91	3.88	4.35	4.64	6.78	3.39	4.78	0.83	-
Cyanophyceae	-	-	-	-	-	-	-	-	-	-	53.72	0.48
Unidentified veg. matter	71.43	55.04	53.93	24.81	30.08	29.37	8.47	8.47	33.05	39.74	53.72	70.60
Protozoa	-	0.24	-	-	-	-	-	-	-	-	-	-
Nematoda	-	1.18	2.01	-	1.65	0.46	1.37	-	-	-	-	-
Celeoptera	-	-	-	-	3.90	2.77	-	-	-	-	8.26	-
Odonata	-	11.83	18.28	-	6.50	4.63	7.93	14.41	-	-	4.13	-
Ephemeroptera	6.74	9.47	5.48	29.92	7.74	14.26	31.43	26.27	9.32	11.31	-	-
Diptera	0.67	18.34	16.45	15.38	16.77	16.67	8.20	6.78	8.48	10.56	-	4.20
Cladocera	-	-	-	-	1.29	0.93	-	-	12.71	-	13.22	-
Copepoda	-	-	-	-	-	-	-	-	3.39	15.08	5.79	-
Ostracoda	-	0.59	0.91	-	-	-	-	-	-	4.52	-	-
Hydracarina	-	1.18	1.83	-	-	-	1.37	3.39	3.39	4.52	-	-
Melacostraca	14.15	-	-	-	-	-	6.83	5.08	-	-	-	-
Gastropoda	-	-	-	20.92	25.81	24.81	24.59	20.34	-	-	-	-
Unidentified animal matter	7.01	1.42	0.91	-	-	-	-	2.54	11.02	13.57	9.92	21.00
Sand particles	-	-	-	-	3.23	0.65	2.05	1.69	3.39	4.52	-	3.36

important items in the gut content. The percentage composition of algae varied from 1.89 (October) to 56.25 (March). It was absent during August and July. Insects were found to be present thoughout the period of study in the gut. The percentage composition of this group varied from 6.25 (July) to 26.77 (October). Protozoa was recorded only during September, October, December, January and February with a percentage variation of 1.67 (December) to 6.51 (January). The percentage composition of Crustacea varied from 0.54 (January) to 17.57 (June). Hydracarina were encountered only from May (1.0%) to October (1.89%). Gastropoda occurred in the gut content only for a period of five months (November-March) and its percentage varied from 5.08 (November) to 38.71 (January). The percentage of unidentified animal matter in the gut content varied from 1.25 (March) to 14.28 (August). It was absent during November to February. The percentage of sand particles varied from 2.60 (April) to 8.33 (December). It was absent in the gut content during August-November and again during June. (The percentage volume of the food items is given in Table 34b).

Seasonal variations in the gut contents of *T. tor* (above 150.0 mm total length):

The percentage number of different items in the gut contents of *T. tor* (above 150.0 mm total length) during different months has been enumerated in Table 35a. Algae and unidentified vegetable matters formed the most prefered items in the gut. The percentage of algae varied from 7.25 (August) to 86.60 (May). Unidentified vegetable matter was present in the gut content throughout the year and its percentage varied

Table 35a: Monthly fluctuations in the percentage number of different food items in the gut of *T. tor* (above 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Chlorophyceae	2.94	-	-	4.13	-	8.54	5.80	14.71	24.39	81.91	35.45	-
Chrysophyceae	-	8.82	27.06	38.82	31.32	43.90	52.17	22.06	13.01	4.09	21.99	-
Cyanophyceae	4.31	-	-	-	-	-	-	-	12.20	0.60	-	6.25
Unidentified veg. matter	73.53	50.00	30.07	25.29	30.13	23.17	17.40	19.12	8.13	10.43	14.18	55.00
Nematoda	-	1.47	-	0.59	-	-	1.44	-	1.63	0.43	-	-
Coleoptera	2.94	-	4.41	0.59	2.41	1.22	2.90	2.94	-	-	-	-
Odonata	2.94	2.94	2.50	0.59	7.23	14.63	-	-	3.25	-	-	-
Ephemeroptera	2.94	17.65	6.02	9.41	-	4.88	5.80	4.41	6.50	0.21	4.96	-
Diptera	8.82	5.90	5.88	5.90	-	-	-	-	5.69	0.43	7.09	6.25
Cladocera	-	-	-	-	-	-	1.45	1.47	-	-	-	-
Copepoda	-	-	-	-	-	-	1.45	7.35	-	-	-	-
Ostracoda	-	-	-	-	-	-	1.45	5.88	7.32	-	-	-
Malacostraca	-	-	-	-	-	-	-	-	3.25	-	-	-
Gastropoda	2.94	3.82	13.53	6.47	10.84	2.44	1.45	2.94	-	-	-	-
Unidentified animal matter	-	-	-	2.35	6.02	-	-	8.82	-	0.21	3.55	12.50
Sand particles	-	4.41	10.53	5.29	10.84	-	8.70	10.29	14.63	7.59	12.77	20.00

Table 35b: Monthly fluctuations in the percentage volume of different food items in the gut of *T. tor* (above 150 mm total length)

Food items	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Chlorophyceae	0.71	-	-	0.77	-	1.22	2.68	1.53	4.29	71.57	12.66	-
Chrysophyceae	-	0.68	3.97	3.50	3.98	3.25	12.87	9.16	2.86	2.19	8.23	-
Cyanophyceae	1.42	-	-	-	-	-	-	-	3.57	0.78	-	0.84
Unidentified veg. matter	59.57	59.30	37.90	39.88	39.37	35.15	45.38	34.35	2.85	15.61	37.98	69.40
Nematoda	-	3.63	-	0.26	-	-	1.34	-	5.71	2.35	-	-
Colepptera	11.35	-	2.52	2.06	3.20	3.25	5.36	3.82	11.43	-	-	-
Odonata	11.35	11.34	2.31	1.55	32.83	2.44	-	-	10.00	-	-	-
Ephemeroptera	1.42	3.40	9.37	18.03	-	22.01	10.72	7.63	-	0.78	9.49	-
Diptera	7.09	6.35	18.01	18.29	-	13.02	-	-	-	3.13	13.29	4.20
Cladocera	-	-	-	-	-	-	3.34	2.29	10.71	-	-	-
Copepoda	-	-	-	-	-	-	5.36	5.34	-	-	-	-
Ostracoda	-	-	-	-	-	-	5.83	6.87	10.71	-	-	-
Melacostraca	-	-	-	-	-	-	-	-	14.29	-	-	-
Gastropoda	7.09	12.47	20.17	10.30	14.05	19.65	5.36	8.40	-	-	-	-
Unidentified animal matter	-	-	-	2.58	6.09	-	-	9.16	-	2.35	10.76	22.20
Sand particles	-	2.83	5.76	2.03	5.50	-	8.04	11.45	14.63	1.17	7.60	3.36

from 8.13 (April) to 73.53 (August). Insect was the next important food item and was found to be present throughout the year. Its percentage varied from 0.64 (May) to 26.49 (September). Nematoda was present during September, November, February, April and May. It varied from 0.43% (May) to 1.63% (April). Crustacea was present only during February to April and varied from 4.35% (February) to 14.70% (March). Hydracarina was present only during April (3.35%). Gastropoda was present in the gut during the period from August to March. Its percentage varied from 1.45 (February) to 13.53 (October). The percentage varied from 0.21 (March) to 12.50 (July) in the gut. Sand particles occurred almost throughout the year in the gut content except during August and January with a varying percentage of 5.29 (November) to 20.00 (July). Seasonal variation of the gut contents in *T. tor* has been shown in Fig. 31. (The percentage volume of the food items is presented in Table 35b).

Feeding intensity in *T. tor*:

The data of gastro-somatic index (G.S.I.) of *T. tor* at different length groups and the monthly fluctuations of the G.S.I. have been presented in Table 28 and Table 29 respectively.

Feeding intensity in *T. tor* at different length groups: It can be observed from Fig. 32A that there is no definite trend in the feeding intensity. However, highest feeding intensity (G.S.I.) has been observed in length group IV (251-300 mm) and the lowest in length group V (301-350 mm).

Seasonal variations in the feeding intensity in *T. tor*: Monthly variations in the G.S.I. during the period of study has been shown in Fig. 32B. It is clear from the figure that there is a wide fluctuation in the feeding intensity. The highest value has been recorded during May in the first year whereas in April during the second year of study and the lowest during October in both the year of study.

Relationship between feeding intensity and condition factor in *T. tor*: The data on gastro-somatic index and condition factor of *T. tor* during different months of the period of study has been tabulated in Table 30 and has been presented in Fig. 33. It is clear from the figure that there exists a positive relationship between feeding intensity and condition factor.

Relationship between gut length and body length of *T. tor*: The logerithmic relationship between gut length (Y) and total body length (X) has been shown in Fig. 34A. The regression equation between these two parameters has been derived as:

$$\text{Log}Y = -0.5021 + 1.3516 \text{ Log } X$$

The value of correlation coefficient 'r' was found to be 0.9724 (Table 31).

Relationship between weight of gut content and body length:

The logerithmic relationship between weight of gut content (Y) and total body length (X) has been shown in Fig. 34B. The regression equation between these two parameters has been derived as:

$$\text{Log } Y = - 4.8757 + 2.2355 \text{ Log } X$$

The value of correlation coefficient was found to be 0.7247 (Table 31).

Relative length of the gut of *T. tor*:

The variation of the relative length of the gut (R.L.G.) with the total length of the fish has been shown in Fig. 35A. The R.L.G. value shows a gradual increase from 1.74 in length group I (101-150 mm) to 2.88 in length group V (301-350 mm). A positive relationship has been observed between gut length and the amount of vegetable matter in the gut whereas a negative relationship has been observed between gut length and the amount of animal matter in the gut content (Fig. 35B) and Table 32).

Food and feeding habits of *T. putitora*:

The percentage composition of different items in the gut content of *T. putitora* has been summarized in Table 24. The following description is based on the numerical percentage of different food items. The corresponding percentage volume has been summarized in Table 24.

The gut contents of *T. putitora* (Fig. 20) can be grouped into 12 broad groups, i.e. i) Algae, ii) Unidentified vegetable matter, iii) Protozoa, iv) Rotifera, v) Nematoda, vi) Insecta, vii) Crustacea, viii) Eubranchiopoda, ix) Hydracarina, x) Gastropoda, xi) Unidentified animal matter, xii) Sand particles.

i) Algae:

This group formed 19.61% in the gut content and was represented by Chlorophyceae and Chrysophyceae.

a) Chlorophyceae: This group of algae was represented by Hyalotheca and Ulothrix and formed 3.01% of the gut content.

b) Chrysophyceae: This group was represented by Fragilaria, Gamphonema, Navicula, Pinnularia, Surirella, Amphora, and Cymbella. Among these genera Fragilaria was the most abundant and the group as a whole formed 16.53% of the gut content.

ii) Unidentified vegetable matter:

This was the most prefered item in the gut content of T. putitora forming 33.46% of the total gut content and was represented by macrophytes, decaying vegetable matter, seed-coat and spore.

iii) Protozoa:

It formed 1.15% of the gut content.

iv) Rotifera:

It formed 0.38% of the gut content.

v) Nematoda:

It formed 1.54% of the gut content.

vi) Insecta:

This group was represented by larva and adult of Coleoptera, Odonata, Ephemeroptera and Diptera in varying percentages and formed 29.10% of the gut content. Among insects, larvae of Ephemeroptera were found to be the most abundant followed by larvae of Diptera.

vii) Crustacea:

This group formed 1.77% of the total gut content and were represented by Cladocera and Copepoda.

viii) Eubranchipoda:

It formed 0.38% of the gut content.

ix) Hydracarina:

It formed 0.38% of the gut content.

x) Gastropoda:

It formed 1.38% of the gut content and was represented by larva only.

xi) Unidentified animal matter:

This item was represented by semi-digested animal matter and invertebrate eggs. It formed 9.10% of the gut content.

xii) Sand particles:

It formed 1.75% of the gut content.

Gut contents of *T. putitora* in different length groups:

The relative importance of different food items in different length groups has been shown in Fig. 36 and percentage composition of food items has been presented in Table 37.

Length group I (50-100 mm): Algae was the most important item and formed 20.0% of the gut content. The next important item was unidentified animal matter which form 36.67% of the gut content. The insects formed 16.66% of the gut content. Other items were Nematoda (10.0%), and Sand particles (3.33%).

Length group II (101-150 mm): Unidentified vegetable matter was found to be the most important food item in this length group, forming 36.21% of the gut content. The next was algae (28.37%). Insecta formed 23.62% of the gut content. Other food items were, Protozoa (0.79%), Eubranchiopoda (0.77%), Rotifera (0.79%), Nematoda (1.57%), Unidentified animal matter (0.79%), Sand particles (7.1%).

Length group III (151-200 mm): Algae was the most important item and formed 46.13% of the gut content whereas unidentified vegetable matter formed 55.17%. Crustacea formed 1.76% of the

Table 36: Monthly fluctuations in the condition factor and gastro-somatic index of *T. tor*

Months		K-factor	Gastro-somatic index
1978	Aug.	0.990	1.358
	Sept.	1.060	2.964
	Oct.	0.880	1.272
	Nov.	0.870	1.674
	Dec.	0.860	1.077
1979	Jan.	0.883	1.038
	Feb.	0.802	2.188
	Mar.	0.840	2.088
	Apr.	0.932	3.290
	May	1.024	4.501
	Jun.	1.037	4.038
	Jul.	1.050	4.575
	Aug.	1.010	2.213
	Sept.	1.030	2.120
	Oct.	0.823	1.120
	Nov.	0.850	1.361
	Dec.	-	-
1980	Jan.	0.807	2.236
	Feb.	0.832	2.541
	Mar.	0.908	3.172
	Apr.	0.911	3.421
	May	-	-
	Jun.	1.010	2.128
	Jul.	1.030	2.432

Table 37: Percentage of different food items in different length groups of *T. putitora*

Food items	50 - 100 (mm)		101 - 150 (mm)		151 - 200 (mm)		201 - 250 (mm)	
	%N	%V	%N	%V	%N	%V	%N	%V
Chlorophyceae	-	-	5.51	1.08	0.88	0.15	-	-
Chrysophyceae	20.00	1.54	22.86	2.85	35.14	2.70	-	-
Unidentified veg. matter	13.33	24.42	36.21	20.47	46.17	43.54	80.00	77.83
Protozoa	-	-	0.79	0.98	1.77	0.53	-	-
Rotifera	-	-	0.79	0.20	-	-	-	-
Nematoda	10.00	1.94	1.57	0.39	0.88	0.15	-	-
Coleoptera	-	-	-	-	1.77	2.25	-	-
Odonata	3.33	7.75	-	-	1.55	3.38	-	-
Ephemeroptera	3.33	3.88	19.69	28.51	1.93	26.88	19.90	22.17
Diptera	10.00	31.01	3.94	5.41	1.73	14.79	-	-
Cladocera	-	-	-	-	0.88	1.50	-	-
Eubranchiopoda	-	-	0.79	0.49	0.88	1.08	-	-
Hydracarina	-	-	-	-	1.65	-	-	-
Unidentified animal matter	36.67	36.67	0.79	1.97	-	1.65	-	-
Sand particles	3.33	3.33	7.08	12.62	4.42	1.35	-	-

Note: N = Number; V = Volume.

gut content. Other items were Protozoa (1.77%), Nèmatoda (0.88%), Hydracarina (0.88%), Unidentified animal matter (2.65%), and Sand particles (4.42%).

Length group IV (201-250 mm): The gut content of this group was constituted mainly by unidentified vegetable matter (80.00%) and insects (19.91%).

Seasonal variations in the gut contents of *T. putitora*:

The percentage composition of the gut contents of *T. putitora* has been recorded for different seasons (summer, monsoon and winter) and has been summerized in Table 38.

Summer: Algae was found to be the most prefered item during summer forming 47.30% of the gut content. Unidentified vegetable matter was next in order of importance and formed 21.64%. Insects formed 12.05% of the gut content. Other items were Crustacea (6.87%), Eubranchiopoda (2.44%), Hydracarina (0.89%), Unidentified animal matter (4.79%) and Sand particles (4.02%).

Monsoon: Unlike summer unidentified vegetable matter formed the most prefered item in the gut content of *T. putitora* during monsoon (68.34%). Insect was next in order of importance (14.61%). Algae formed 4.01% of the gut content during this season. Other items were Protozoa (0.54%), Rotifera (0.40%), Nematoda (1.01%), Eubranchiopoda (0.74%), Hydracarina (0.74%), Unidentified animal matter (8.05%) and Sand particles (1.82%).

Winter: Alike summer algae formed the most important group

Table 38: Seasonal fluctuations in the percentage of different food items in the gut of *T. putitora*

Items	Summer		Monsoon		Winter	
	% N	% V	% N	% V	% N	% V
Chlorophyceae	24.56	7.16	1.74	0.10	22.12	11.13
Chrysophyceae	22.74	4.51	2.27	0.18	23.90	5.44
Unidentified veg. matter	21.64	38.14	68.09	58.77	25.47	23.18
Protozoa	-	-	0.54	0.07	-	-
Rotifera	-	-	0.40	0.55	-	-
Nematoda	-	-	1.01	0.97	2.73	0.62
Coleoptera	-	-	-	-	1.08	1.66
Odonata	1.64	5.36	2.50	9.14	1.81	4.75
Ephemeroptera	6.86	12.07	4.20	6.58	11.28	36.59
Diptera	3.55	6.11	7.91	12.04	5.80	14.26
Cladocera	2.27	3.01	-	-	0.54	0.55
Copepoda	4.60	7.50	-	-	-	-
Eubranchiopoda	2.44	2.44	0.74	0.46	-	-
Hydracarina	0.89	2.67	0.74	0.91	0.72	0.34
Unidentified animal matter	4.79	8.76	8.05	9.21	-	-
Sand particles	4.02	2.27	1.82	1.02	3.93	1.48

Note : N = number; V = volume

during winter in the gut content of *T. putitora* (46.02%) followed by unidentified vegetable matter (25.47%). Insect was the next prefered food item (19.97%). Other items were Nematoda (2.73%), Crustacea (0.54%), Hydracarina (0.72%), Sand particles (3.93%).

Feeding intensity in *T. putitora*:

The gastro-somatic index (G.S.I.) at different length groups of *T. putitora* has been presented in Table 28 and the seasonal fluctuations have been presented in Table 19.

Feeding intensity in *T. putitora* at different length groups: It can be observed from Fig. 38A that feeding intensity shows a decreasing trend from lower to higher length group. The highest G.S.I. (7.417) was observed in the length group I (50-100 mm) and the lowest G.S.I. (0.628) in the length group VI (301-350 mm).

Seasonal variations in the feeding intensity of *T. putitora*: The G.S.I. of *T. putitora* during different seasons (summer, monsoon, and winter) has been presented in Table 19 and shown in Fig. 38B. It is clear from the figure that feeding intensity is higher during summer and lower during winter.

Relationship between feeding intensity and condition factor in *T. putitora*: The data of gastro-somatic index and condition factor in *T. putitora* during different seasons have been presented in Table 19 and shown in Fig. 39.

It is clear from the Fig. 39 that there exists a positive relationship between feeding intensity and condition factor.

Relationship between gut length and body length in *T. putitora*:

The relationship between gut length (Y) and total length (X) has been presented in Fig. 40A. The regression equation between these two parameters derived as:

$$\text{Log } Y = -4.6029 + 2.7892 \text{ Log } X.$$

The value of correlation coefficient 'r' was found to be 0.9985 (Table 31).

Relationship between weight of gut content and body length in *T. putitora*:

The logerithmic relationship between weight of gut content (Y) and total body length (X) has been shown in Fig. 40B. The regression equation between these two parameters is derived as:

$$\text{Log } Y = -3.9865 + 1.7119 \text{ Log } X.$$

The value of correlation coefficient is found to be 0.7494 (Table 31).

Relative length of the gut (R.L.G.) in *T. putitora*:

The variation of the R.L.G. with the total length of the fish has been shown in Fig. 41B.

The R.L.G. value shows an increasing trend from 1.245 in length group I (50-100 mm) to 2.456 in length group IV (201-250 mm). A positive relationship has been observed between gut length and the amount of vegetable matter in the gut content, and a negative relationship between gut length and the amount of animal matter in the gut content (Fig. 41B and Table 32).

DISCUSSION

D I S C U S S I O N

MORPHOMETRIC AND MERISTIC CHARACTERS

In the present study, an attempt has been made to compare the morphometric and meristic characters between two populations of A. hexagonolepis from Simsang and Pagladia rivers. Interspecific variations in the two populations have been observed in various morphometric characters, viz. head depth, eye diameter and rostral-barbel length, were found to be significantly higher in the specimens from Pagladia River (Table 5), whereas snout length, gape and number of lateral line scales were found to be significantly higher in the specimens from the Simsang river. Such variations are also quite evident from the differences in the regression equations (Table 4). However, statistically significant difference (at 5% level) could only be observed in the case of number of lateral line scales. Such variations can only be attributed to the different ecological conditions which suggest the adaptability of organisms to their new environment as has also been pointed out by many workers (Schmidt, 1921; Vladykov, 1934; Taning, 1944; Lindsay, 1954; Fage, 1958; Barlow, 1961; Tandon, 1977; Suzuki and Yamaguchi, 1980; Kaur, 1981).

According to Gould (1966) ratios between morphological characters will not necessarily be constant for the organisms of the same species due to variation resulting from differences in sex, race and nutrition and/or 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 environments and in particular the thermal factor during the period of incubation and the beginning of larval life (Schmidt, 1921; Vladykov, 1934; Taning, 1944; Lindsay, 1954; Fage, 1958; Barlow, 1961). According to Hubbs (1922) and Tanning (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.

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 with the effect of the duration of periods of growth and of the relating differentiations which determines the number of vertebrae and of segments. Many authors (Schmidt, 1921; Vladykov, 1934; Taning, 1944; Lindsay, 1954; Barlow, 1961) have reported that meristic characters exhibit plasticity under the influence of environmental factors, as has also been seen in the present study.

According to the observations of Hora (1939) the most distinguishing character between T. tor and T. putitora is that, in the former head length is considerably shorter than body depth whereas in the latter, head length is considerably greater than the body depth which has also been observed in the present observations (Table 7). Apart from these differences a considerable difference in other parameters between T. tor and T. putitora have also been observed in the present study such as head length, body depth, girth (expressed as percentage of total length), inter-orbital distance, gape, rostral barbel length (expressed as percentage of head length) was found to be greater in *T. putitora*.

In *A. hexagonolepis*, it has been observed that the males have greater dorsal fin height whereas the females were found to have greater girth, gape and maxilary-barbel length. In the case of *T. tor* it is seen that males have greater height of pectoral fin and females have greater length of free margin of dorsal fin, eye diameter and maxilary-barbel length and also the predorsal length, snout length and gape. The difference in the morphometric parameters between males and females of *T. putitora* are not so well defined.

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 are slightly larger than the females. A similar results have been found in case of *A. hexagonolepis* and *T. tor* in the present study. Nikolsky (1963) 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 Sculpins, *Cotio comephorus*, the thoracic fins were found to be significantly larger (Nikolsky, 1963). He further stated that in *Xiphophorus* (Fam. Poccilidae) there is a long outgrowth on the caudal fin 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 male than in the female of the 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 Tinch 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-diamorphic characters.

The morphometric ratios and meristic counts in A. hexagonolepis, Tor tor and T. putitora observed in the present study, were found to be quite similar as observed by earlier workers (McClelland, 1839; Hora, 1940a, c; Hamilton, 1822) in all the above mentioned three species.

Biometric study of A. hexagonolepis (Fig. 3) revealed that the eye diameter becomes smaller in relation to head length. A similar case has been reported by Tobor (1974) for Lates niloticus and Kaur (1981) for Channa gachua. The biometric indices of head length, girth and inter-orbital distance were found to be almost 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

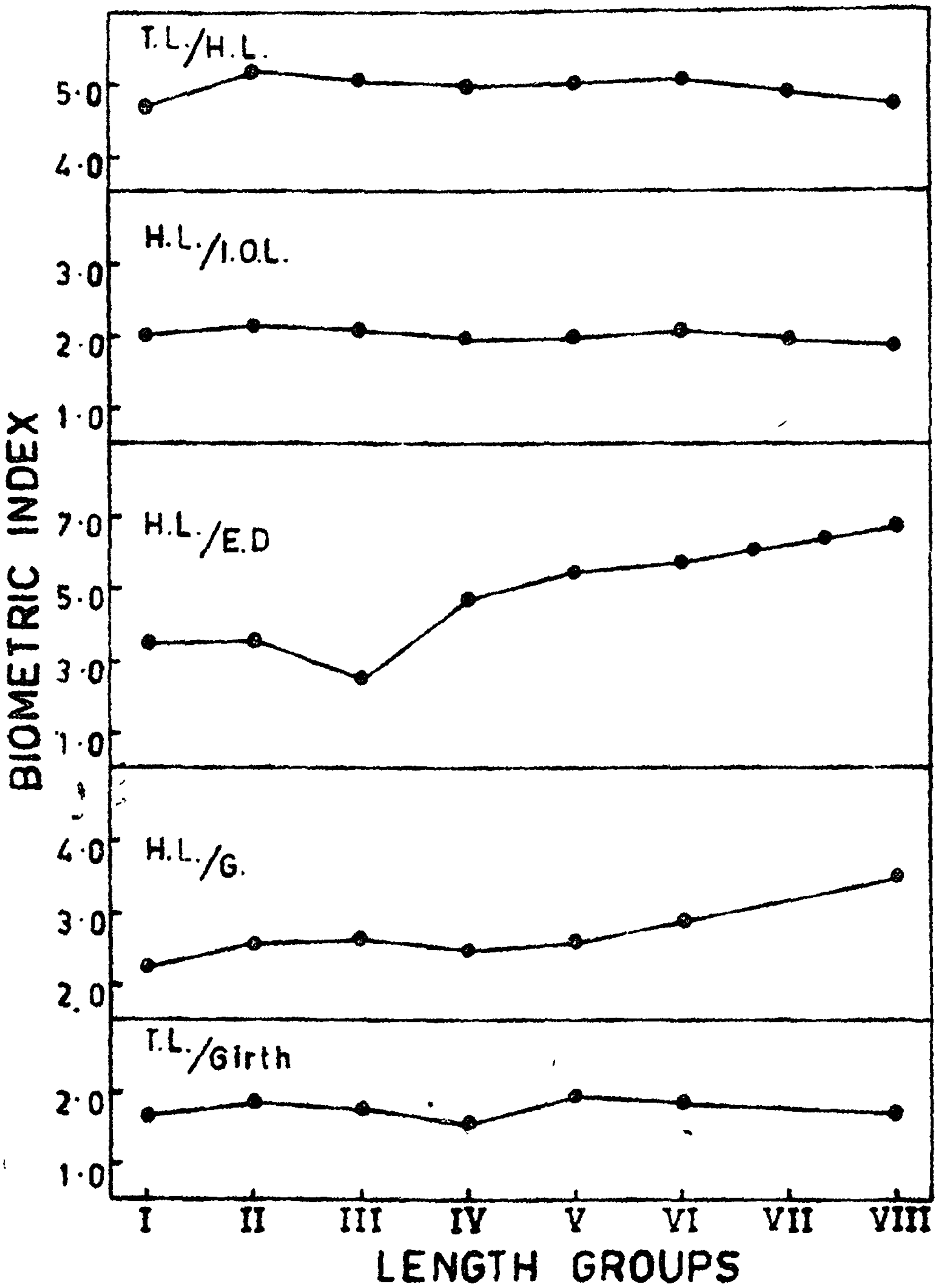


Fig.3. Biometric indices of *A. hexagonolepis* from Simsang river.

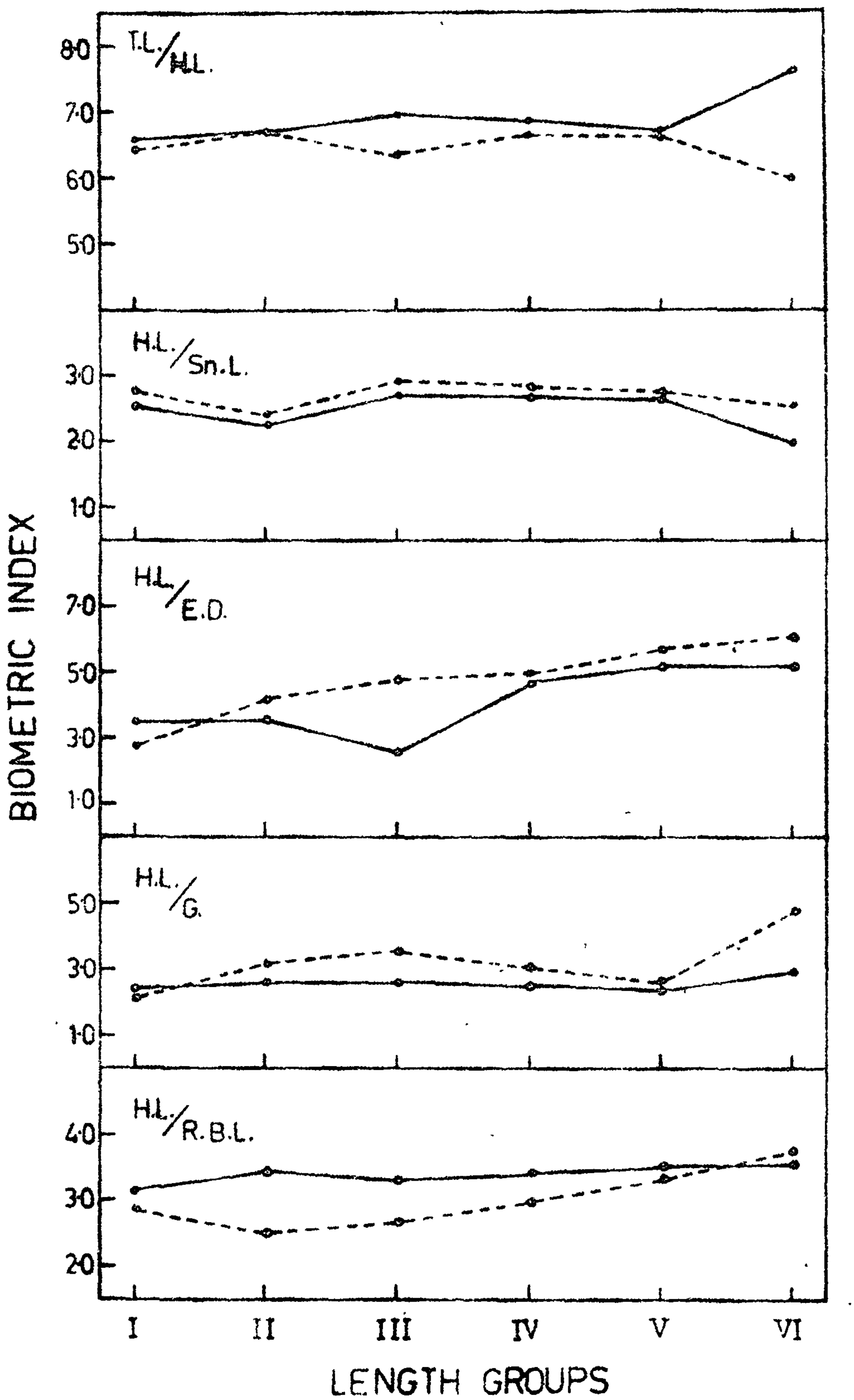


Fig. 4. Comparative biometric indices of *A. hexagonolepis* from Simsang river (——) and Pagladia river (- - - -).

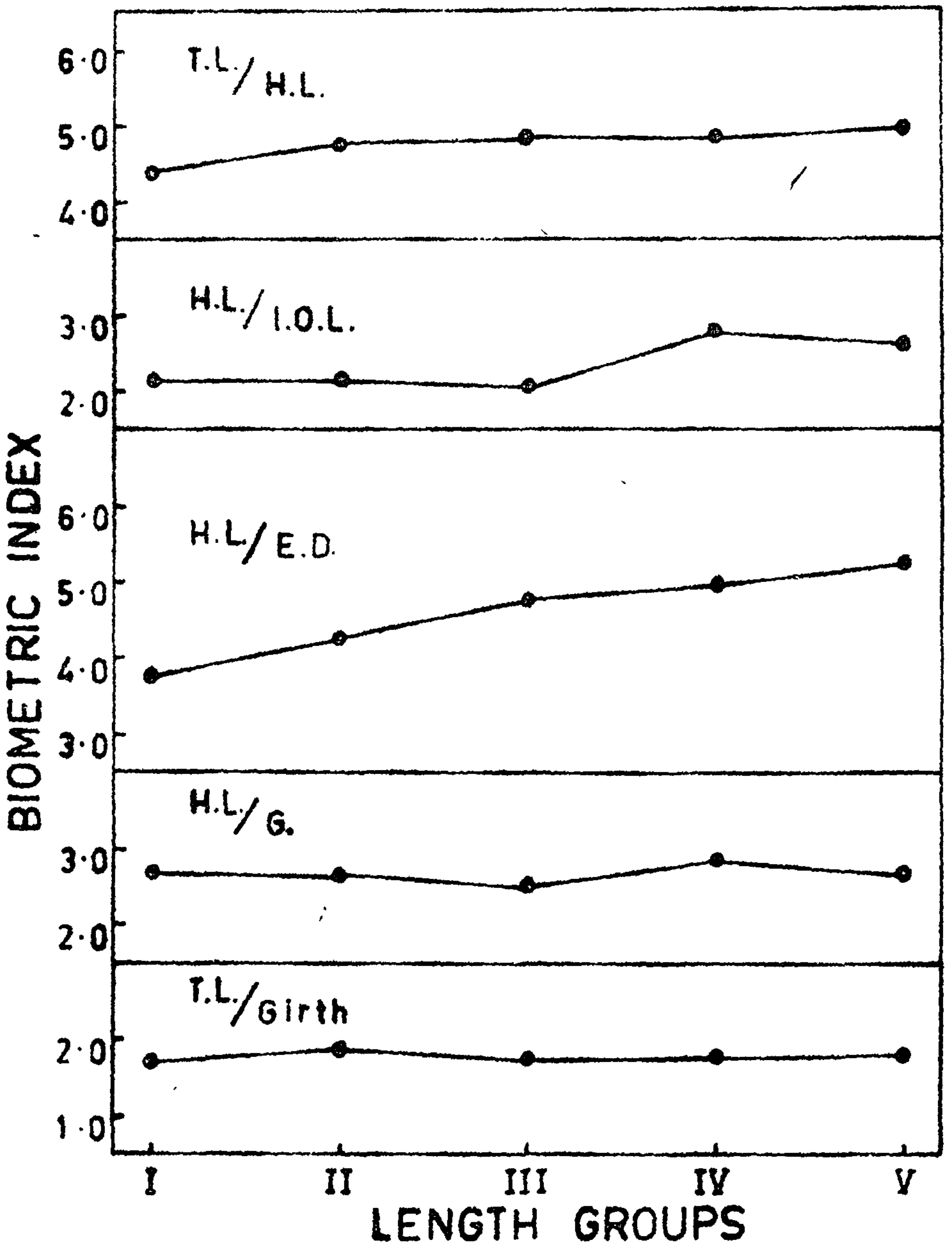


Fig.5 Biometric indices of T.tor at different length-groups.

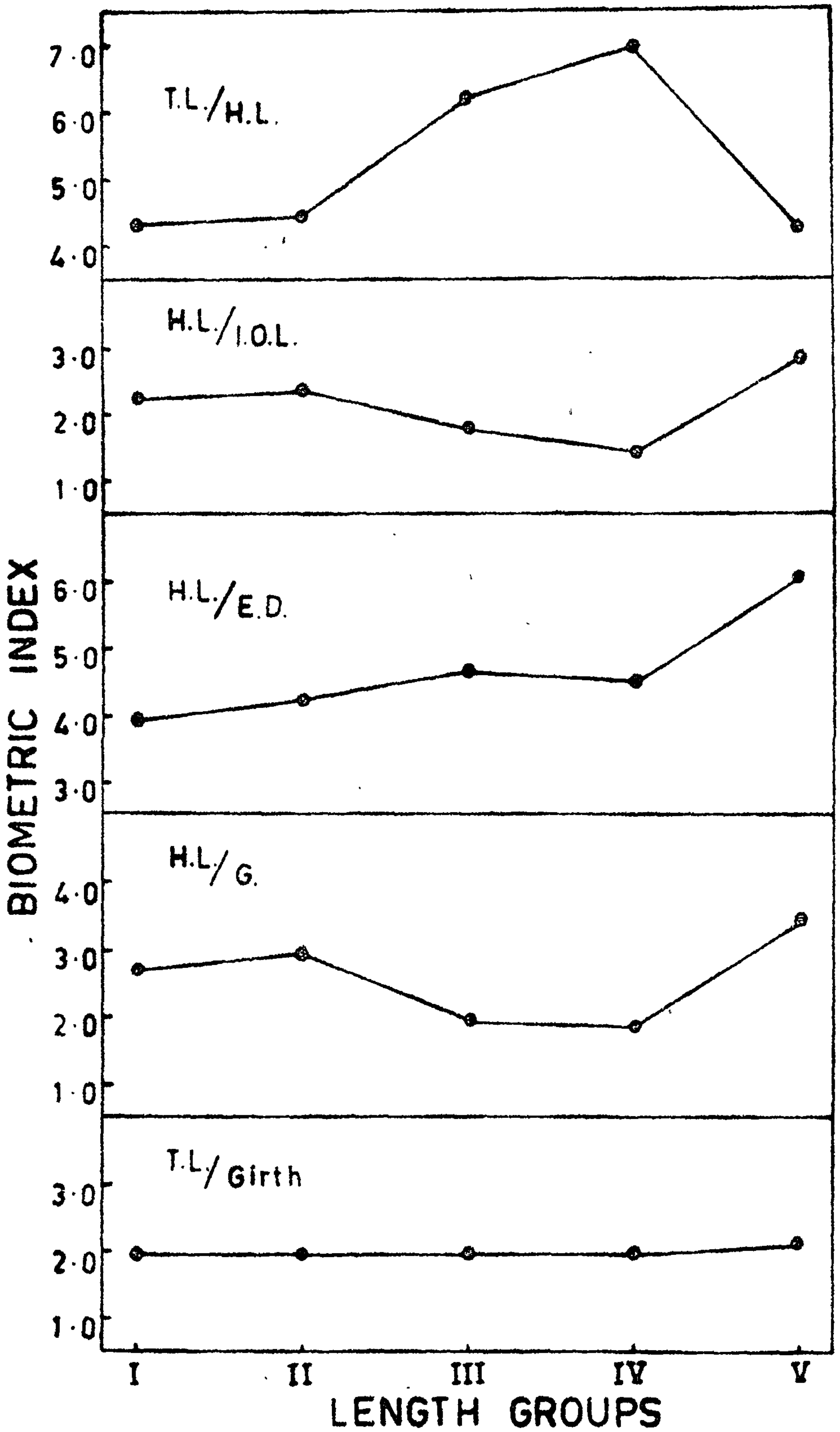


Fig.6. Biometric indices of T. putitora at different length-groups.

is isometric. Minor differences in allometry of the Biometric characters such as head length, total length, eye diameter and rostral-barbel length (Fig. 4) were observed between the two populations of *A. hexagonolepis*.

In case of *T. tor* (Fig. 5) and *T. putitora* (Fig. 6) alike *A. hexagonolepis*, the eye diameter becomes progressively smaller in relation to head length. The growth of girth in relation to total length has been found to be isometric in *T. tor* and *T. putitora* as also in *A. hexagonolepis*. In *T. putitora*, the growth of head length in relation to total length is allometric unlike *A. hexagonolepis* and *T. tor*. In *T. tor* and *T. putitora* the growth of inter-orbital distance in relation to head length was found to be allometric and showed wide variations.

LENGTH-WEIGHT RELATIONSHIP

It is evident from the results on length-weight relationship (Table 15) that there are inter-specific variations in the exponential value. The exponential value (b) of the length-weight relationship in *A. hexagonolepis* and *T. tor* were found to follow the cubic law, indicating an isometric pattern of growth in the fishes. The value of 'b' in *T. putitora* approximates to the cubic law, but is less than '3', thereby indicating allometric growth. Jhingran (1975) reported that the 'b' values of *T. tor* from river Narmada to be 2.9851 (male) and 3.0522 (female), whereas Chaturvedi (1976) found the 'b' value in *T. tor* to be 3.1609 (male) and

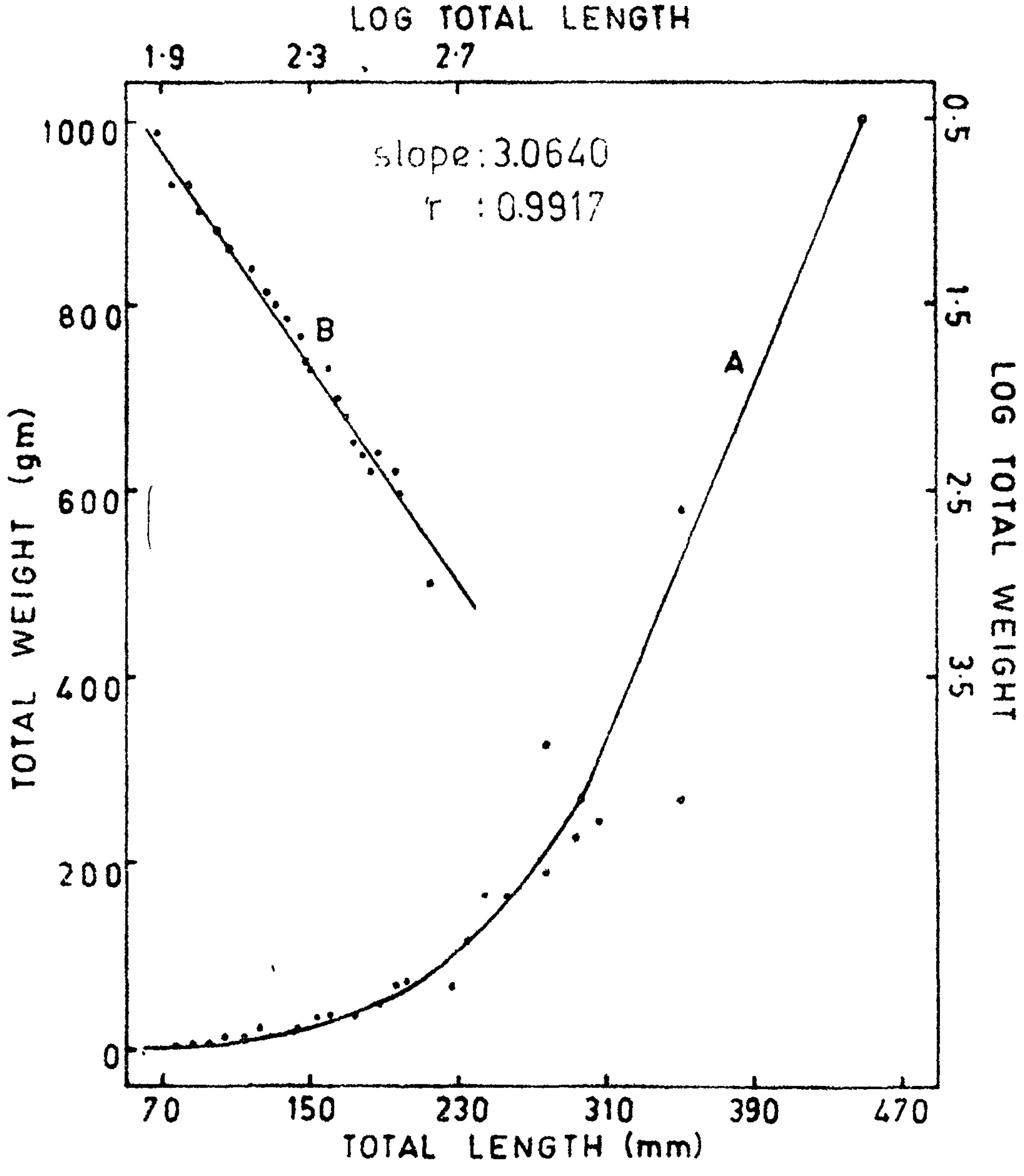


Fig. 7 Length-weight relationship of *A. hexagonolepis*.
A: Absolute values. B: Log-log transformation.

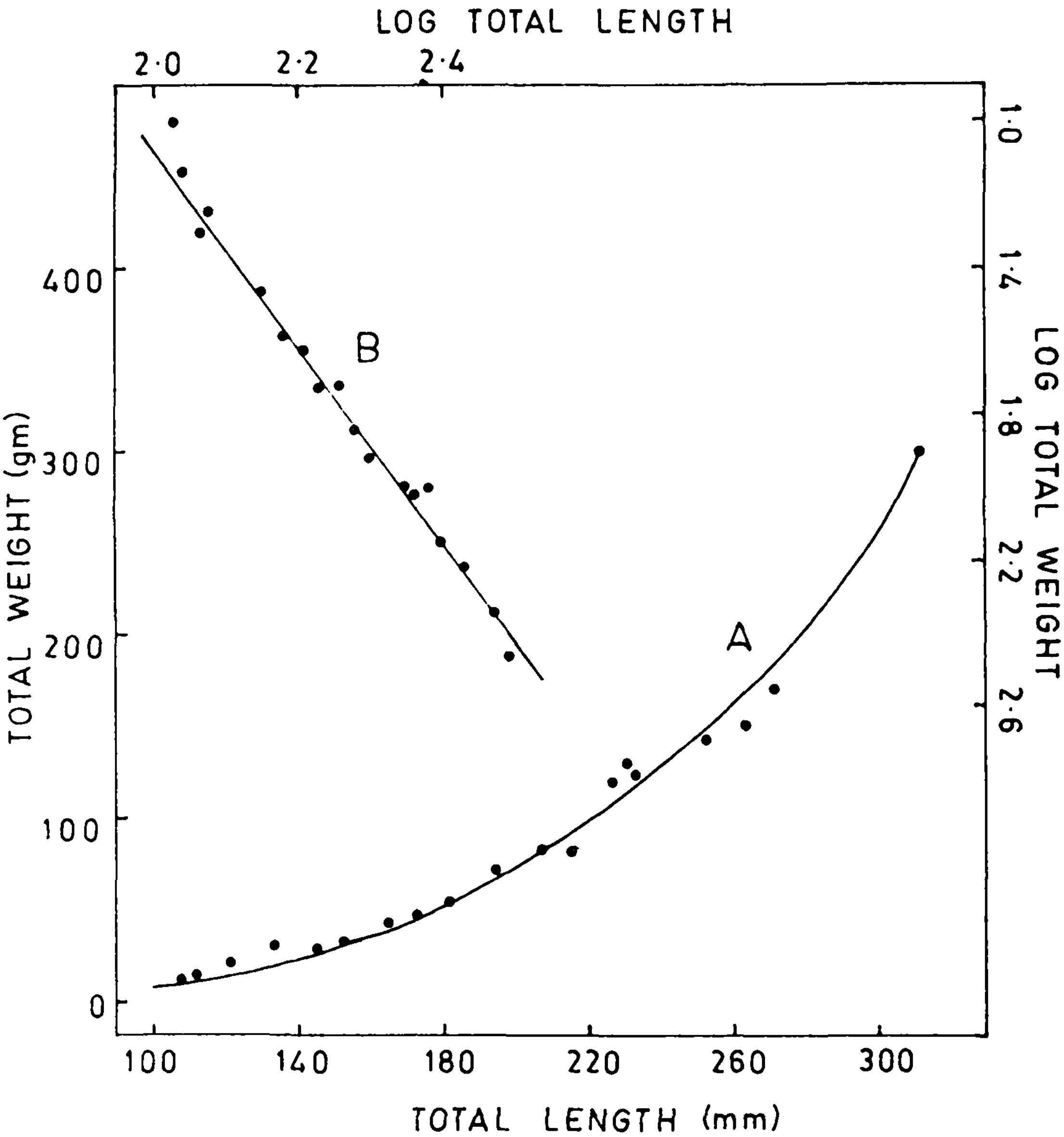


Fig. 8. Length- weight relationship of *T. tor* A: Absolute valuses. B : Log-Log transformation

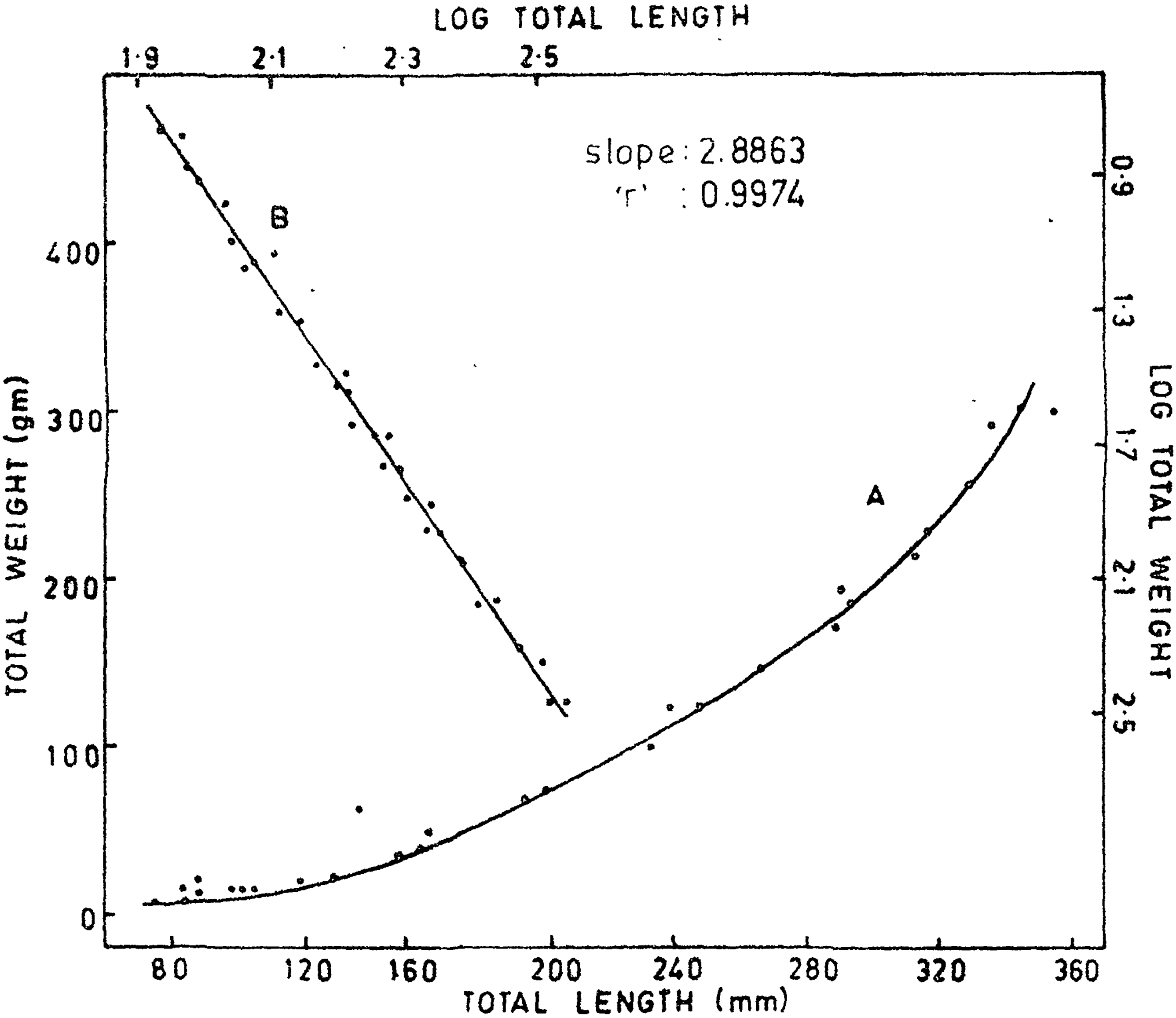


Fig.9. Length-weight relationship of *T. putitora*. A: Absolute values. B: Log-log transformation.

3.3927 (female). However, in the present study, the 'b' value(s) for the same species was found to be 2.7525 (male) and 2.7807 (female). This indicates that the 'b' values of the specimens from the Simsang River (present study) are quite less in comparison to the results obtained by Jhingran (1975) and Chaturvedi (1976).

The variations in the exponential value 'b' is supposed to be under the influence of numerous factors viz. seasonal fluctuations; physiological conditions of the fish at the time of collection, sex, gonadal development and nutritive conditions of the environment of the fishes as reported by Sinha (1973). Hence, it is quite likely that the difference in the 'b' values obtained in the present study in case of T. tor with that of Jhingran (1975) and Chaturvedi (1976) might be due to the reasons stated above, as the specimens belonged to different geographical locations as well as different population. Another probable reason for the difference in the 'b' values seems to be the difference in the size-ranges studied with that of the other workers.

The exponential values of A. hexagonolepis and T. tor were found to vary in different seasons (summer, monsoon and winter), sexes, and also during life stages. The exponential values in case of A. hexagonolepis during different seasons, were found to follow the cubic law, indicating an isometric pattern of growth whereas in the case of T. tor, the allometric growth is evident.

Lal and Dwivedi (1965), Sekheran (1968) and Kaur (1981) have also observed an intra-specific difference in the power function (b) of length in relation to body weight in *Rita rita*, *Sardinella albella*, *S. gibbosa* and *Channa gachua* respectively at different stages of their growth. Huges *et al*. (1974) while studying the effect of growth on gills and accessory respiratory organs of *Saccobranchus* (=*Heteropneustes*) *fossilis* have mentioned the compressed body shape of the fish, a probable cause of the increase of the power function (b=3.325).

According to Hile (1936) and Martin (1949) the value of 'b' usually ranges between 2.5 and 4.0. Allen (1938) suggested that the value for 'b' remains constant at '3.0' for an ideal fish. However, in the present study, the 'b' values were found to be 3.064, 3.028 and 2.886 for *A. hexagonolepis*, *T. tor* and *T. putitora* respectively. Hence, these fishes can be considered as 'ideal' as per the suggestion of Allen (1938). However, Beverton and Holt (1957) suggested that the departure from 3.0 of 'b' value, is rather rare. Narashimham (1970) reported that the value of 'b' increases in the carnivorous fish - *Trichiurus lepturus*, which devours big prey. Accordingly, Soni and Kathal (1979) reported that the higher value of 'b' (4.36) obtained for *Cirrhina mrigala* is due to the presence of large quantities of sand and mud in the stomach, resulting in an increase in the total weight and Kaur (1981) reported that the departure of 'b' values from 3.0 in case of *Channa gachua* may be due to the feeding habits of the species and presence of good amounts of detritus along with vegetable matter in the stomach.

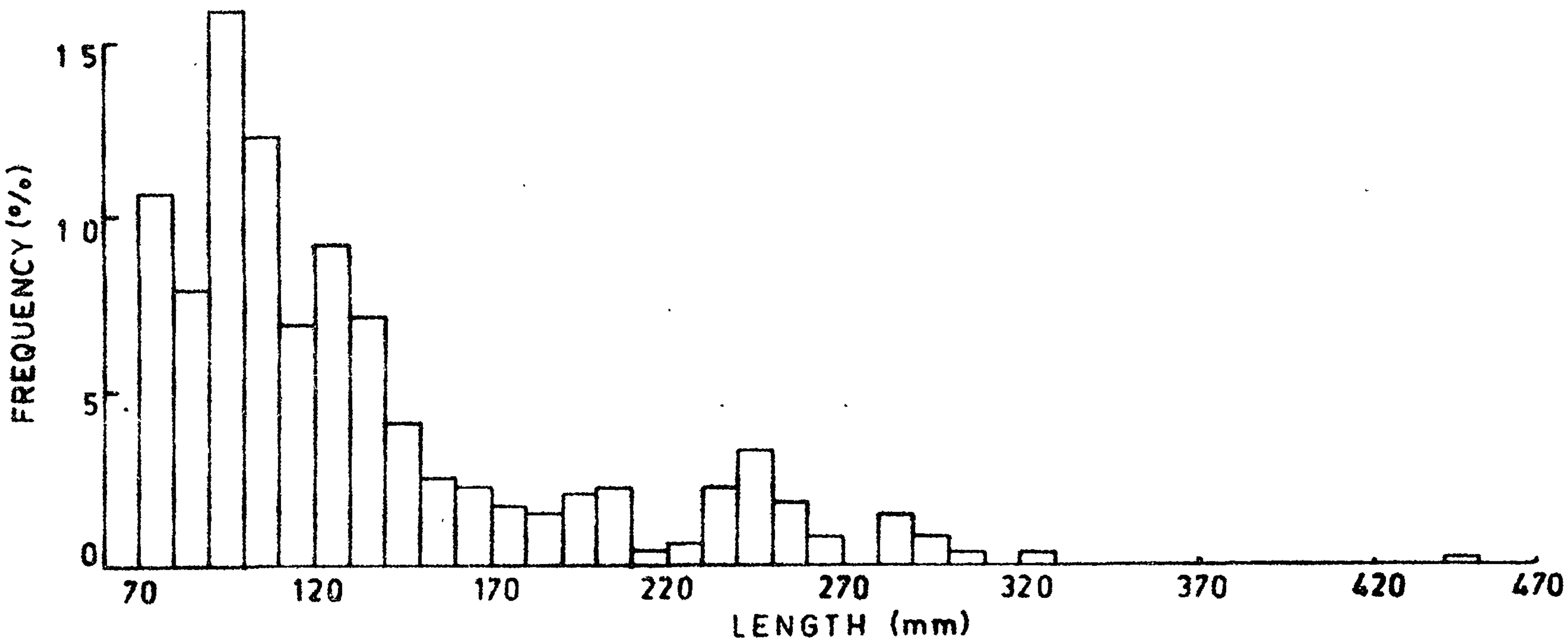


Fig. 10 Length-frequency distribution of *A. hexagonolepis*.

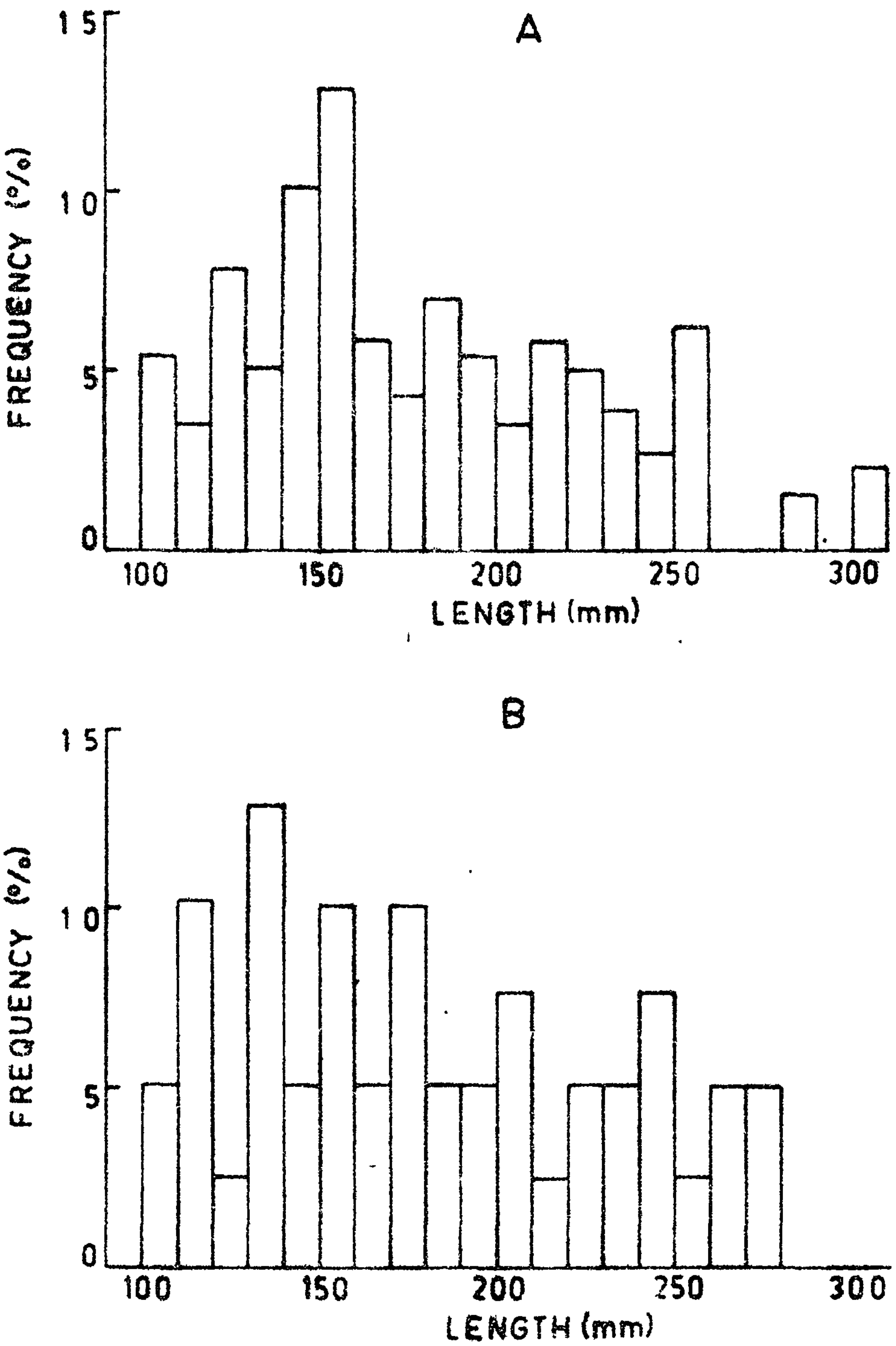


Fig11. Length-frequency distribution. A: T.tor. B: T.putitora.

CONDITION FACTOR

Monthwise averages of 'K' has been calculated to elucidate the seasonal fluctuations and has been summarized in Table 18 for A. hexagonolepis and T. tor. But for T. putitora the same has been presented season wise (summer, monsoon and winter) (Table 19).

Such variations (Tables 18 & 19) in the condition factor may be attributed to different factors, such as environmental condition, food availability and the gonadal maturity as has also been suggested by many workers (Le Cren, 1951; Jhingran, 1972; Basirulla, 1975). According to them study on the changes in the condition value with the increase in length may yield evidences concerning the size at first maturity, while the seasonal fluctuation may reflect the condition of fatness and gonads.

In A. hexagonolepis, the 'K' values show an increasing tendency from the month of January onwards and attain a peak in May (Fig. 12B). It is also evident from Fig. 12B that the attainment of peak is quite long and remains almost from May to November, whereafter K- values drop abruptly, which indicates that the species has a prolonged spawning period viz. from April/May-October/November, which is further supported by the results obtained on ova-maturation (Fig. 16) in the present study.

With regard to length, the 'K'-values (Fig. 12A) in A. hexagonolepis show an increasing tendency with the increase in length. Higher 'K' values observed in higher length groups in the present study could be associated with the attainment of gonadal maturity. Further, it is evident from the results that increase in the weight of the body due to the weight of maturing gonads follow by a decrease due to spawning, which is also reflected by the values of the condition factor of the fish (Table 30).

In the case of T. tor, the 'K' values show an increase-ing trend, (with slight variation) with the increase in length of the fish (Fig. 14A) alike A. hexagonolepis. Whereas, in T. putitora, the 'K' value showed a decreasing trend with the increase in length of the fish (Fig. 15A) which indicates that juveniles (young ones) have better condition factor. Many workers (Menon, 1950 Pillay, 1954; Sarojini, 1957; Varghese, 1961; Nasar and Kaur, 1984) have also observed higher 'Kn' values in juvenile of either species.

The present results (Fig. 12A) also supports the view of Wheatherley (1972) that even among the members of one population, sampled on a single date, there may be considerable variation in condition with length. According to him, fish populations display considerable changes in average condition, reflecting normal seasonal fluctuations in their metabolic balance and in the pattern of maturation and subsequent release of reproductive products. Even the state of fullness of the alimentary canal may influence 'K' factor (Weatherley, 1972). Since the specimens of T. tor and T. putitora studied were all immature which indicate that the state of fullness of the alimentary canal are responsible in influencing 'K' factor.

LeCren (1951) proposed a relative condition factor (Kn) and discussed its superiority over condition factor (K). According to him the former measures all the variations not connected with length, which the latter fails to do unless n = 3. Hence, in the present study, 'Kn' values were also studied which showed different pattern in its variations than the 'K' values with the increasing length in A. hexagonolepis and T. tor, whereas in T. putitora 'Kn' values showed almost the same pattern of variation as the 'K' values with the increasing length of the species. As far as seasonal variations are concerned, the 'Kn' values showed almost the same pattern of fluctuation as 'K' values in all the three species taken into consideration.

As mentioned earlier, the condition factor has also been calculated from the eviscerated specimens (Total weight of the fish minus weight of the gonad and gut) to eliminate the influence of gonad and food present in the alimentary canal in the present study. The pattern of fluctuation in these indices is almost similar to that of indices obtained from whole fish (i.e. including guts and gonads) (Table 18 & 19), the difference being only that of magnitude. This indicates that condition factor is not only influenced by the maturation of the gonads and the food present in the alimentary canal, but may be due to seasons. Similar observations have also been reported by Jhingran (1972) for Setipinna phasa and

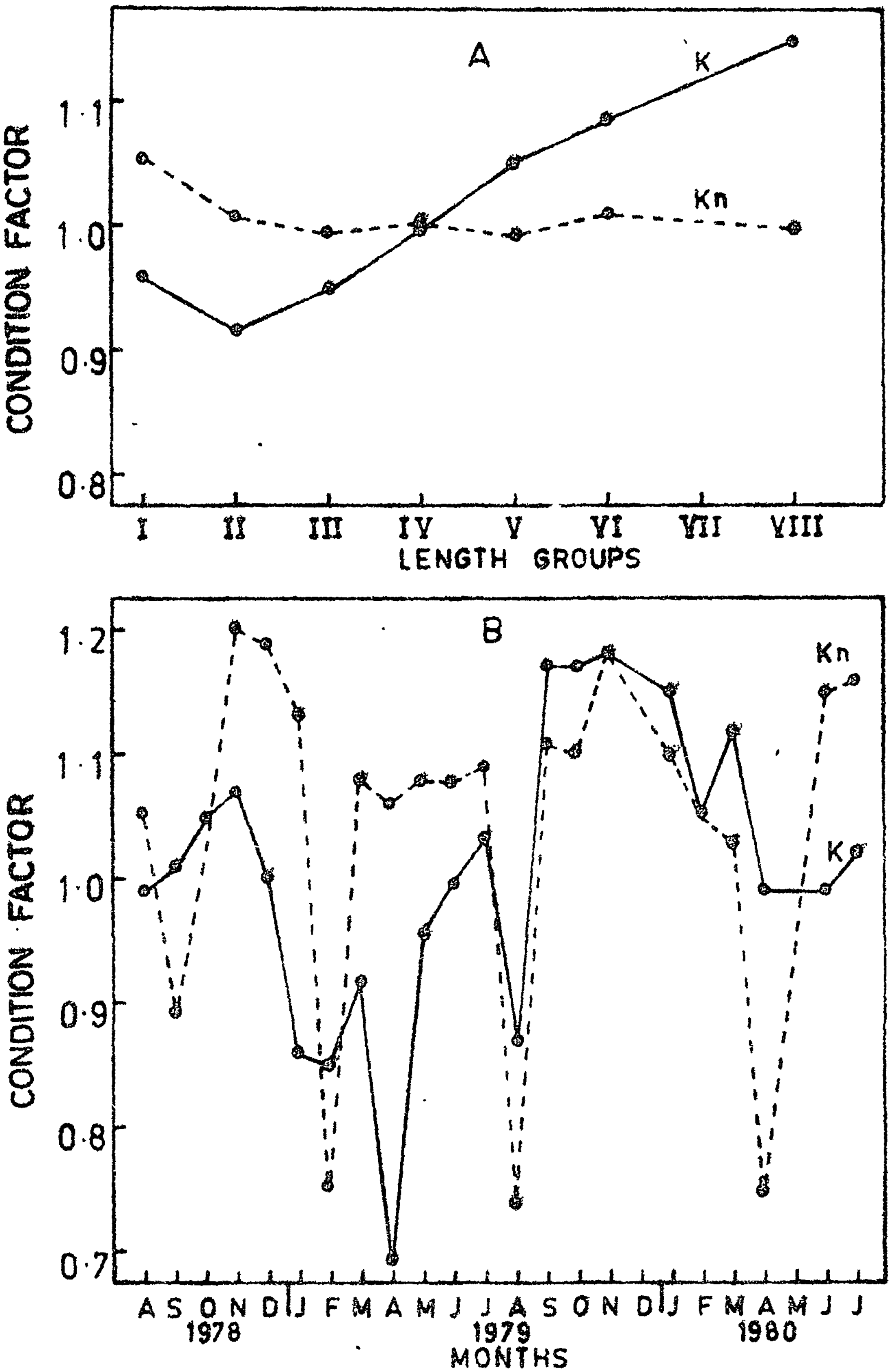


Fig. 12 Condition factor of *A. hexagonolepis*. A: At different length-groups. B Seasonal variations.

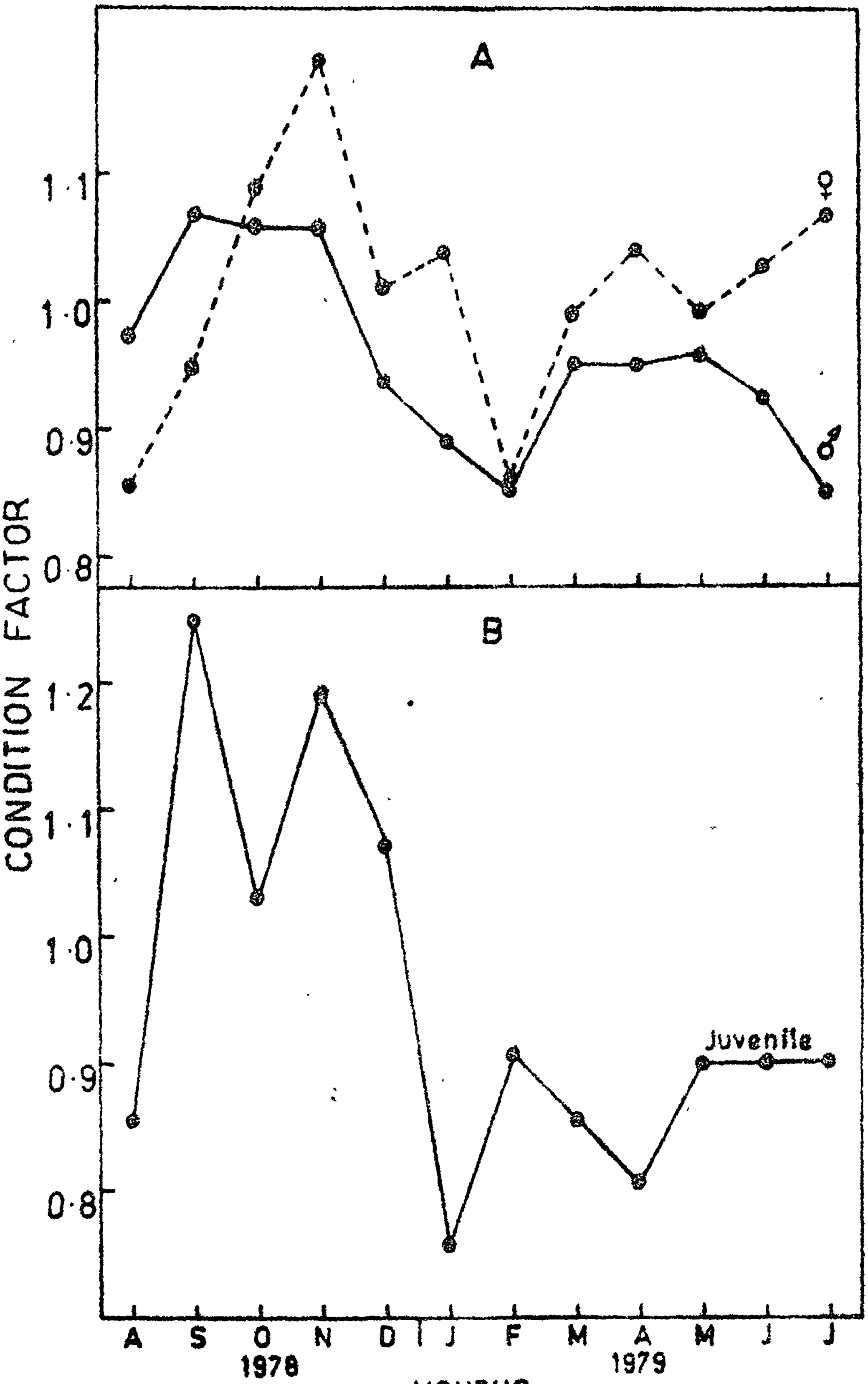


Fig.13 Seasonal variations in the condition factor of A. hexagonolepis. A:Male and female. B: Juvenile.

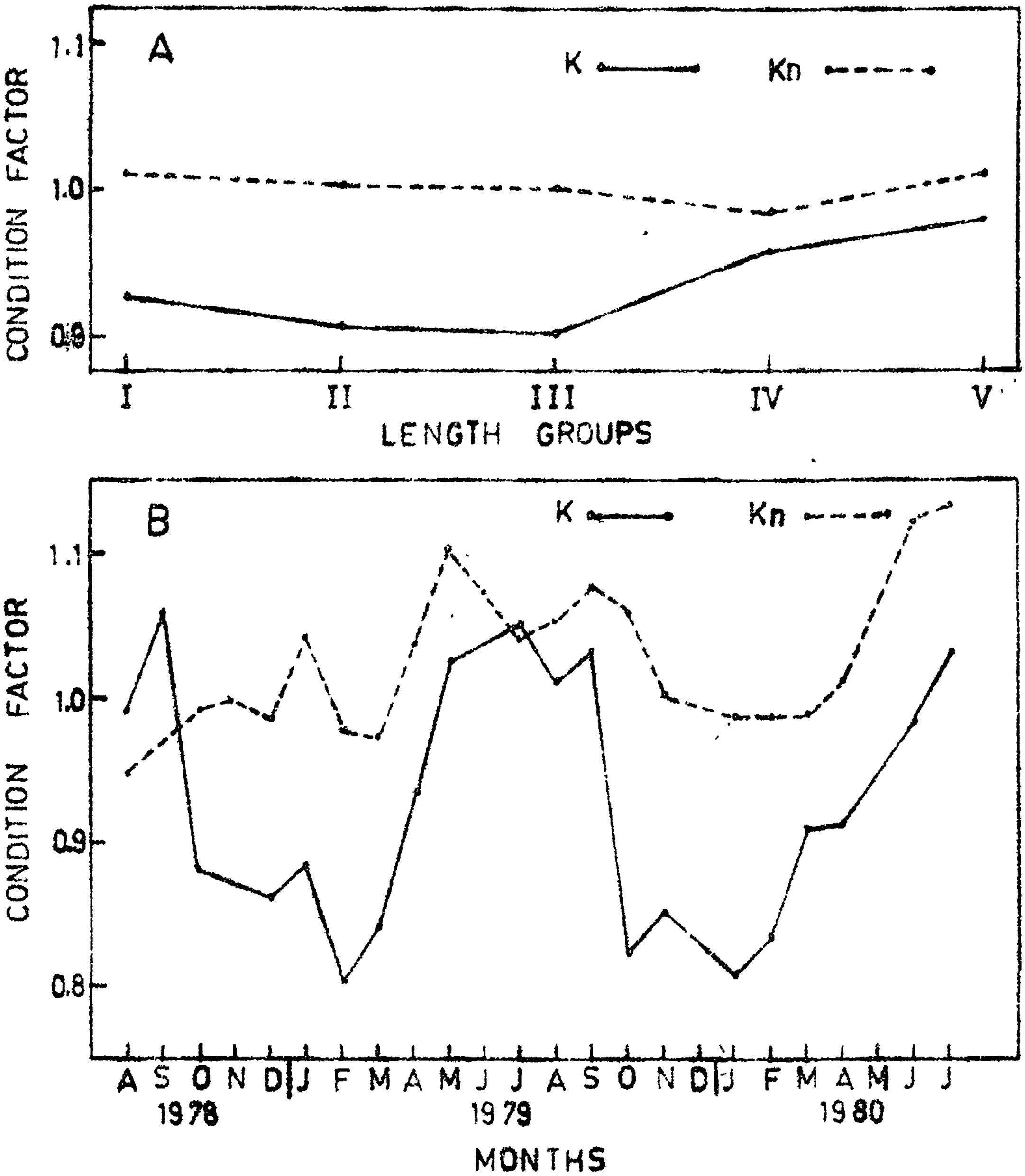


Fig.14. Condition factor of I.tor. A: At different length-groups. B: Seasonal variations.

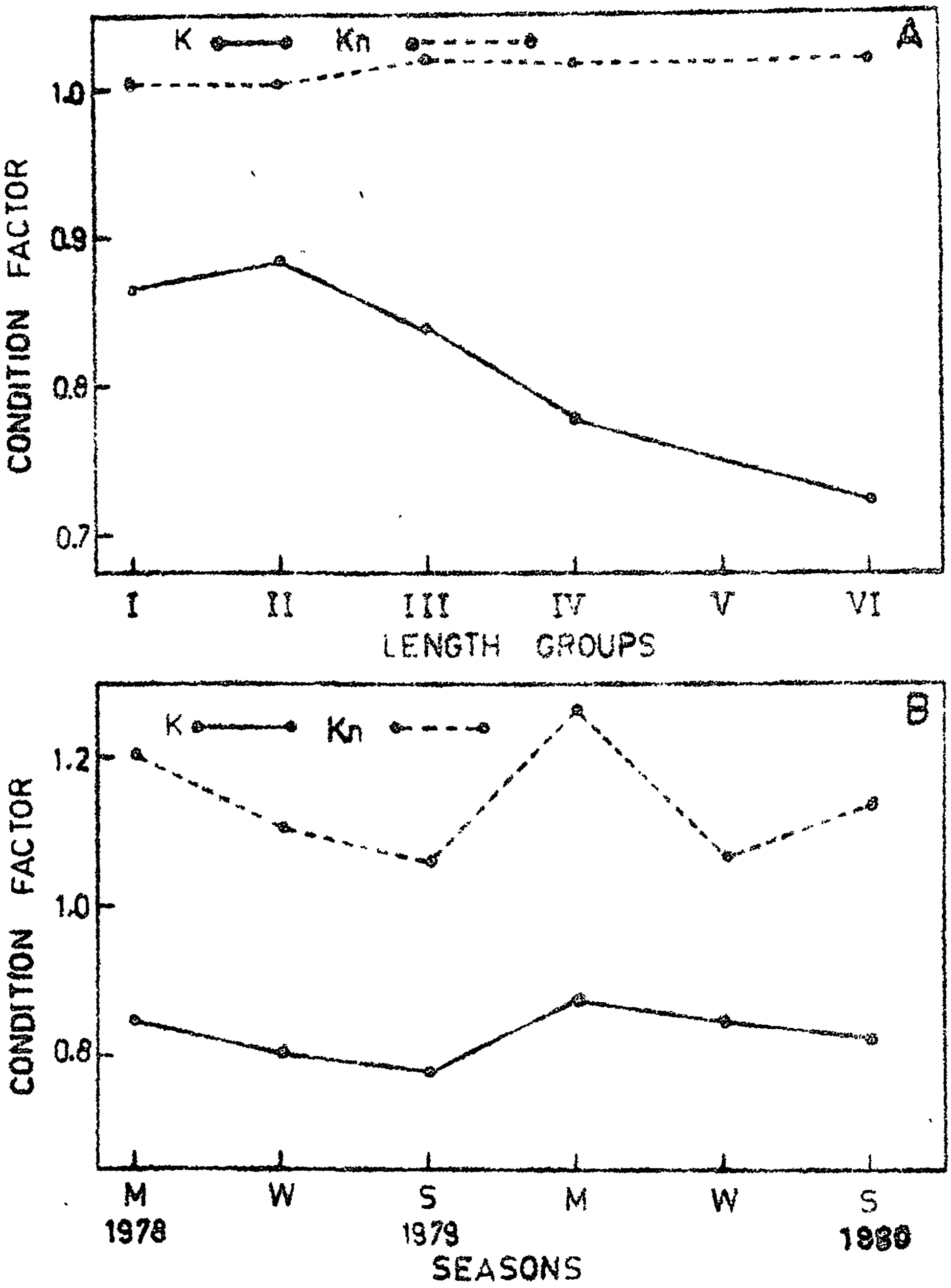


Fig.15. Condition factor of I.putitora.

A: At different length-groups.

B: Seasonal variations.

Kaur and Nasar (1984) for Channa gachua.

MATURITY AND SPAWNING

The results of maturity studies in A. hexagonolepis indicates that the males mature earlier than the females and the species has a prolonged spawning season (April/May to October/November). The condition factor or 'ponderal index' also indicate towards a similar trend regarding the spawning season. Walford (1932) stated that fishes which spawn only, once in a season but have long spawning duration, the number of immature ova is nearly half of the total number of entire intra-ovarian eggs irrespective of the number of modes representing them. Similar observations have also been reported by Hickling and Rutenberg (1936), Prabhu (1956), Qasim and Qayyum (1961) and Natarajan and Jhingran (1963). However, in A. hexagonolepis the batch of fully matured ova were not clearly demarketed from the immature stock. The frequency distribution of ova at various stages of development between the immature and mature stock was more less uniform. The spawning/spent ovary (Stage VII) contained a second batch of ova progressing maturation. This indicates that A. hexagonolepis lays eggs in batches.

Gonado-somatic index (Gn.S.I.) when plotted against different lengths (Fig. 18A) indicated a tendency for the Gn.S.I. to increase with the increase in the body length. It is also seen that the seasonal peaks (Fig. 18B) in the mean Gn.S.I. coincided with the peak in the percentage of

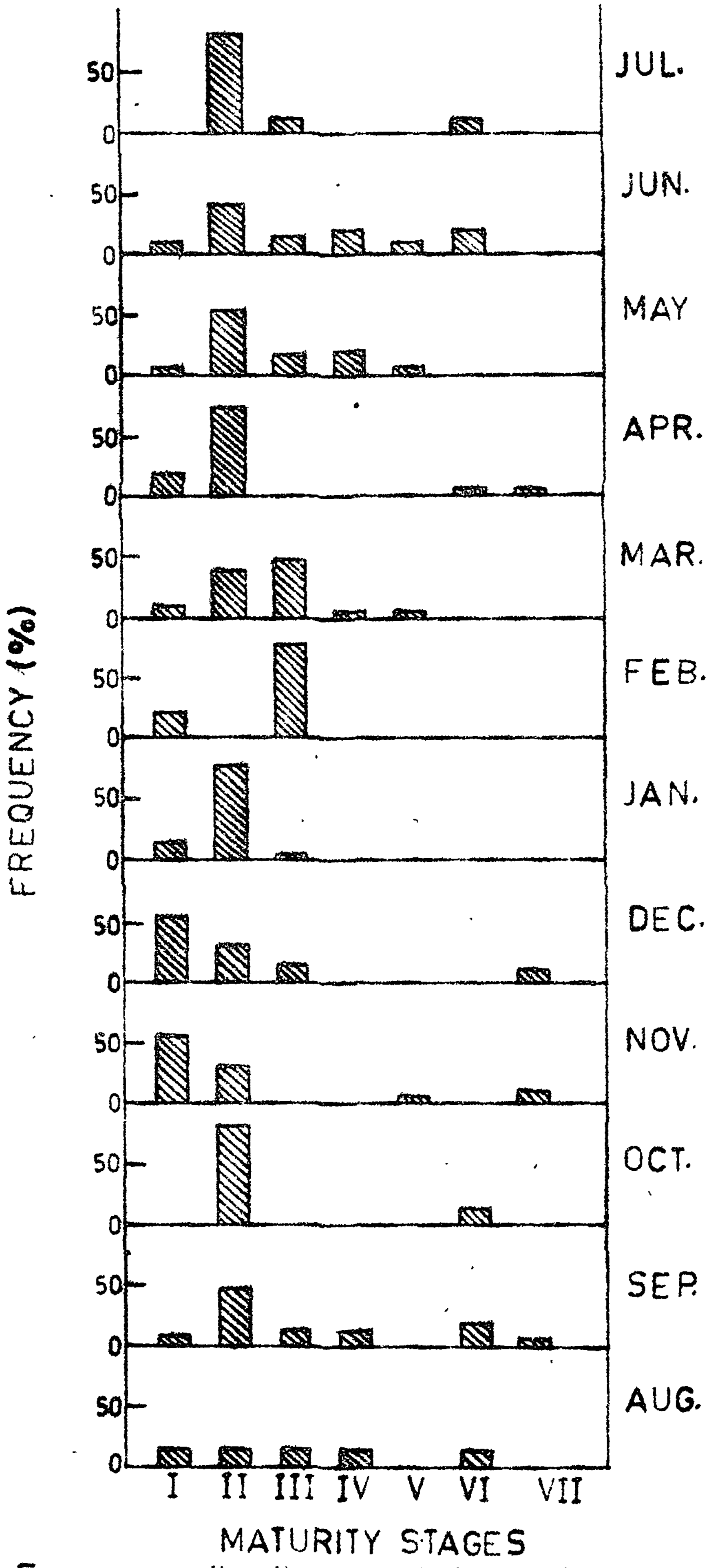


Fig.16. Frequency distribution of the different maturity stages of A.hexagonolepis during different months.

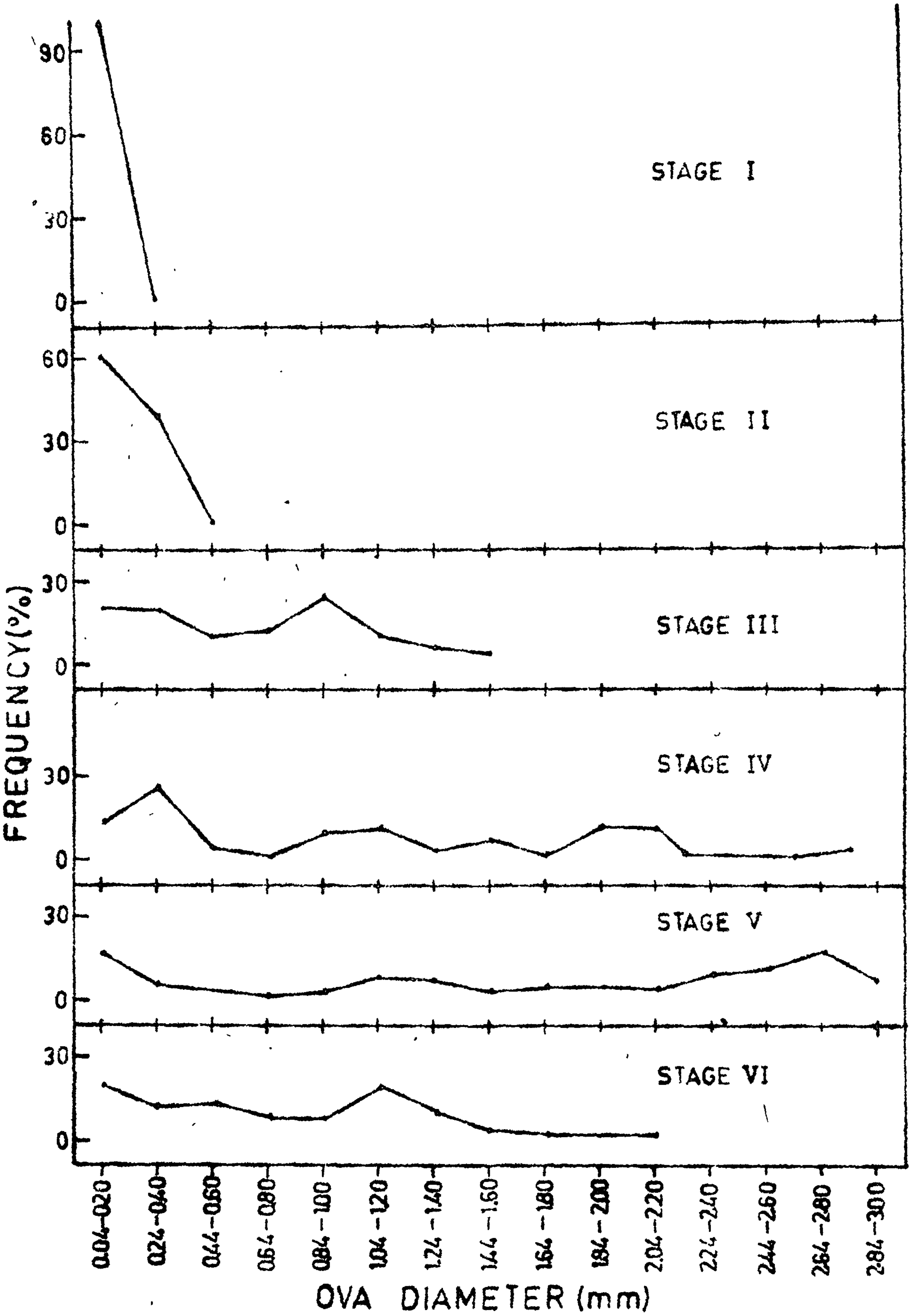


Fig.17. Ova diameter frequency at different maturity stages of *A. hexagonolepis*.

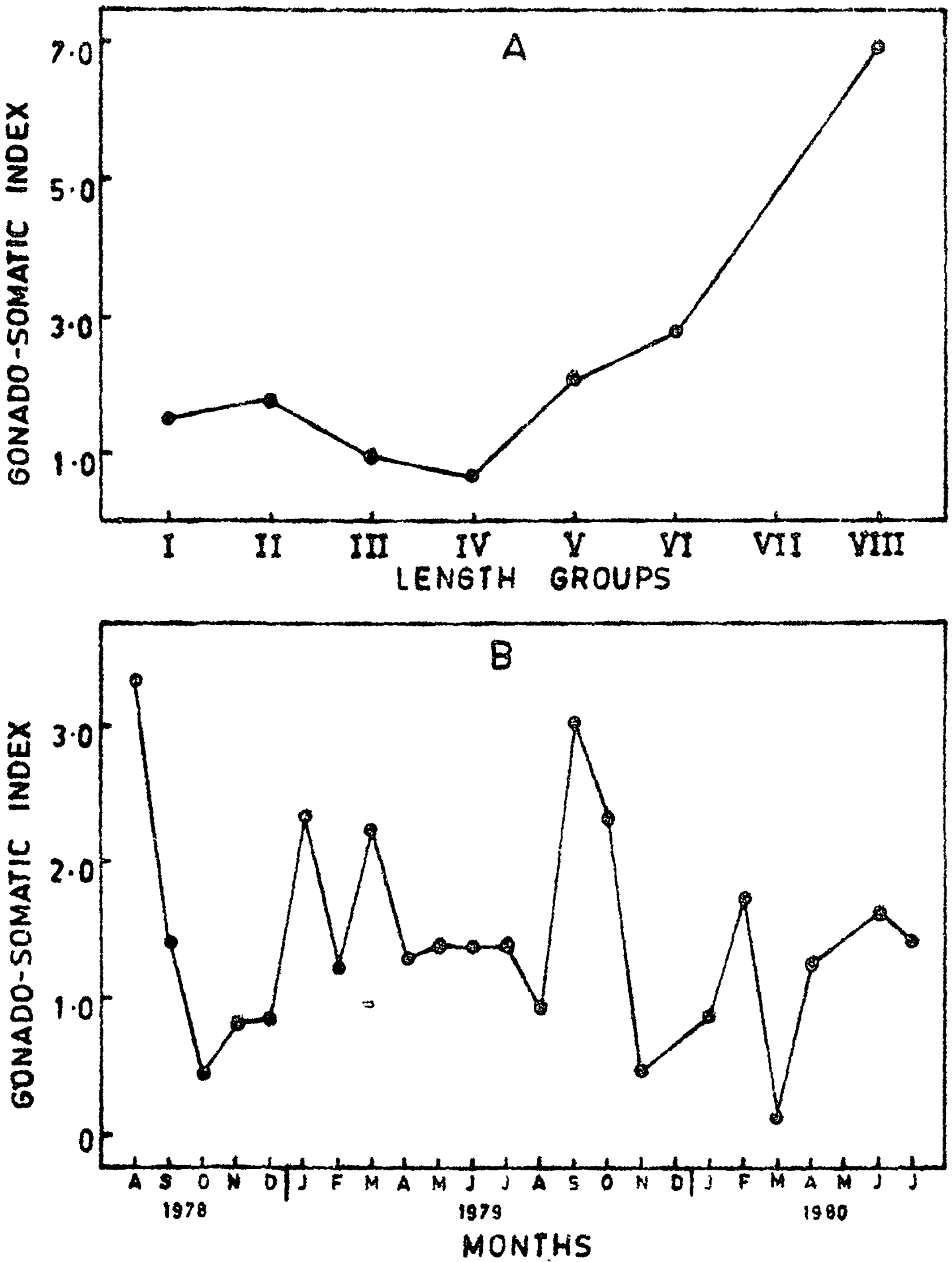


Fig.18. Gonado-somatic index of *A.hexagonolepis*.

A: At different length-groups.

B: Seasonal variations.

occurrence of mature individuals, hence, Gn.S.I. can be used as an index of gonadal development. Such a case has also been reported by Kakuda and Nakai (1981), and Kaur (1981). According to Kesteven (1942) 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 weight will show an exponential relationship with the length in the same way as does the length of the entire organism. Jhingran (1961), Qasim and Qayyum (1963), Begenal (1967) have studied the relationship between fecundity and fish length and reported that the exponential value to range around three. Higher values of 4.5 in case of Irish Herring (Farran, 1938) or at a rate proportional to fifth power of body length (Hodder, 1963) have also been reported. However, in the present study, the exponential index was found to be 0.5278 for A. hexagonolepis, which indicates that the fecundity of the fish increases at a lower rate than that of the body weight, in relation to total length, as is also evident from the exponential value of 3.064 as obtained in the length-weight relationship (Table 15).

The value of exponent obtained in the relationship between ovary weight and total length of A. hexagonolepis were found to be 0.6568 which indicate that the ovary weight increases at a lower rate than the total weight.

FECUNDITY

On plotting fecundity values against body length

(Fig. 19), it has been observed that the egg counts increased with the increase in the spread points, describing this relationship with increasing size of the species. Similar case has also been reported by Habib (1979) in Puffer fish and Kaur (1981) in Channa gachua. According to Simpson (1951), fecundity is directly proportional to body weight. Bagenal (1967) pointed out that weight is more closely connected with the condition of fish than its length. Yuen (1955) found that relationship between fecundity and weight to be curvilinear as has also been recorded in the present study, which indicates that fecundity is more dependent on weights rather than length as has also been reported by Manooch (1976) for Red Porgy and Kaur (1981) for Channa gachua. The logerithmic relationship between fecundity of A. hexagonolepis and its length, body weight and ovary weight were found to be linear (Fig. 20A & B, 21A).

Relative fecundity, which is the ratio of egg number to body weight (Hardisty, 1964) is a measure of fecundity that takes into account the weight difference of individuals. In the present study, relative fecundity was also found out and the basic assumption in using relative fecundity is that the number of eggs per gram does not increase or decrease with the size of fish (Bagenal, 1973). LeCren (1951) and Raitt (1968) while working on Perch and Norway Pent respectively, stated that the relative fecundity may change markedly due to change in the condition of the species.

According to Bagenal (1963) in most of the fishes, the number of eggs does not change significantly as the season progresses but the gonad weight increases due to an increase in water content or organic matter derived from food, or organic matter transferred from somatic tissues and only in the latter case, if the total weight remains constant and thus makes the calculation of relative fecundity meaningful. The maximum fecundity values for A. hexagonolepis in the present study has been found to be 11660 in the specimens having total length of 442.0 mm and total weight of 1000.0 gm. Fecundity estimates suggests that the species is not very fecund in comparison to other Carps, which might be due to the fact that a species that protects its eggs and young ones is usually less fecund than the one that does not (Kryzhanoviskii, 1949). Such cases have also been observed by Fryer and Isles (1972) who discussed the significance of brood and egg size in Cichlids and attributed a close association between egg number and size, as the Mouth Brooders were found to have fewer and larger eggs than the Guarders. Kaur (1981) also pointed out that the reason for low fecundity in Channa gachua may be that the species builds nest and guards its young ones. Hence, these studies suggest that parental care has profound effect on the number of eggs produced, as it would be easier for the fish to take care of their eggs and young ones if they are less in number.

Mahseer also exhibits parental care although to a lesser degree by laying its eggs in sheltered pools and sandy

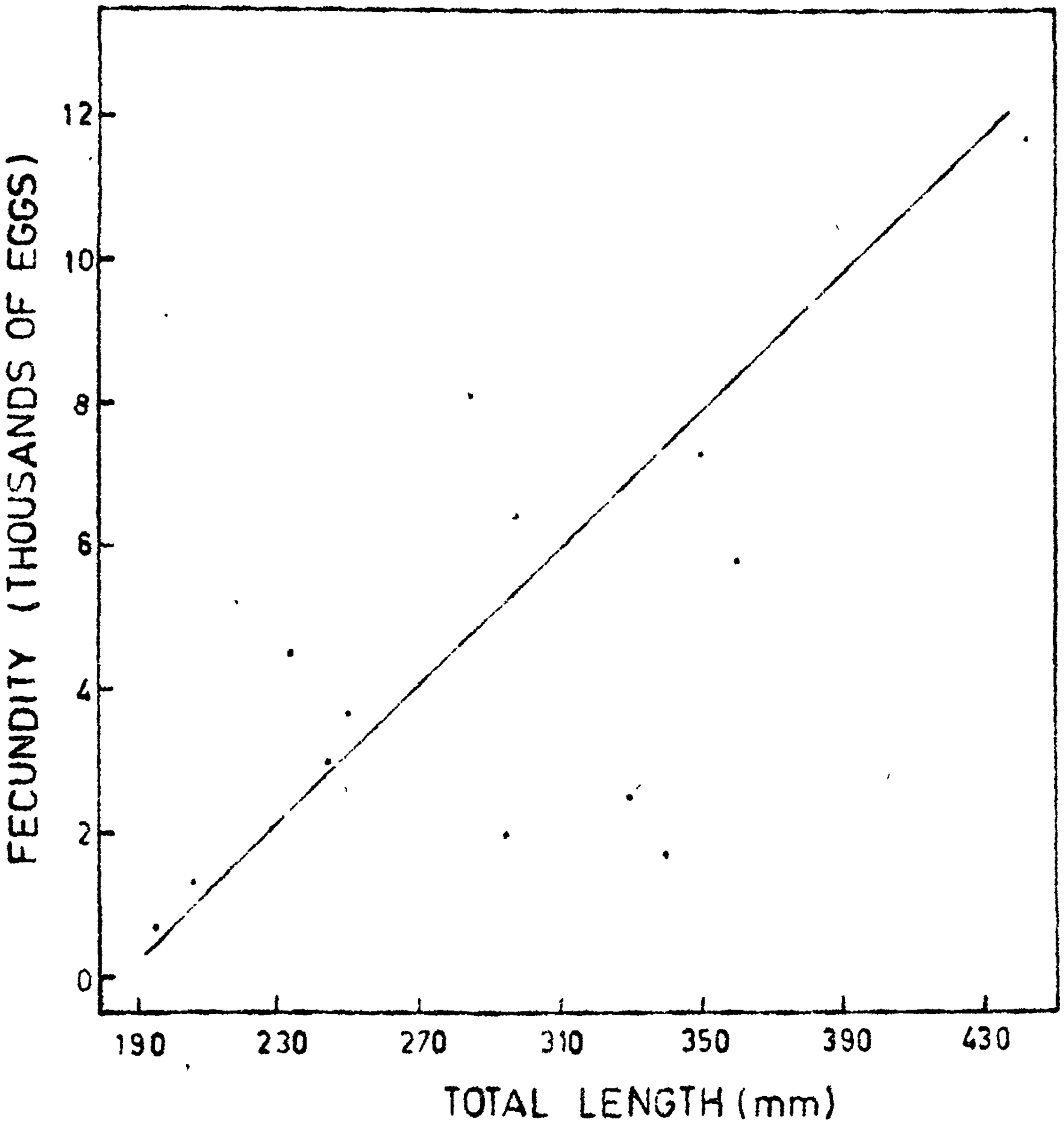


Fig.19. Fecundity of *A. hexagonolepis* at different lengths.

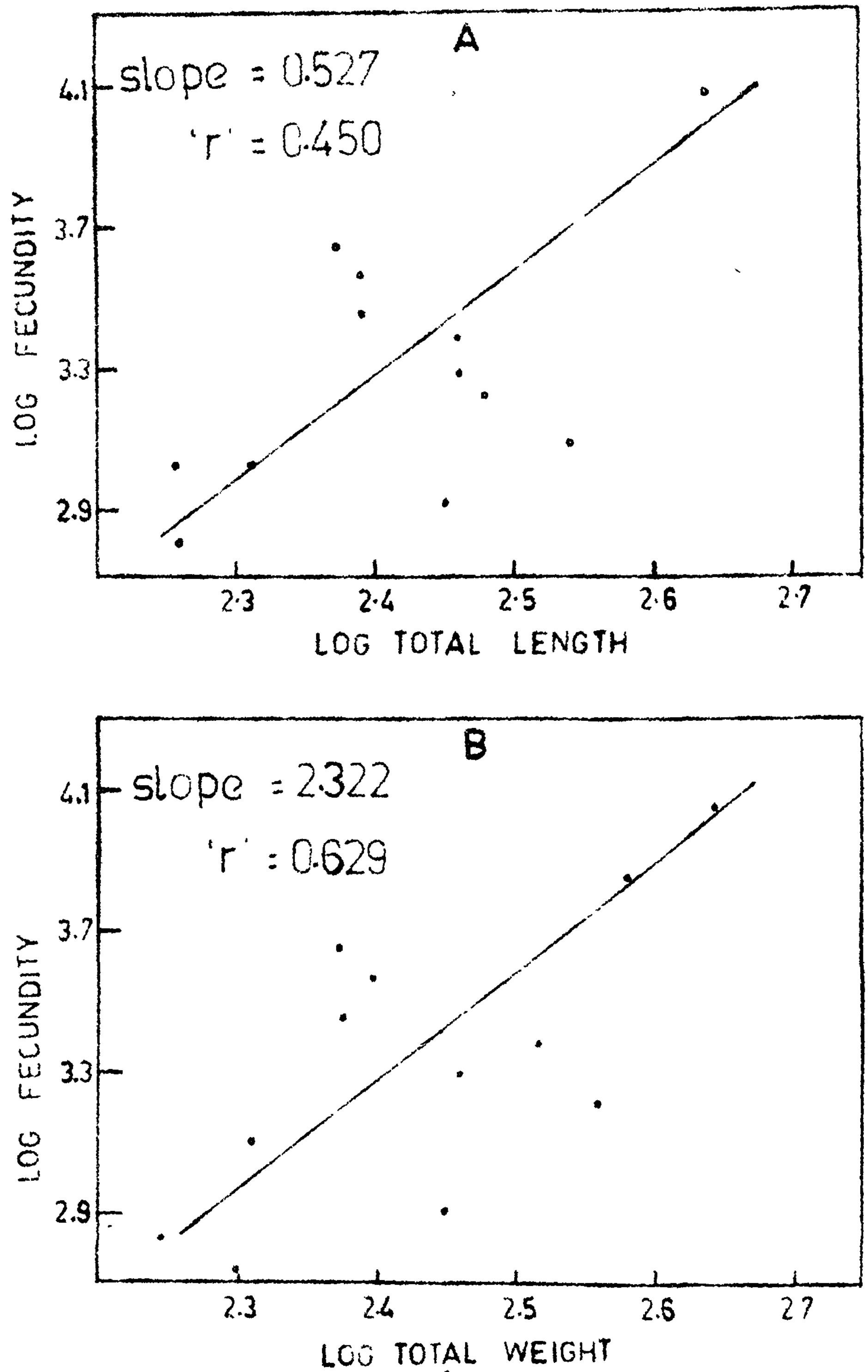


Fig. 20. Relationship between A: Fecundity and body length.
B: Fecundity and body weight.

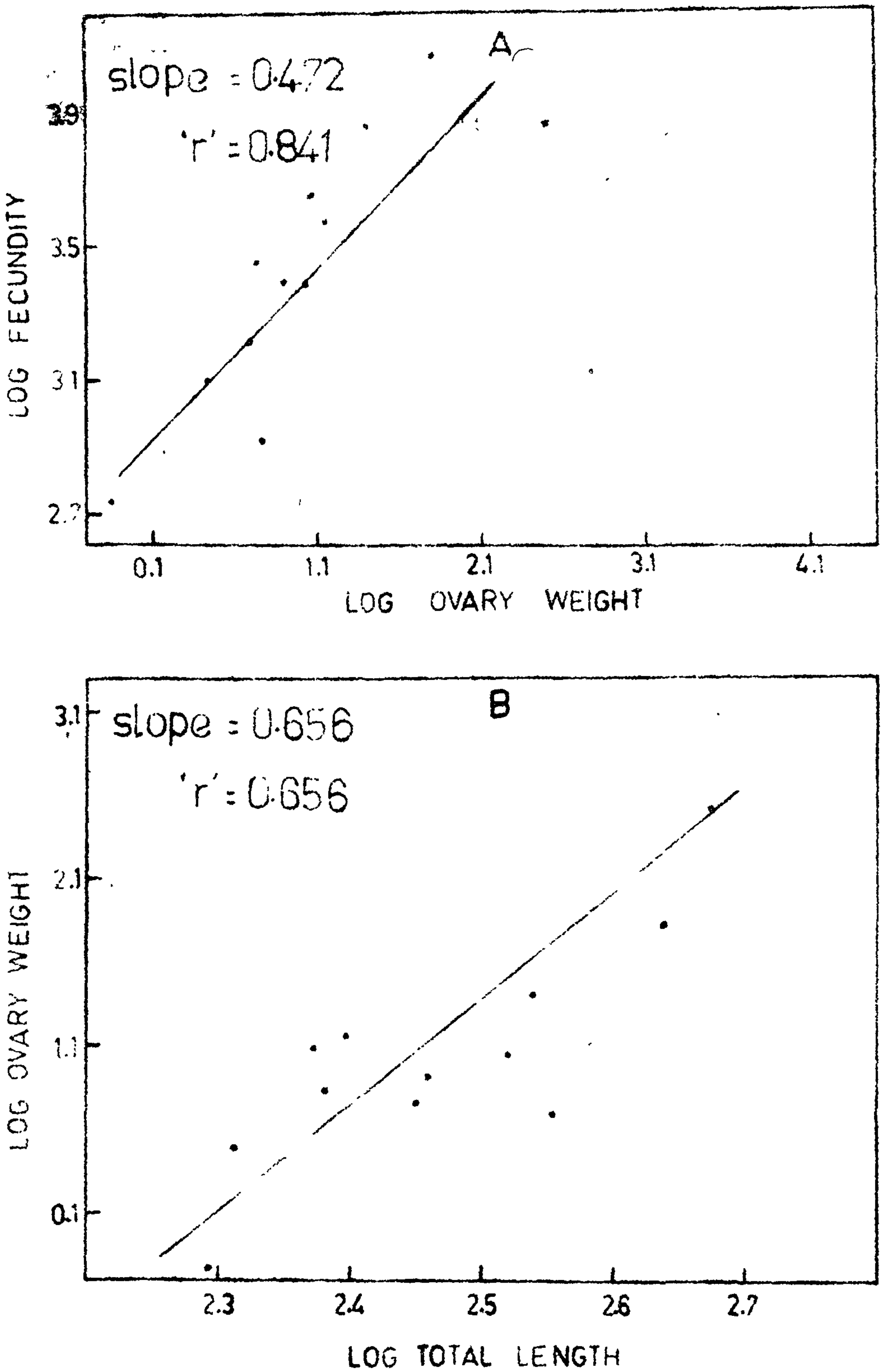


Fig 21 Relationship between A: Fecundity and ovary weight. B: Ovary weight and total length.

beds (Karmachandani, 1972) which may be the reason of lower fecundity in Mahseer. It is a general assumption that fecundity and egg size are negatively correlated (Bagenal, 1971). The relationship is complicated by what appears to be a general tendency for fish which spawn later in the season to lay smaller than average eggs. According to him, since the egg size and parent length are usually correlated positively, suggest that the larger fish spawns first, but in contrast older individuals of Perch spawn later. In the present study too, it has been observed that the egg size and parent length are positively correlated.

McFadyen et al. (1965) found that Trout from infertile streams had a lower egg production. He further stated that the difference in age at first spawning and growth rate, together with an actual lower fecundity all led to a lower reproductive rate than in fertile streams. Leggett and Power (1969) correlated fecundity and food supply with Land Locked Salmon. The variations in fecundity as reported by Bagenal (1971), Raitt (1968), and Hooder (1965) are associated with food through population density. Nikolsky (1961, 1969) mentioned a number of Russian papers associating food supply and fecundity and the relationship of nutrition and fecundity were reviewed by Woodhead (1960). Thus, fecundity can be associated with the food availability, which has also been supported by certain experimental works (Scott, 1962; Hester, 1964; Bagenal, 1969; Wotten, 1973) relating food to fecundity, confirming the low food intake leading to lower number of eggs.

Several environmental effects on fecundity are also believed to act through the food supply. Hodder (1965) suggested that the fecundity differences of grand banks Haddock were associated with water temperature as in cold water they concentrate along the edge of the banks resulting in over crowding, leading to a food shortage and a lower fecundity. Kaur (1981) also made similar observations in *Channa gachua*.

FOOD AND FEEDING HABITS

Nikolsky (1963) recognized three main categories of food on the basis of their importance in the diets of fishes.

a) Basic food: which is normally eaten by fish and covering most of the stomach contents;

b) Secondary food: which is frequently found in the stomach, but in smaller amounts, and;

c) Incidental food: which is found rarely in the stomach contents.

Accordingly, algae (35.90%) and vegetable matter 31.92%) can be considered as the basic food of *A. hexagonolepis* as found in the present study and Insecta, Protozoa, Rotifera, Nematoda and Crustaceae and unidentified animal matter together constituted 32.17%, can be regarded as the secondary food. Sand particles formed 0.019% of the gut content and hence, can be regarded as an incidental item, due to the fact that it forms a very small portion of the gut content and occurs without any regularity. This indicates that this item is probably swallowed accidently along with other materials.

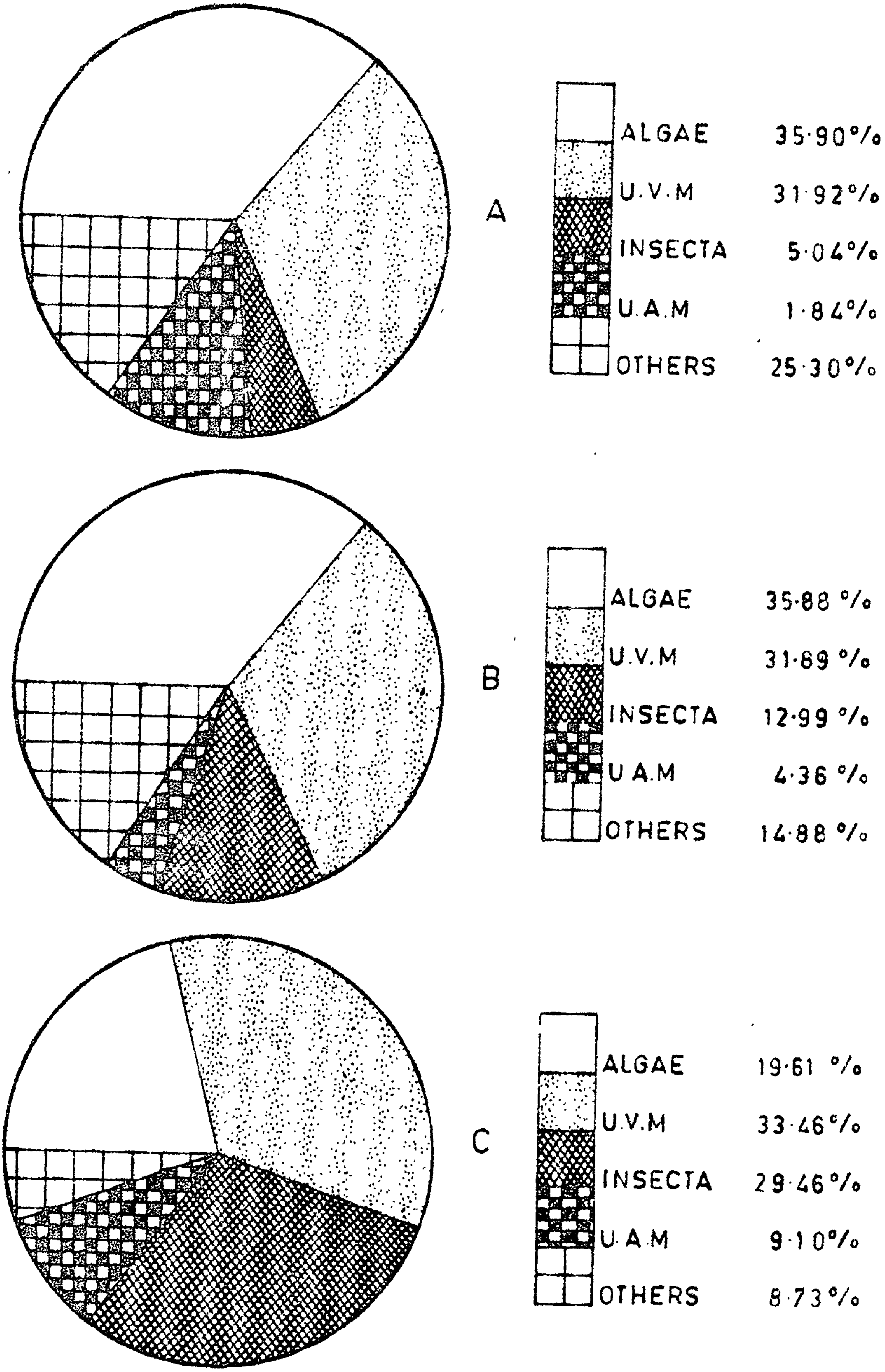


Fig 22 Food spectrum of A: *A. hexagonolepis*. B: *T. tor*. C: *T. putitora*.

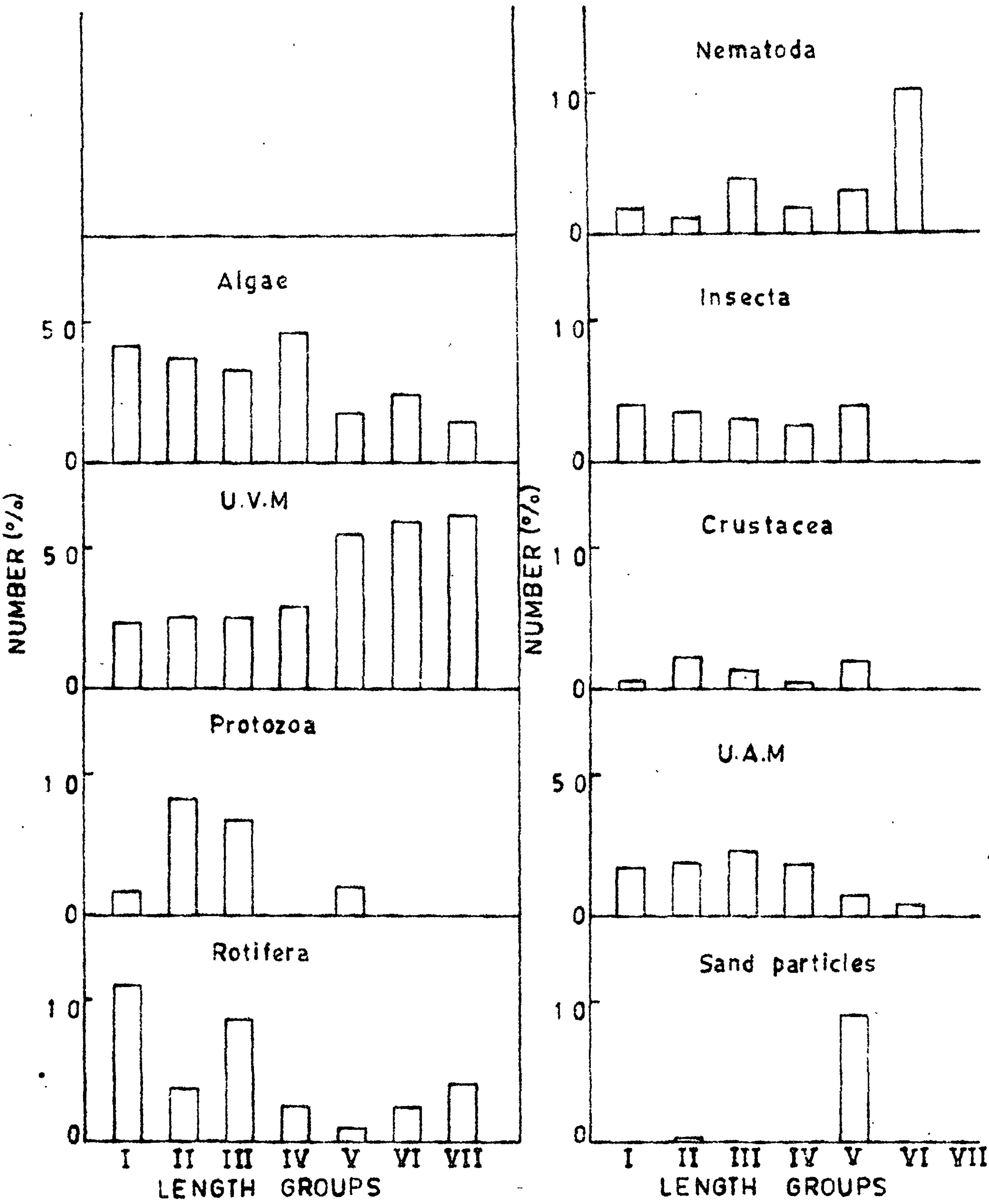


Fig. 23. Relative importance of different food items in the gut of A hexagonolepis.

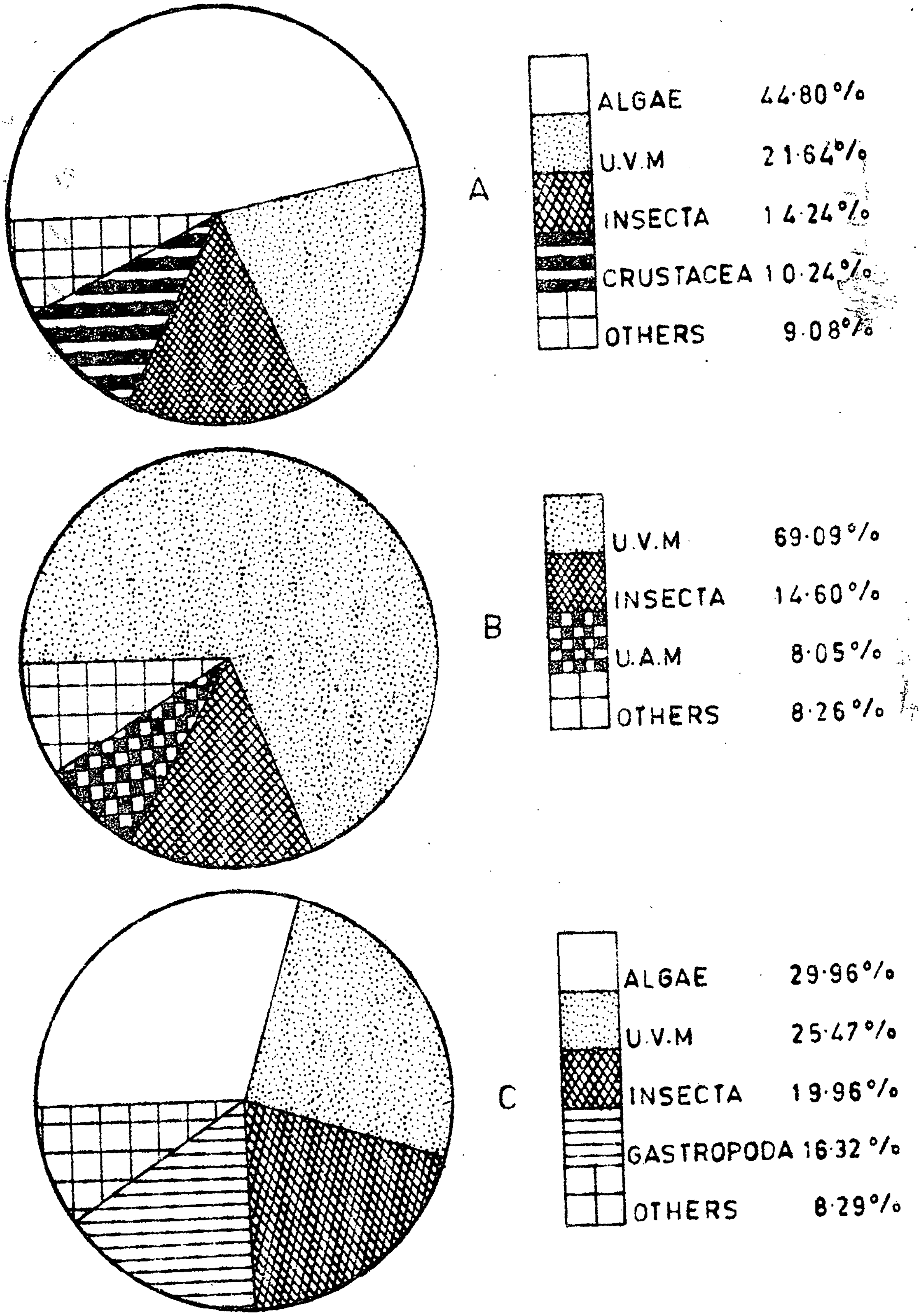


Fig. 24. Food spectrum of *A hexagonolepis* during different seasons.
A: Summer B: Monsoon C: Winter

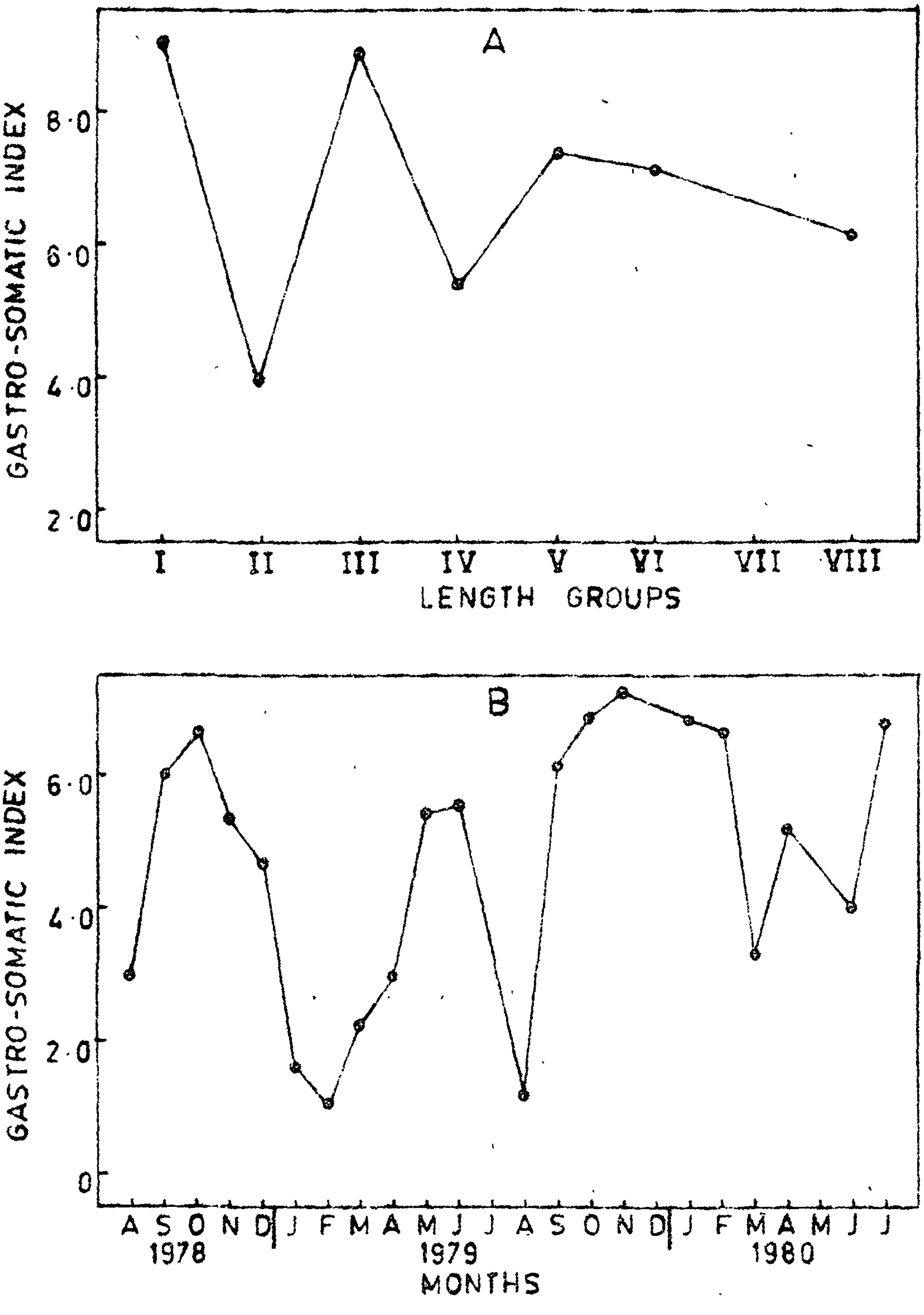


Fig.25. Gastro-somatic index of *A. hexagonolepis*. A: At different length-groups. B: Seasonal variations.

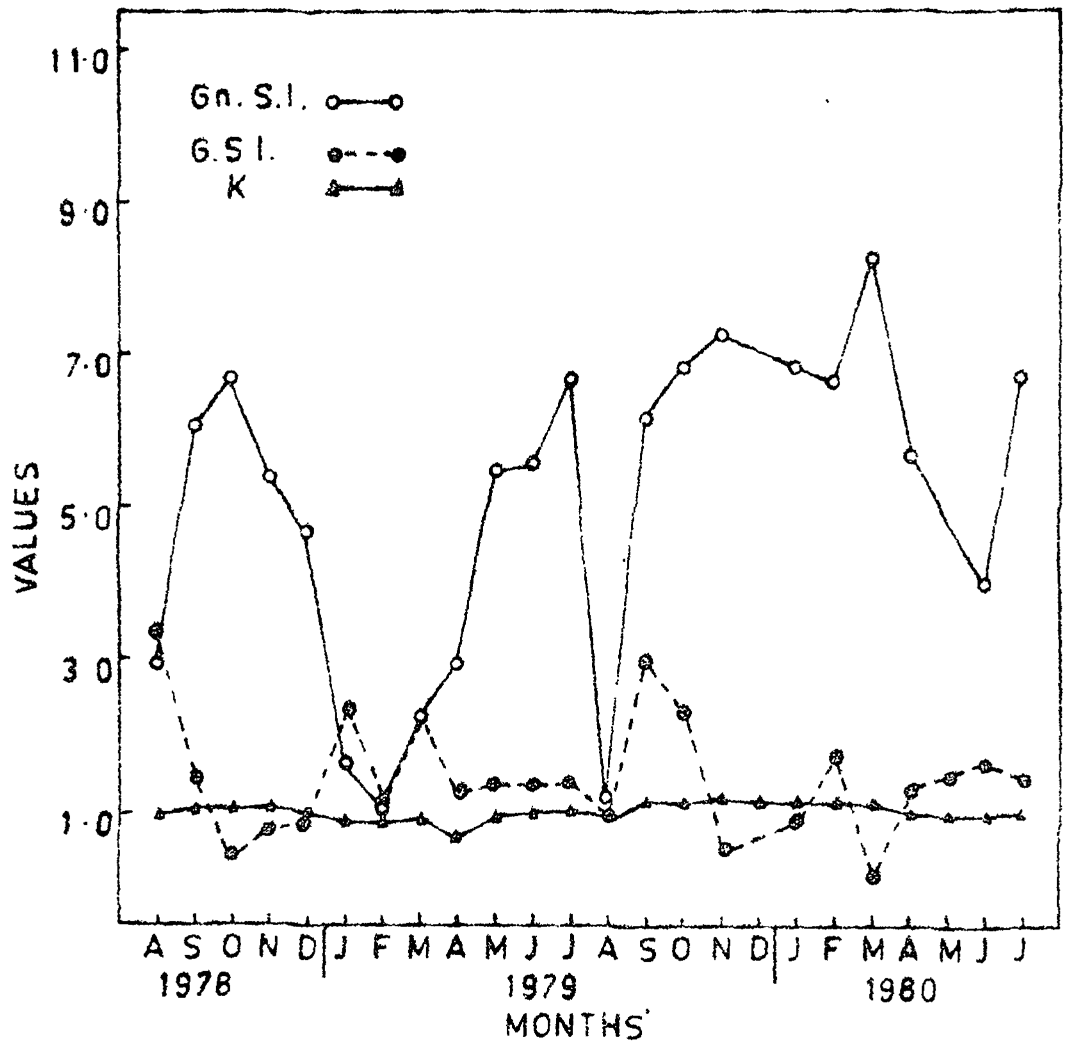


Fig 26. Relationship between condition factor, gastro-somatic and gonado-somatic index in _A.hexagonolepis_.

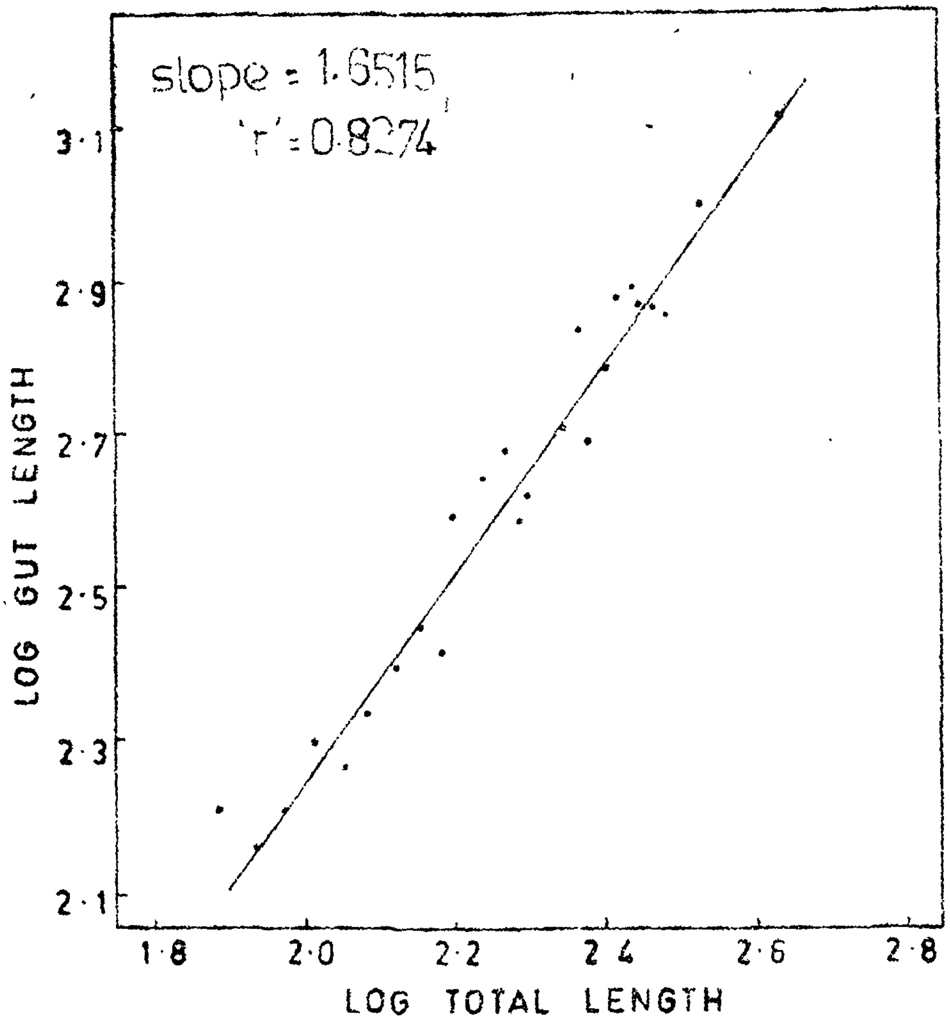


Fig 27. Relationship between gut length and body length in A. hexagonolepis.

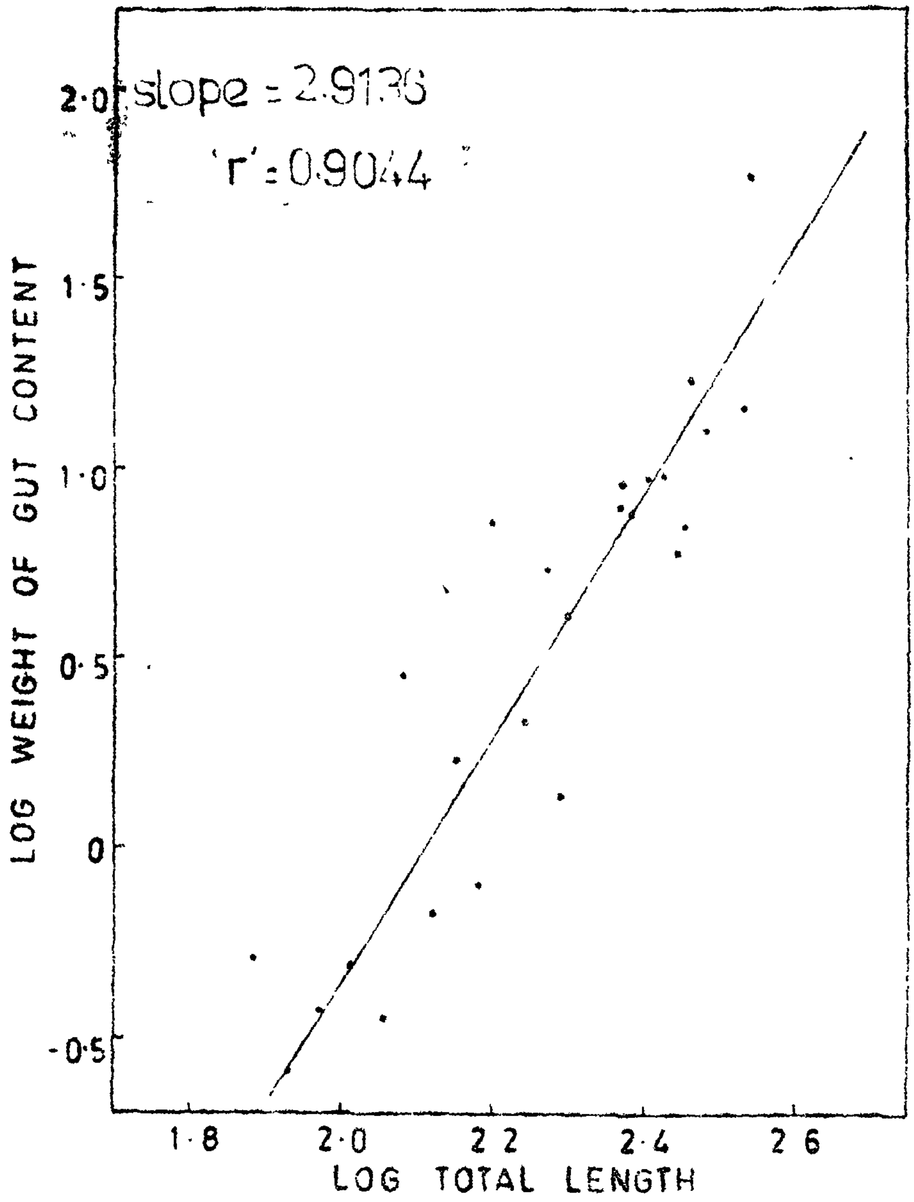


Fig. 28. Relationship between weight of gut content and body length in A. hexagonolepis.

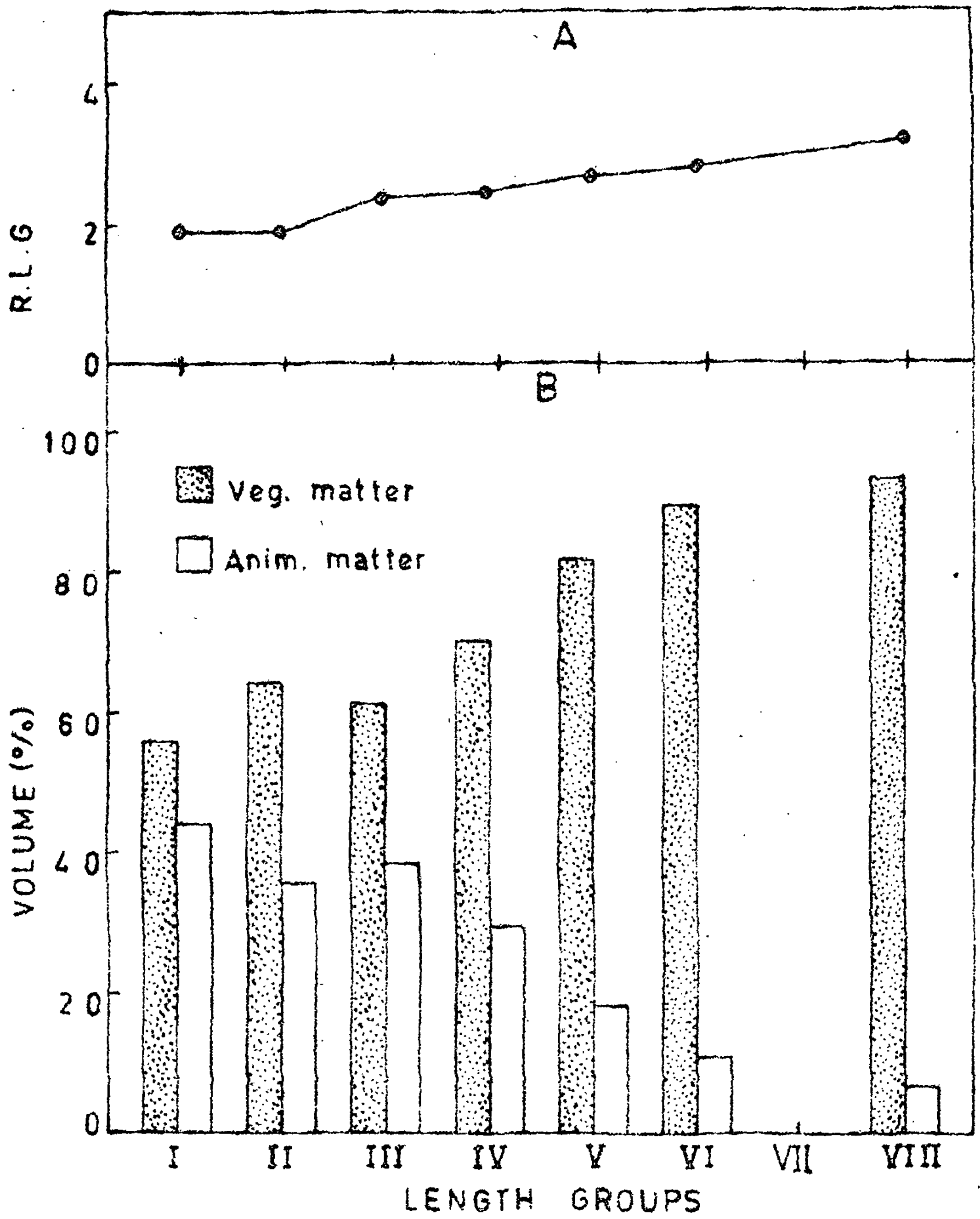


Fig. 29. A: Relative length of the gut of A. hexagonolepis at different length-groups. B: Percentage of vegetable and animal matter in the gut of A. hexagonolepis at different length-groups.

According to Jhingran (1975) the Copper Mahseer (A. hexagonolepis) is a veracious feeder subsisting on gastropod shells, filamentous and planktonic algae and vegetable debries. He also recorded sand and mud in the stomach. The fish has bottom feeding habit, browsing near the litoral zone. This species has been found to feed mainly on insect larvae, aquatic bettles and flies in the early fingerling stages (Jhingran, 1975) and aquatic vegetation and marginal grass constitute the main food found in the gut of advanced fingerlings and adults.

In the present study also, A. hexagonolepis was found to be a voracious feeder as indicated by the high values of its gastro-somatic indices (G.S.I.). The results of gut content analysis, are also quite similar to that reported by Jhingran (1975). However, Gastropod shells were never encountered in the gut contents of A. hexagonolepis in the present study. The presence of large quantities of macrophytes in the gut contents of advanced fingerlings and adults supports the reports of Jhingran (1975) that the advanced fingerlings and adults feed mainly on aquatic vegetation and marginal grass. The percentage of vegetable matter was found to increase with the increase in length of the species which further supports the above findings that A. hexagonolepis prefers mainly animal matters in the early fingerling stages and vegetable matter in the adult stages.

In the present study, it has been found that algae (35.88%) and vegetable matter (31.89%) can be considered as the basic food in T. tor. Insect, unidentified animal matter, Protozoa, Nematoda, Crustacea, Hydracarina and Gastropoda which altogether formed 24.88% of the gut content can be regarded as the secondary food. Like A. hexagonolepis sand particles (7.35%) can be regarded as an incidental item.

According to Jhingran (1975), T. tor is insectivorous in its juvenile stage, but becomes herbivorous on reaching to the adult stage, which is in accordance with the results obtained in the present investigation. In this species also the amount of animal matter was found to decrease in the gut content with the increase in length.

Qualitative and quantitative studies of natural food of T. tor made by Desai (1970) from River Narbada have shown that the species is herbivorous, feeding mainly on higher aquatic plants and fillamentous algae as well as the species also subsists on molluscs and insects. However, in the present study, it has been found that the species consume more of insects in its juvenile stage (upto 150 mm in length) but thereafter prefer, mainly macrovegetation. Thus, the findings of Desai (1970) is in accordance with the results obtained in the present study.

In case of T. putitora, Vegetable matter (33.46%), Algae (19.61%) and insects (29.1%) formed the primary food, as is evident from the present study (Table 24). The animal matter, Protozoa, Rotifera, Nematoda, Crustacea, and Gastropoda were found to constitute 15.32% of the gut content, hence it can be regarded as secondary food. Accordingly, Eubranchiopoda, Hydracarina and Sand particles altogether formed (2.51%) of the gut content and therefore, it can be considered as an incidental food item.

Sehgal et al. (1971) observed that the fry and fingerlings of T. putitora of the size range 25 - 130 mm subsisted on algae belonging to the families Bacillariophyceae (46.98%), decayed organic matter (22.28%), green algae (13.33%), insects (10.21%), Rotifers (1.42%), blue-green algae (1.38%), Protozoa (0.76%) and Fish (0.41%). All these items except fish were encountered in the gut content of T. putitora in the present study too.

A change in diet with increase in size, has been widely reported by Keast (1966), Larsen (1967), De Silva (1973), Adams (1976), Kakuda and Matsumoto (1978). In the present study also a change in diet has been observed in all the three species taken into consideration. The smaller specimens were found to consume Insect larvae and Gastropods (only Insects in case of A. hexagonolepis) and larger specimens consumed both larval and adult forms of Insects. The present study also indicates that the percentage of feeding is higher among young individuals than the bigger specimens, may be owing to the fact that metabolic activities are generally higher in young ones. Similar results have also been reported by Hardy (1924); Marshall et al. (1939), De Silva (1973) and Kaur (1981) in other species also.

The present results supports the view of Nikolski (1969) that the fish fauna of high latitudes are usually adapted to eating various types of food, on account of the

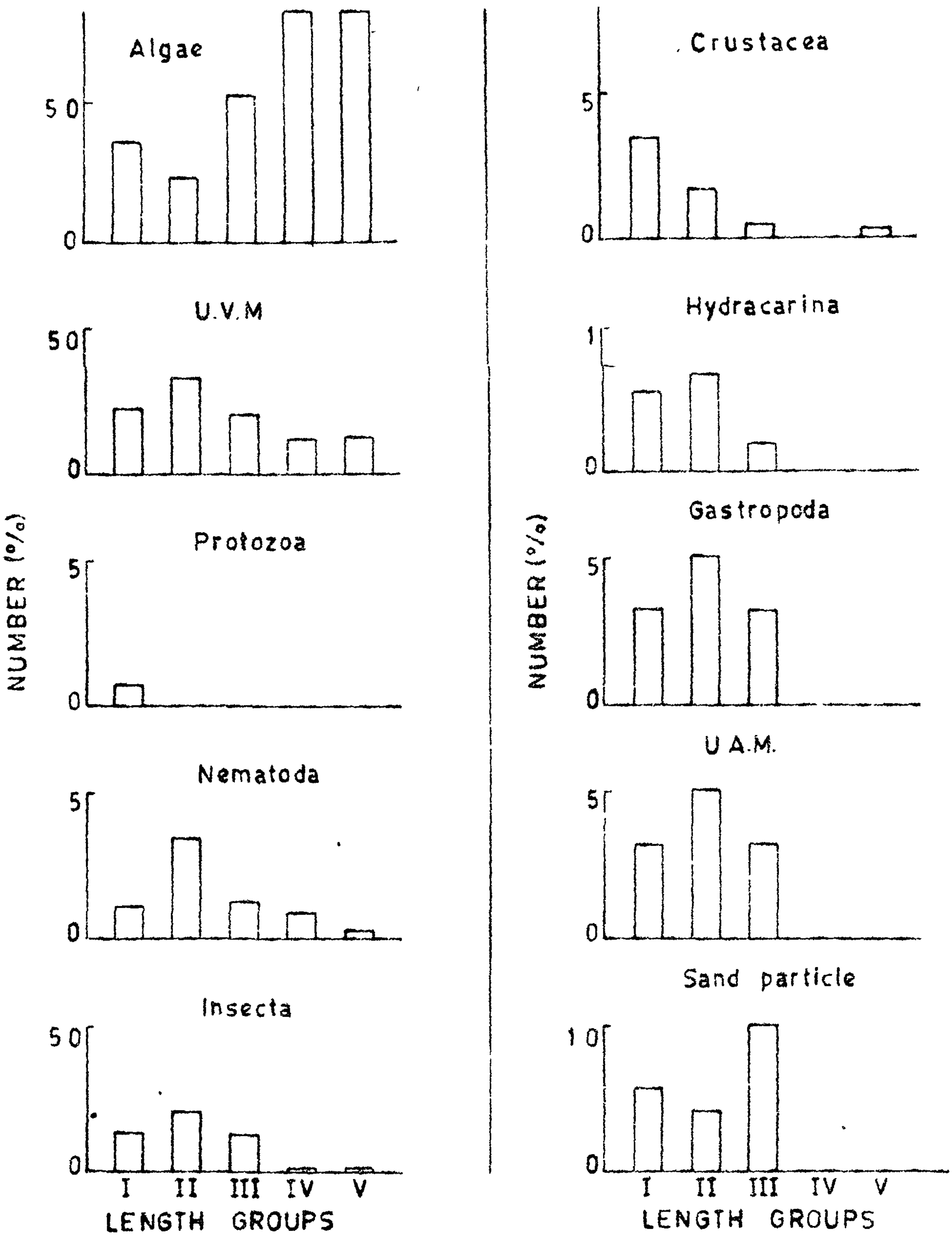


Fig 30.Relative importace of different food items in the gut of *I tor* at different length-groups

Fig. 31. Food spectrum of *T. tor* during different seasons.
A: Summer. B: Monsoon. C: Winter.

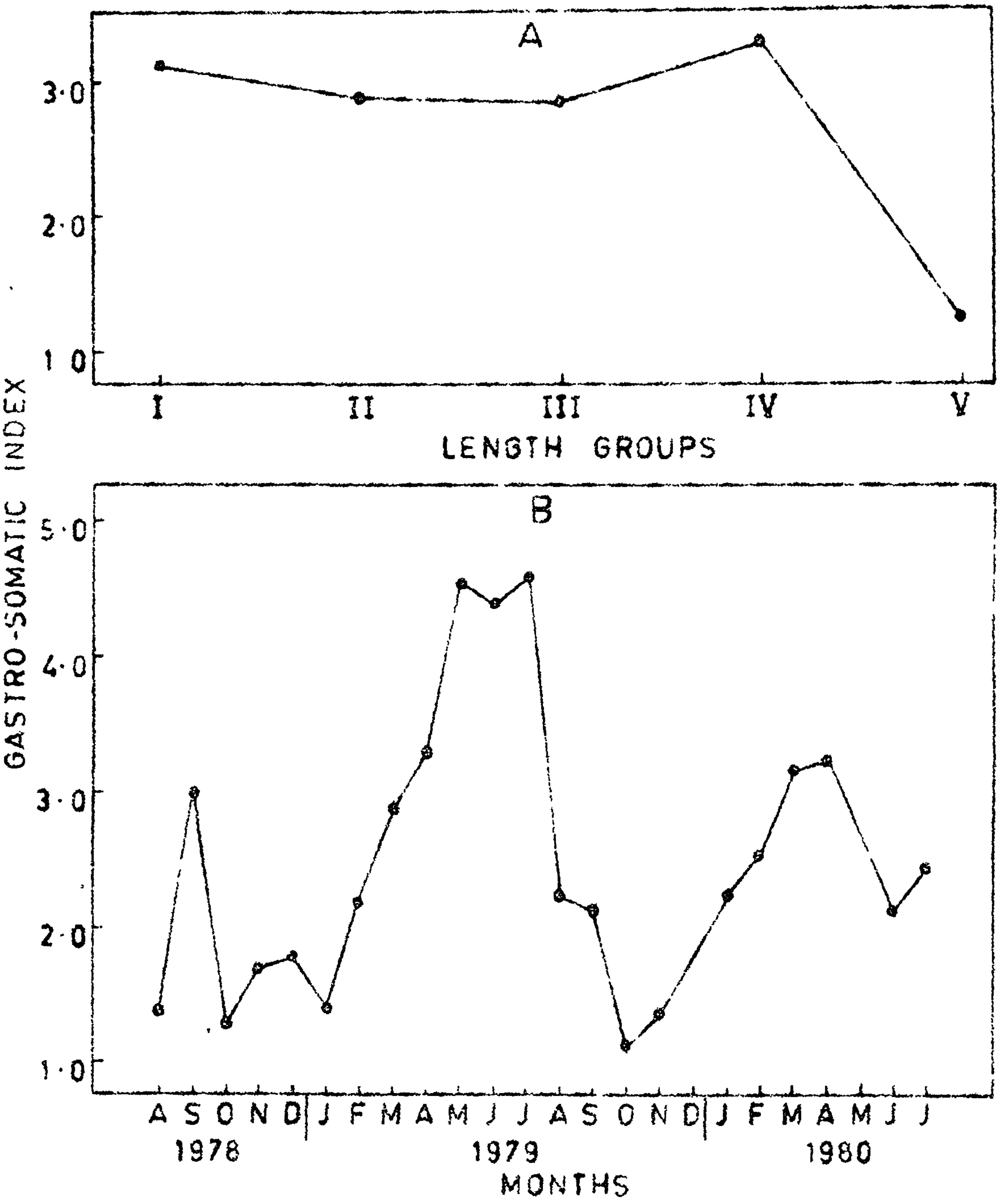


Fig 32 Gastro-somatic indices of T.tor. A At different length-groups B. Seasonal variations

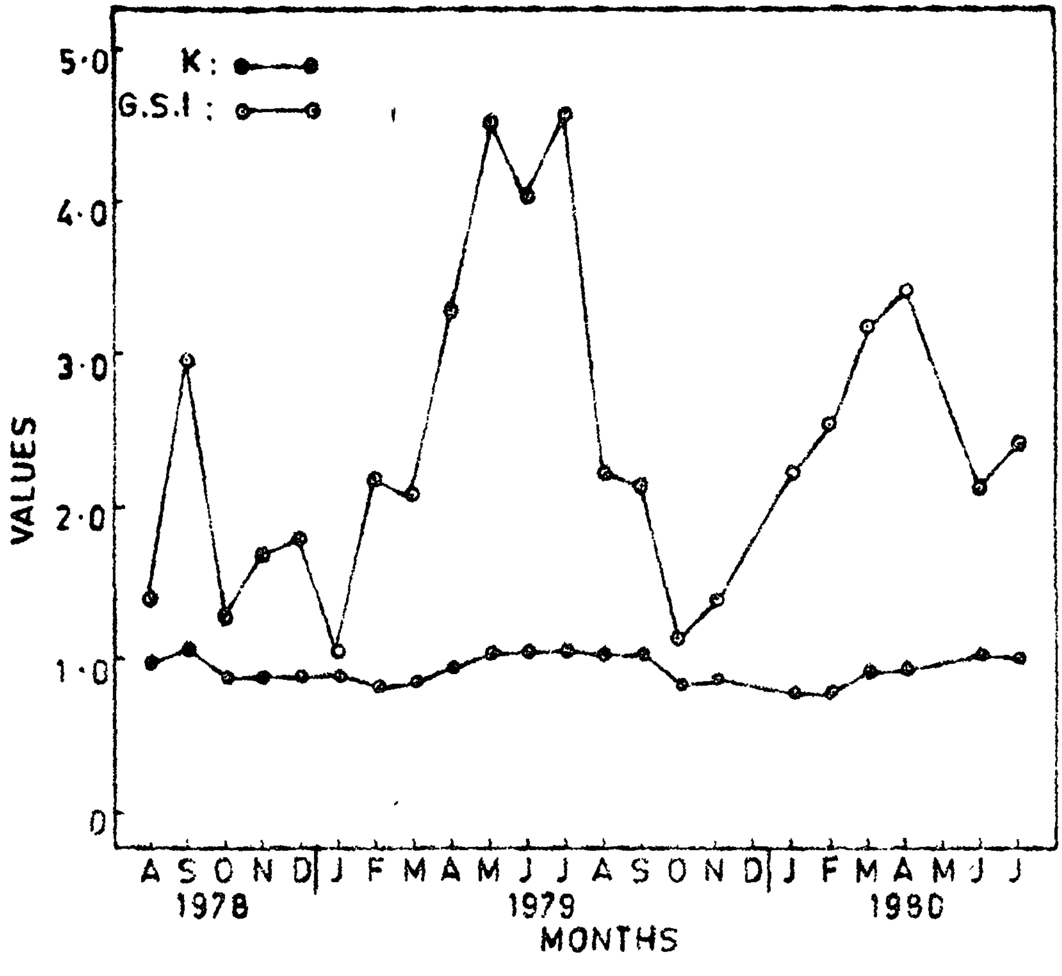


Fig. 33. Relationship between condition factor and gastro-somatic index in *T. tor*.

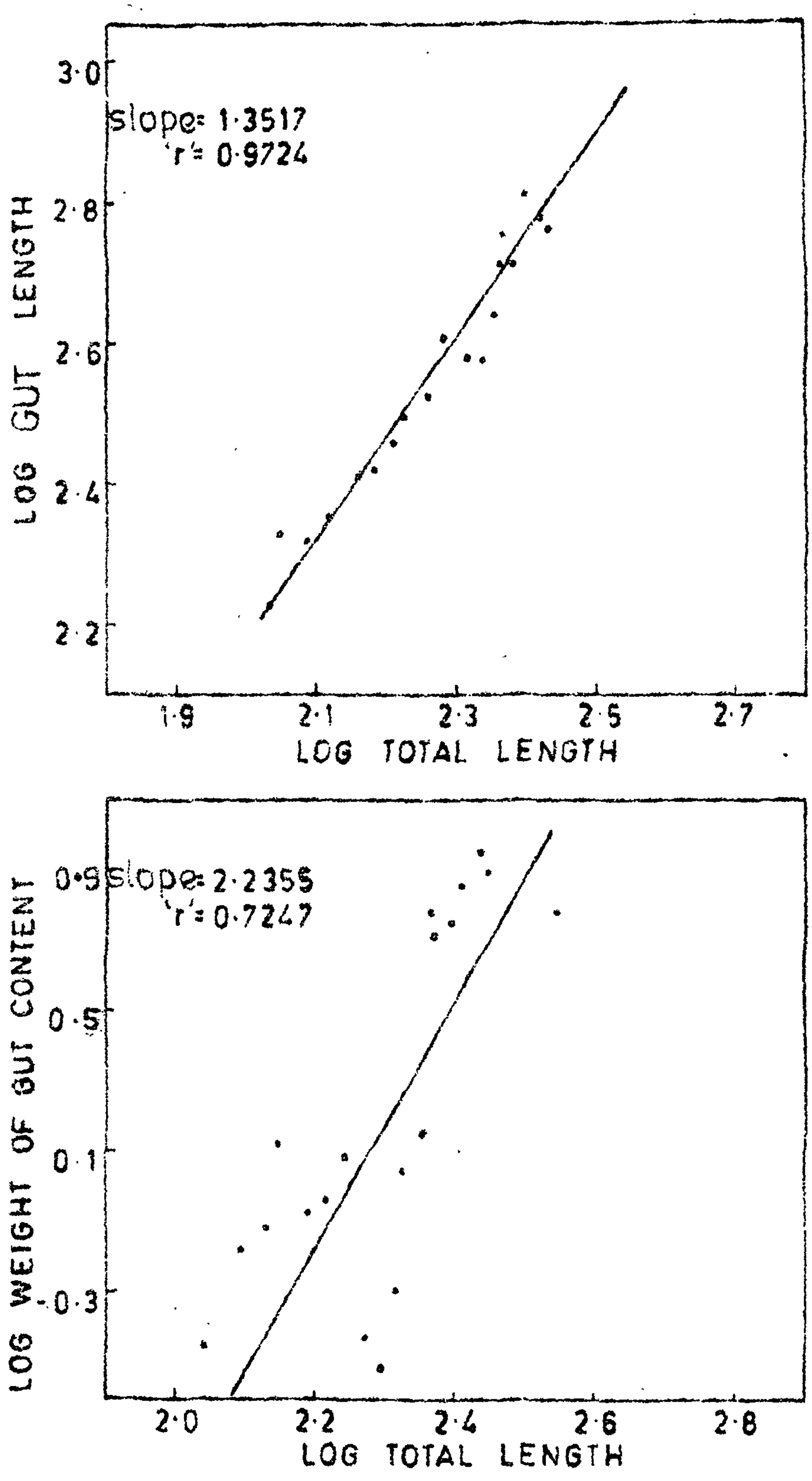


Fig.34. A: Relationship between gut length and body length in *T. tor*.
B: Relationship between weight of gut and body length in *T. tor*

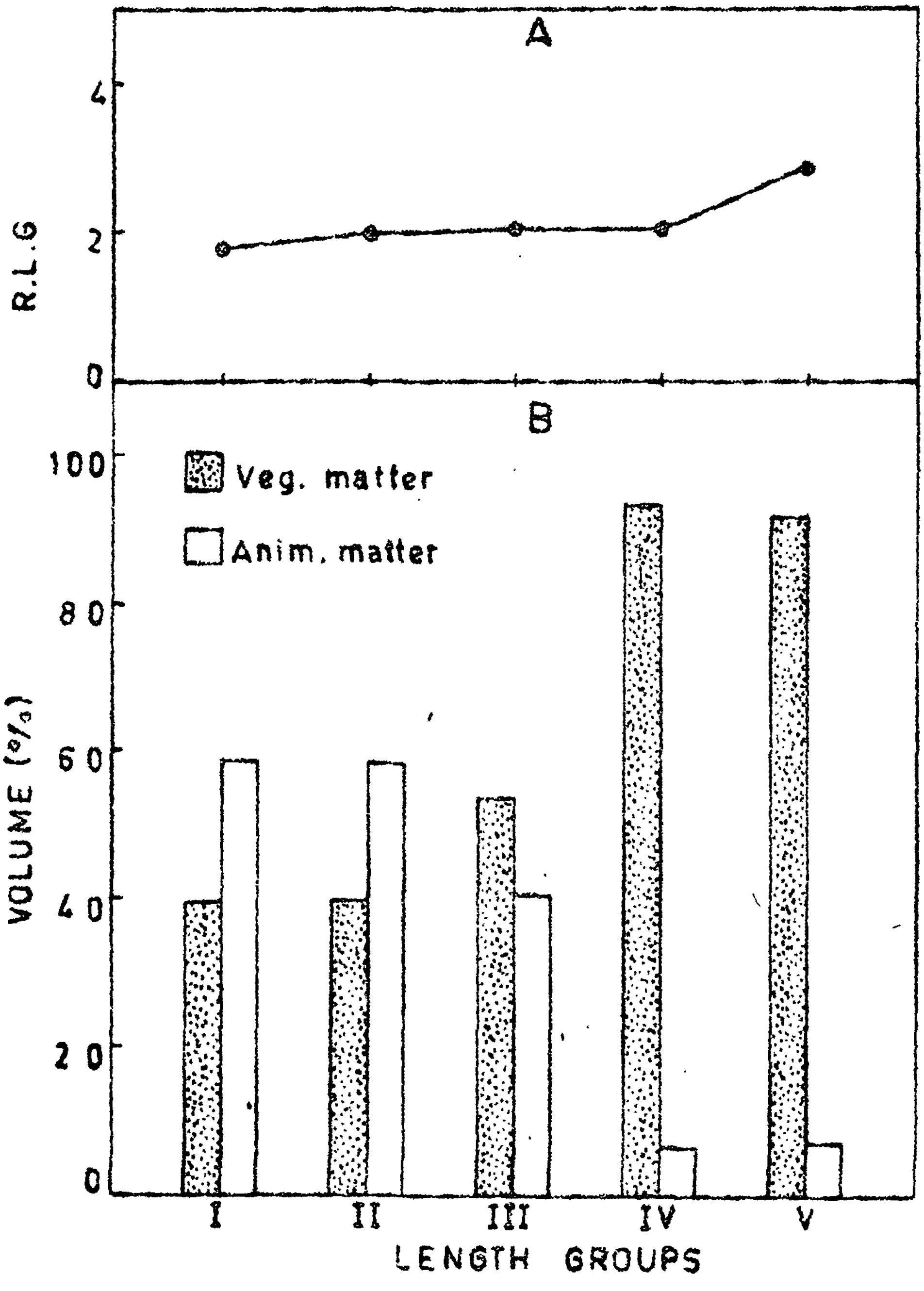


Fig. 35. A: Relative length of the gut of T. tor.
B: Percentage of vegetable and animal matter in the gut of T. tor.

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 associations from high altitudes are usually at an advantage when the food base is labile, since they tend to be eryphagus; conversely, those from the lower latitudes are so when the food base is stable.

The study indicated a positive relationship between feeding intensity and condition factor in A. hexagonolepis and T. tor (Fig. 26 and 33). However, in T. putitora the relationship is not evident (Fig. 39),and an inverse relationship between feeding intensity and gonad-somatic index has been observed (Fig. 26), which could be due to the spawning season of the fish, compelling reduced feeding. Similar view has also been expressed by Walfret and Miller (1978) for Northern pike. Jacobson (1974) observed that spawning brings down a sharp decrease in the condition.

According to Jhingran (1971), the principal factors that are likely to affect the monthly variations in the ponderal index are generally food and sexual maturity. The data on G.S.I. as obtained for A. hexagonolepis reflects the assessment of spawning season which is also indicated by the monthly fluctuations in the condition factor (Table 18). The feeding intensity declined with the progressive maturation of gonads (Fig. 26 and Table 30). Observations on the maturity and breeding season of the species (A. hexagonolepis) have shown that the fish breeds during April/May - October/November indicating that the periods of low feeding intensity coincides with the spawning season. The low feeding activity during peak breeding season may be attributed to the completely developed gonads, permitting limited space in the abdominal cavity for intake of food. Further, it is seen that the feeding intensity increased after the spawning season.

The coincidence of low feeding with peak breeding season has also been observed by many workers. Hardy (1924), Hickling (1933), Fage and Veillet (1938), Menon (1950) and Desai (1970) have reported a decrease in the rate of feeding and amount of food consumed with the maturation of gonads. Bhimachar and George (1952) have also referred to the reduced feeding in Indian mackerel, Rastralliger kanagurta with the progressive maturation of gonads. Karekar and Bal (1958) have also noticed the coicidence of peak breeding with low feeding phase in Polynemus indicus. Jhingran (1961) has observed the feeding intensity of Setipinna phasa to decline during its peak breeding season. Natarajan and Jhingran (1963) have reported a low level of feeding during maturation phase in the case of female Catla catla.

It has been observed in the present study that R.L.G. values of A. hexagonolepis, T. tor and T. putitora increases with the increasing length of the fishes. It is also evident that R.L.G. value has a close relationship with the nature of food of the fish. It is a known fact that vegetable matter requires more time for digestion due to which herbivorous fishes have higher R.L.G. value. In herbivorous fishes such

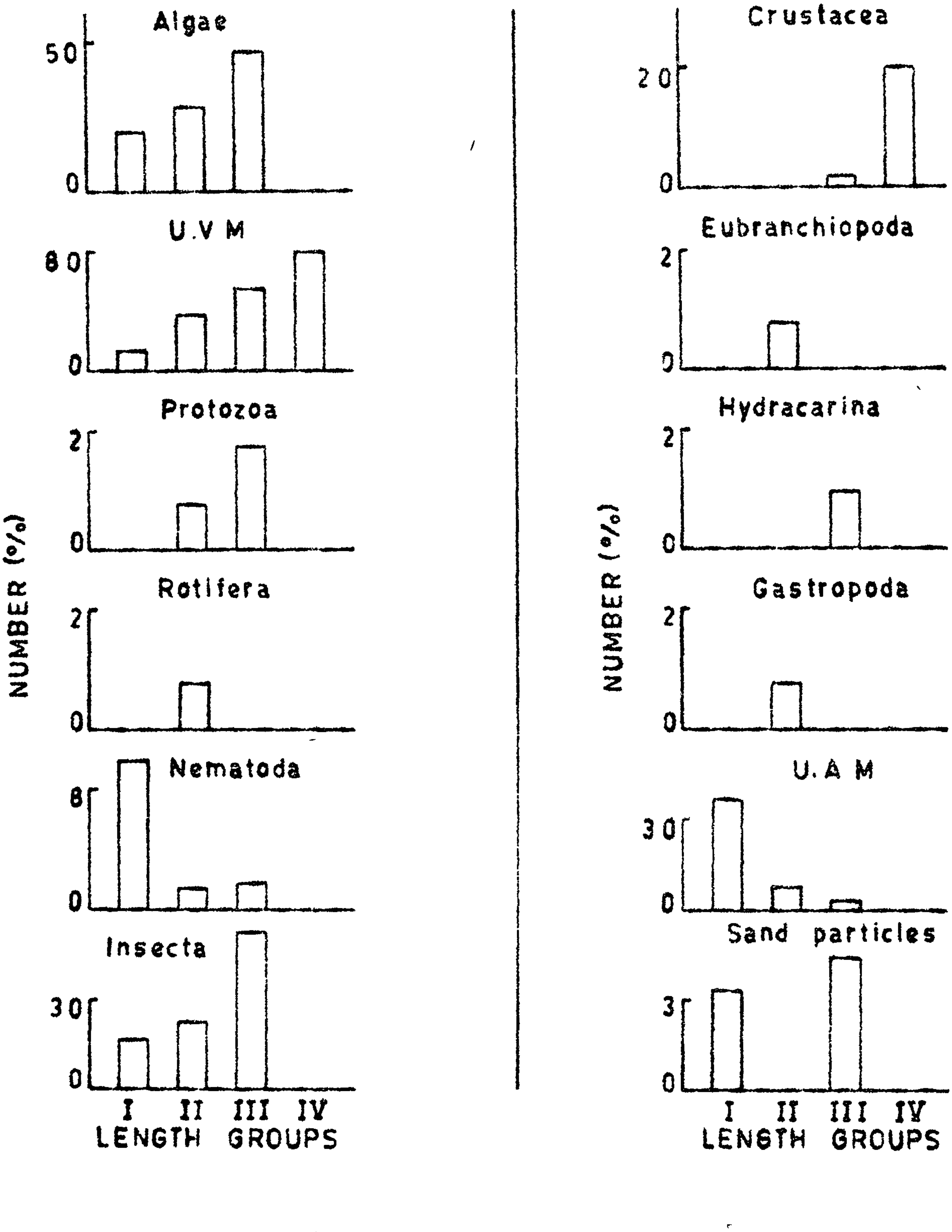


Fig.36. Relative importace of different food items in the gut of *T. putitora* at different length-groups.

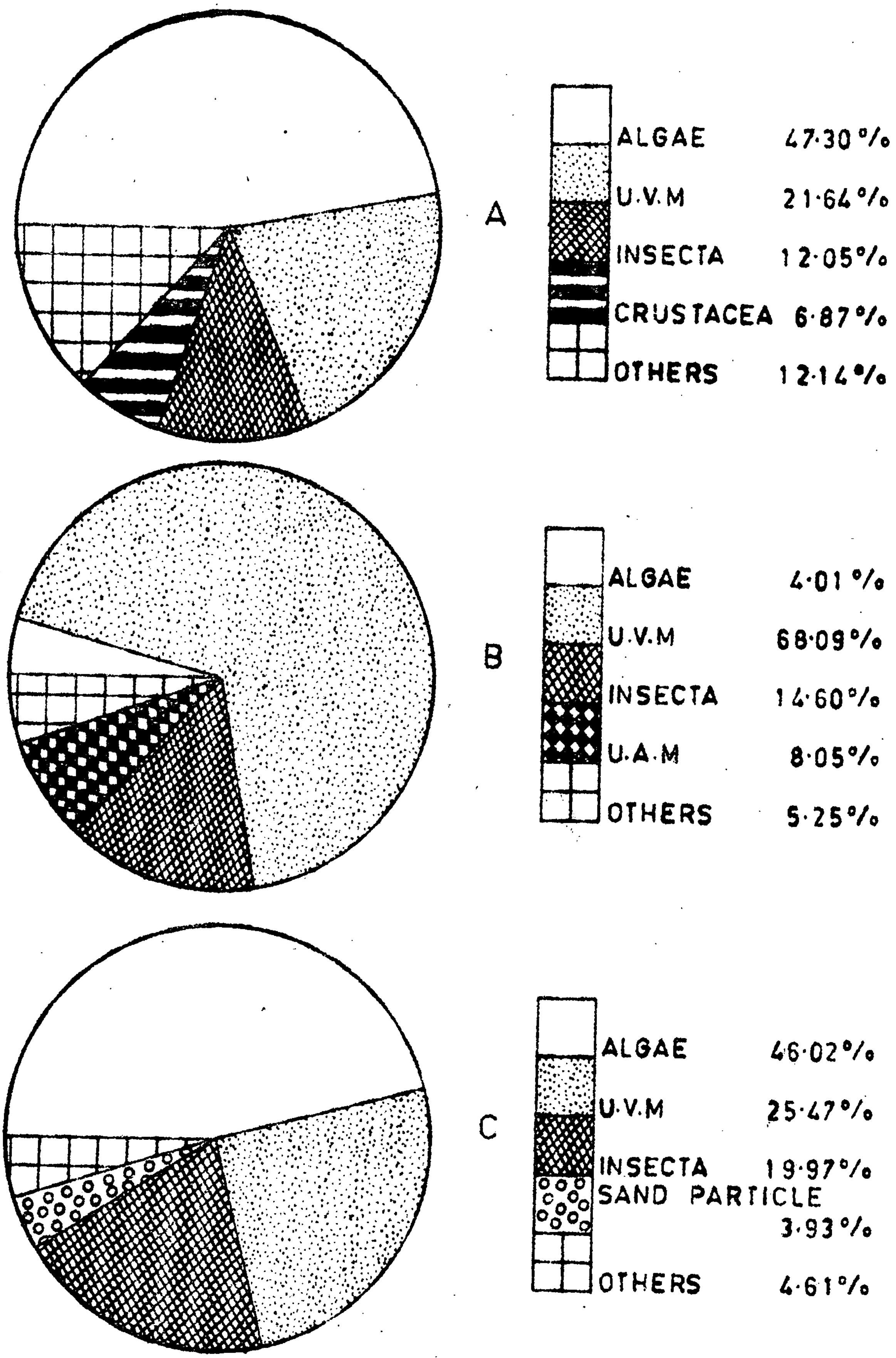


Fig. 37. Food spectrum of *T. putitora* during different seasons.
A: Summer. B: Monsoon. C: Winter.

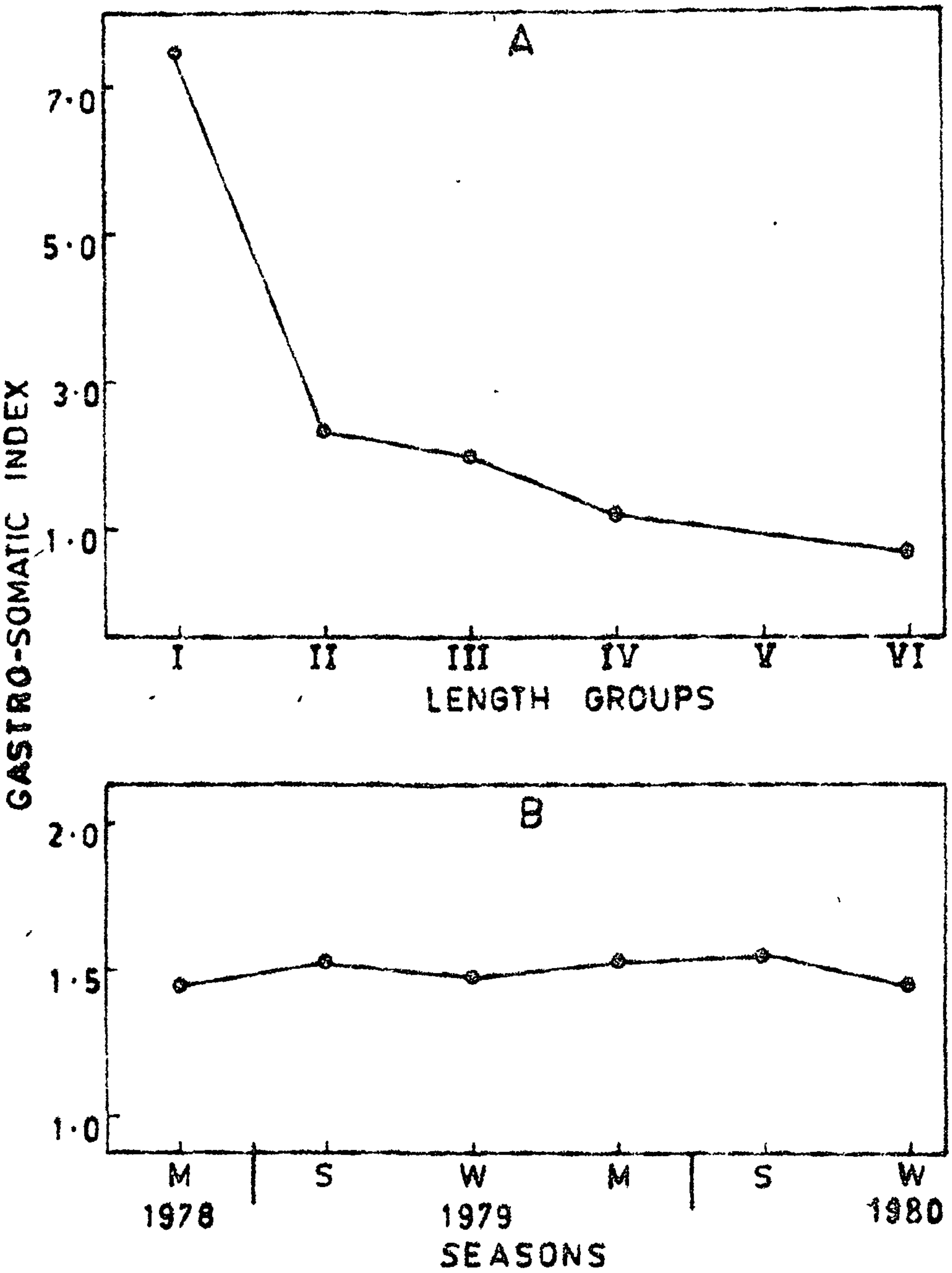


Fig.38 Gastro-somatic index of T. putitora

A: At different length-groups.

B: Seasonal variations.

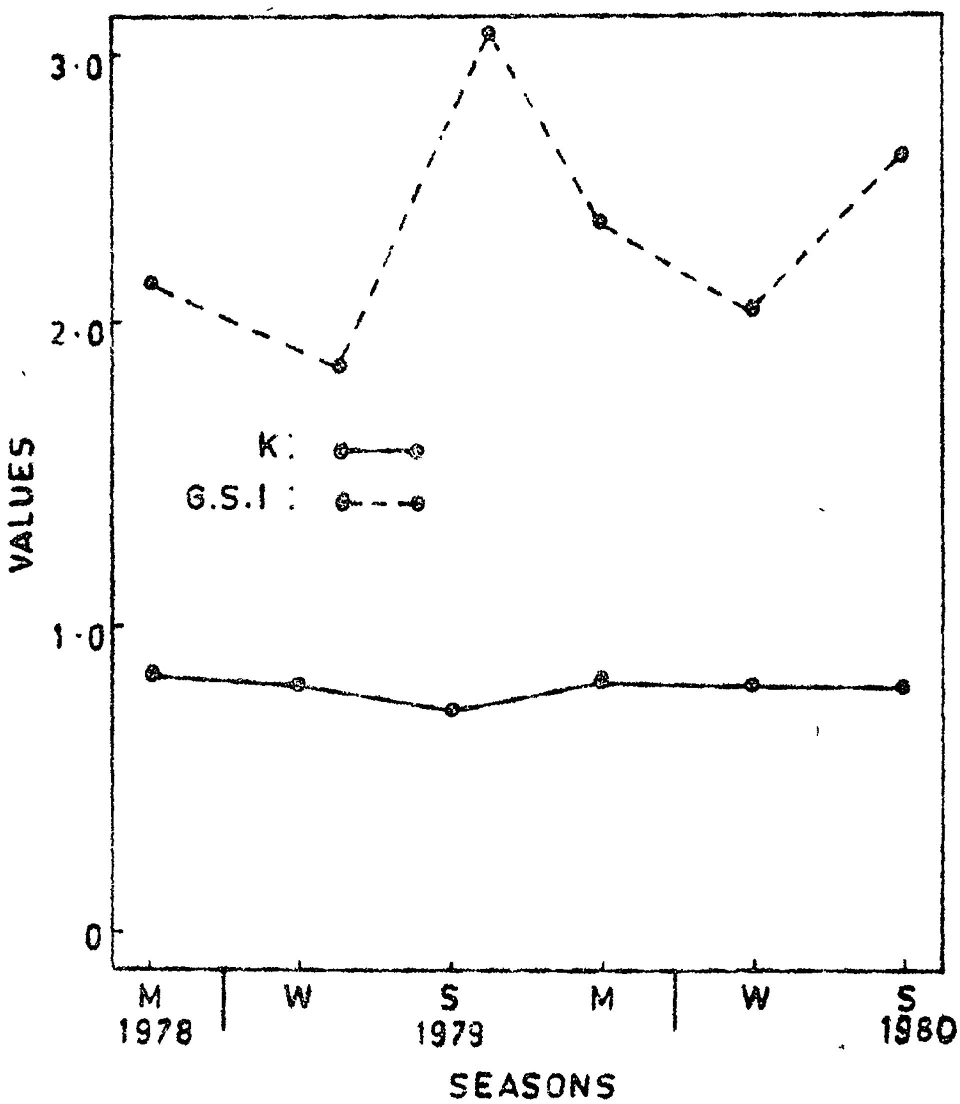


Fig 39. Relationship between condition factor and gastro-somatic index in *T. putitora*.

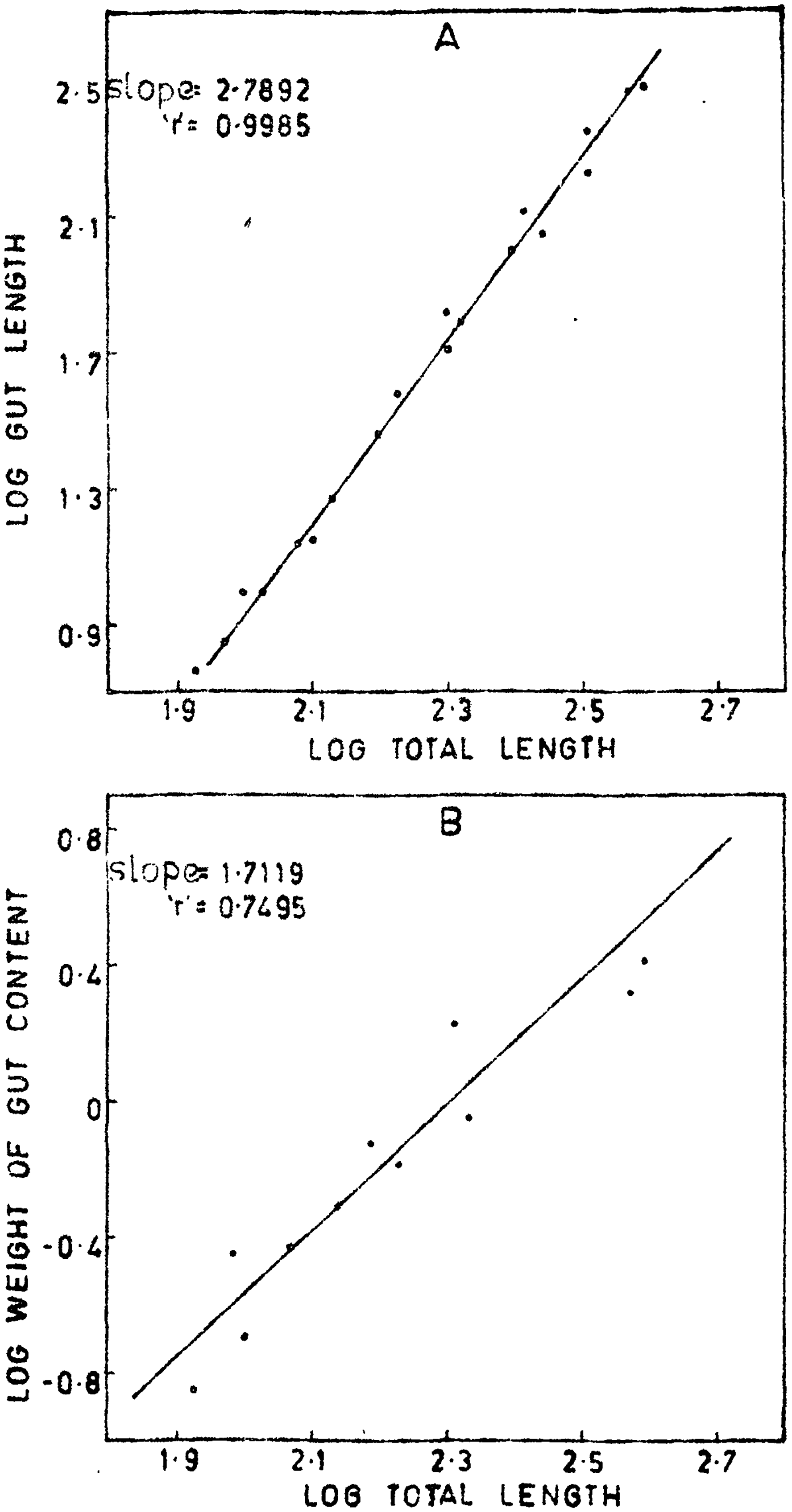


Fig. 40 Relationship between A: Gut length and body length in T. putitora. B: Weight of gut content and body length in T. putitora.

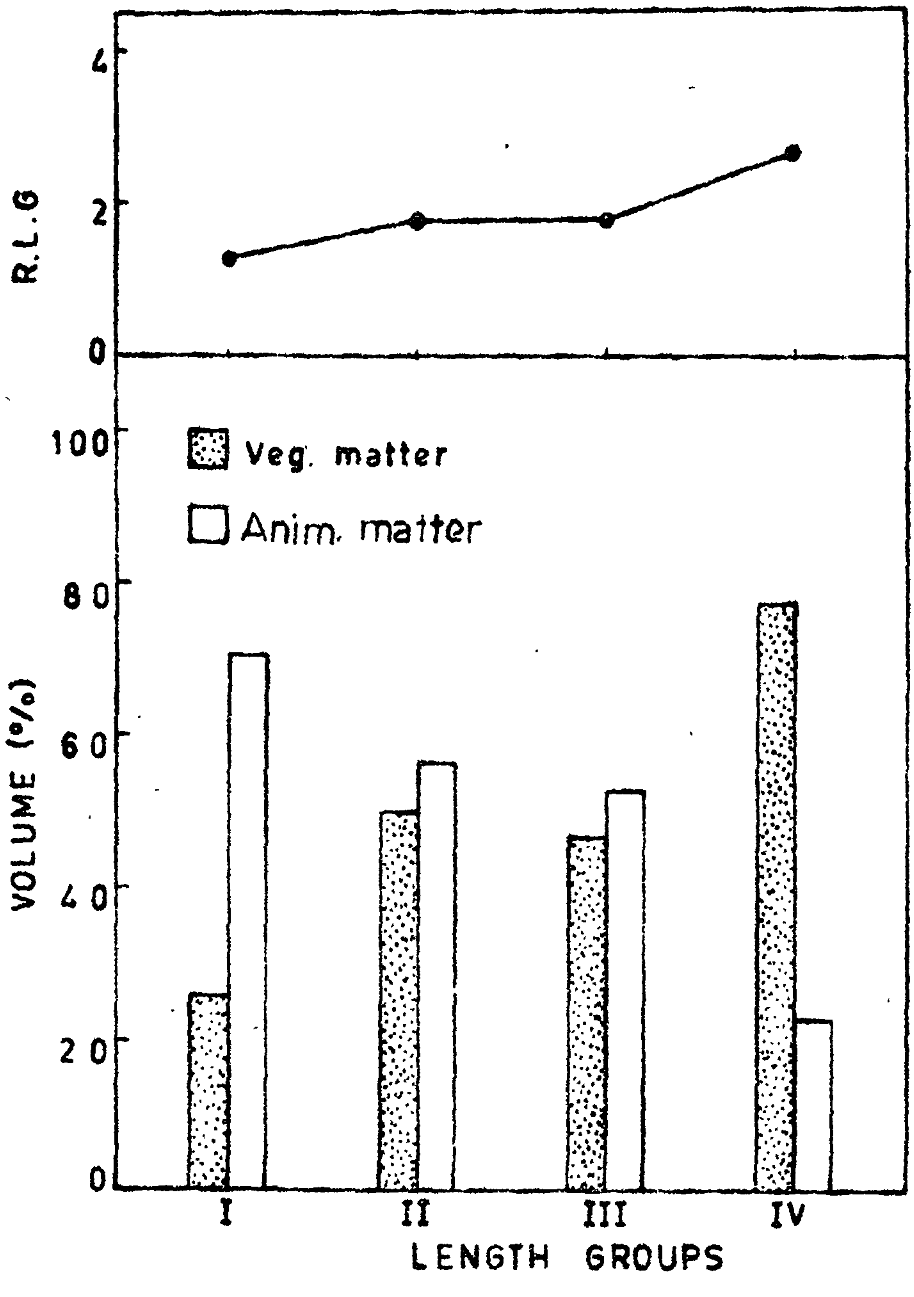


Fig. 41. A: Relative length of the gut of *T. putitora*.
B: Percentage of vegetable and animal matter in the gut of *T. putitora*

as *Labeo rohita* and *Labeo gonius* (Das and Moitra, 1956a, b, c, 1958, 1963) the R.L.G. values were about 12.0 and 9.5 respectively. Whereas in omnivorous fishes (Das and Nath, 1965) the R.L.G. values were lower, e.g. *Puntius conchonius* had 3.3 and *Barbus hexastichus* had 2.3. It is reported that in carnivorous fishes such as *Bagarius bagarius* and *Notopterus chitala* are generally low i.e. less than 1.0 (Das and Moitra, 1956a). However, in the present study, the average R.L.G. values were found to be 2.4, 2.1, and 1.3 in *A. hexagonolepis*, *T. tor* and *T. putitora* respectively. Thus, accordingly they can be kept in the category of omnivorous fishes, which is further supported by the results obtained by the food and feeding habits as well as the morphology of the alimentary canal as morphologically the bile duct opens at 1/3 length from the anterior end in *A. hexagonolepis*, *T. tor* and *T. putitora*. This has also been recorded earlier by Das and Pathani (1978) in *T. putitora*. Such a case can be regarded as a transitional stage between herbivorous and omnivorous condition. But if the bile duct opening shifted towards the posterior end of the sac, then the entire sac could have been considered as stomach. The shift of the bile duct opening from the junction of the oesophagus and intestinal bulb to one third posteriorly appears to be an adaptation due to increase in animal matter in the diet of these fishes.

SUMMARY AND CONCLUSION

S U M M A R Y   A N D   C O N C L U S I O N

Keeping in view, the basic necessity to have a knowledge on the biology of Mahseers viz., *Acrossocheilus hexagonolepis*, *Tor tor* and *Tor putitora* indigenous to the highlands of North-Eastern India, coupled with its great economic importance and also because of the fast gaining popularity of culturing these fishes, the present investigation has been undertaken. The thesis entitled "An investigation on the biology of Mahseers 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

Interspecific variations in the two populations (Simsang and Pagladia Rivers) of *A. hexagonolepis* have been observed in various morphometric characters viz., head depth, eye diameter and rostral barbel length. These characters were found to be higher in the specimens from Pagladia River whereas the characters viz., snout length, gape, and number of lateral line scales were found to be significantly higher in the specimens from the Simsang River. These variations were also indicated from the regression equations and such variations can be attributed to the different ecological conditions which suggest the adaptability of the organism to its new environment. Considerable differences in several morphometric parameters have also been observed in the present study between *T. tor* and *T. putitora*.

It can be concluded from the results that there exists an inter- and intra-specific difference as well as sexual dimorphism, at least in some morphometric characters, viz., number of lateral line scales, gape, rostral barbel length, pectoral fin height, However, the morphometric ratios and meristic counts in all the three species were found to be quite identical.

The results of the biometric characters for A. hexagonolepis reveal that eye diameter becomes smaller in relation to head length. The similar trend has also been recorded in case of T. tor and T. putitora. The trends of growth of girth in relation to total length were found to be isometric in all the three species. The growth of head length in relation to total length, is isometric in A. hexagonolepis and T. tor but the same is allometric in the case of T. putitora.

LENGTH-WEIGHT RELATIONSHIP

It is evident from the results obtained on length/mass relationship that there exists an inter-specific variation in the exponential or "b" value. The exponential value in the length-weight relationship of A. hexagonolepis and T. tor was found to be more than "3" indicating isometric pattern of growth whereas in T. putitora the growth is allometric as the "b" value was found to be less than "3".

It is also evident that exponential values in these fishes differs seasonally, sexually and also life-stage wise. Since, the exponential value in these species approximates the cubic law, they can be considered as an "ideal" fish as per the recommendation of Allen (1938).

CONDITION FACTOR

It has been seen that there are seasonal fluctuations in the "K" values in these fishes and such variations can be attributed to different factors such as food availability and gonadal maturity. The 'K' values of _A. hexagonolepis_ and _T. tor_ showed an increasing trend with the increase in length whereas in _T. putitora_, the case is opposite.

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.

MATURITY AND SPAWNING

The results on maturity of _A. hexagonolepis_ indicates that the male matures earlier than the famale and the species has a prolonged spawning season i.e. April/May to October/November, which is further supported by the fluctuation trend in the values of condition factor. The relation between Gn.S.I. and length of the species indicated a tendency for the Gn.S.I. to increase with the increase in body length. It has further been noticed that seasonal peaks in the Gn.S.I. values coincided with the peaks in the percentage of occurrence of matured individuals. This suggests that Gn.S.I. can be used as an index of gonadal development.

FECUNDITY

The data on fecundity reveal that fecundity is more dependent on weight than the length in A. hexagonolepis. The logerithmic relationship between fecundity of the species and its length, body weight and ovary weight were found to be linear. The maximum fecundity of A. hexagonolepis has been found to be 11, 660 in the specimen having a total length of 442.0 mm and a total weight of 1000 gm.

The fecundity estimate suggests that the species is not very fecund in comparison to other carps, might be due to their nature of parental care. This further indicates that parental care has profound effect on fecundity. It has been observed in the present investigation that the egg size and parental length are positively correlated.

FOOD AND FEEDING HABIT

The results on the food and feeding habits of A. hexagonolepis and T. tor indicates that the basic food of this species are algae and vegetable matters. However, animal matters can be regarded as secondary food of these species as per the classification of Nikolsky (1963). The species has bottom feeding habit and browsing near the littoral zone.

As indicated by the high values of G.S.I., A. hexagonolepis can be considered as a voracious feeder. The percentage of vegetable matters was found to increase with the increase in length of the species, which indicate that they mainly prefer animal matters in the early fingerling stages whereas in the advanced fingerling and adult stages they prefer only vegetable matters. In case of T. putitora vegetable matters, algae and insect can be regarded as "primary food."

In the present study it has been observed that the diet preference changes from animal matter towards vegetable matters.in all the three species. The results also indicate 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.

The study indicates a positive relationship between feeding intensity and condition factor in A. hexagonolepis and T. tor,whereas in T. putitora, the relationship has been found to be inverse. The feeding intensity declined with the progressive maturation of gonads or in other words, the periods of low feeding intensity coincides with the spawning season. The low feeding intensity during peak breeding season 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 been observed that R.L.G. values of all the three species in the present study increases with the increase in length. The average R.L.G. values were found to be 2.4, 2.1 and 1.3 in *A. hexagonolepis*, *T. tor* and *T. putitora* respectively. All these results reveal that the Mahseers of this region are omnivorous.

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APPENDIX

AUTHOR'S LIST OF PUBLICATIONS

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

1. Dasgupta, M. and Nasar, S.A.K. 1980. On the feeding ecology of Lebeo dero (Ham.) from river Pagladia, Assam. Proc. 67th Indian Science Congr., Abs. No.261: pp.197.

2. Dasgupta, M. and Nasar, S.A.K. 1981. Morphological comparisons of *Acrossocheilus hexagonolepis* (McClelland) from the different riverine systems in the North-Eastern region of India. Proc. 68th Indian Science Congr., Abs. No.99: pp.35.

(B): Papers published:

1. Dasgupta, M. 1979. Underwater sampter for limnological work. Rec. & Ind., 24: 240-250.

2. Nasar, S.A.K. and Dasgupta, M. 1979. On the occurrence of Ichthyopthiriasis in *Acrossocheilus hexagonolepis* (McClelland). Matsya, 5: 73-74.

3. Dasgupta, M. and Nasar, S.A.K. 1980. Preliminary observations on the biology of the juvenile of *Barilius bendelisis* Ham. from River Simsang, Meghalaya (India). Arquivos do Museu Boeage. (In Press).

4. Dasgupta, M. and Nasar, S.A.K. 1981. A record of an abnormal specimen of the Indian carp, *Labeo rohita* (Ham.). Uttar Pradesh Journal of Zoology. (In press).