LIMNOLOGY OF GADIGARH STREAM (MIRAN SAHIB, JAMMU) WITH SPECIAL REFERENCE TO CONSUMERS INHABITING THE STREAM

Thesis

Submitted for the award of Ph. D. Degree
of
University of Jammu

By

Sunt Pall Singh Dutta

MARCH : 1978

DEPARTMENT OF BIO-SCIENCES
UNIVERSITY OF JAMMU
JAMMU-180001.

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ii. The candidate worked under me for the period required.

iii. The candidate has put in attendance in the Department during the period required under rules.

iv. The thesis being submitted for the degree of Ph. D. by Sh. Sunt Pall Singh Dutta is worthy of consideration for the award of Ph. D. degree of the University of Jammu.

Signature
Supervisor

Signature
Head of the Department

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I N T R O D U C T I O N

In the underdeveloped world, provision of food has been an invincible problem for man because the ratio between man and agricultural land in these countries is so low that even the most sophisticated and modern techniques have failed to produce desired results. The situation is further

aggravated by ever-increasing population. However, other urban land uses such as, increasing demand through housing, industry, recreation etc., further reduces the already insufficient agricultural land. It has thus become imperative to explore and harvest alternative sources which can help augment food production (in both quality and quantity).

Since about 70 % of total area of earth is occupied by water masses, it provides a promising alternative to ameliorate food deficiency. In India ponds, tanks, lakes, reservoirs and brackish waters occupy an area of 6.5 million hectares. Besides 27,359 km of rivers and 11 2654km of irrigation canals and channels (Jhingran, 1972) flow through the country. Hitherto, most of these water bodies have mainly been used for irrigation (to boost the agricultural production on lands), but have not been scientifically harvested for aquatic productivity.

Inland water resources of the country (if properly managed) can enrich the human diet by providing additional animal protein. For purposes of harvesting this important protein source initiation of aquaculture and fish husbandry practices may provide an appropriate answer. However, a

thorough insight into the delicately balanced interacting abiotic and biotic factors in an aquatic ecosystem would be an essential prerequisite.

Ecosystems in the biosphere are being studied for their biotic and abiotic composition under international programmes such as IBP (International Biological Programme) and MAB (Man and Biosphere). The productivity potential of the inland aquatic systems (PF section of IBP) is receiving special attention, in view of the promise they hold for future.

Jammu and Kashmir state is an extensively hilly area, bestowed with large number of lotic and lentic water bodies. To the best of my knowledge no work has so far been attempted on any limnological aspect of lotic and lentic water bodies of Jammu province. Keeping all this in view a limnological study of Gadigarh stream (situated 12 km south of Jammu) was undertaken as a representative study of non-torrential lotic waters of the area so as to obtain a basic knowledge of aquatic biota and their interaction with the environment (in the region), in order to formulate necessary policies for management of lotic waters of Jammu.

Gadigarh stream at various places is observed to be variable in depth, rate of flow of water, nature of the land surrounding it, soil structure of stream bed, turbidity and salt concentration etc. All these features have further been observed to be under the seasonal influences. The speed of water (in the stream) determines habitats ranging from near stagnant to torrents, thereby supporting a variety of adaptations in flora and fauna. A definite relationship exists between physico-chemical factors and biological systems in the stream. In its totality the present study is aimed to be a source work for rational and scientific aquaculture; because this slow running stream with a soft alluvial bottom supports a rich and diverse fauna thereby indicating a promising future in productive potential of such lotic waters in similar topography.

The biotic components of any ecosystem comprise of primary producers, consumers, and decomposers. The present investigation from the point of view of biota is restricted to the study of consumers inhabiting the stream (producers being explored separately by a contemporary worker).

Broadly speaking consumers of the stream include all ecological categories such as, zooplankton, neuston, nekton, periphyton, and benthos.

Main plant groups inhabiting the stream (as investigated by contemporary worker; unpublished) are algae, pteridophytes and angiosperms. Study of primary producers is an integral aspect of any limnological investigation. These producers provide cover to most of animals (against the predators); they are food for primary consumers both in living and decomposing condition. They also enrich the stream by producing oxygen and by absorbing carbon dioxide from water (photosynthesis) thereby reducing its toxicity.

Amongst biota, plankton is an important fish food, and their production depends upon interaction of physico-chemical and biological factors. It is therefore, essential to understand the intricate and cryptic phenomenon through which the plankton production increases. The bearing of physico-chemical conditions on the seasonal variation of plankton is thus investigated. It may, however, be noted that although plankton have been recognized

as an important fish food, very little attention has been paid to the study of seasonal distribution of planktonic fauna in lotic waters of India.

The benthos is an important link in the trophic cycle of any aquatic ecosystem. The abundance, diversity and distribution of the benthic animals in nature is also related to various physico-chemical and biotic factors. The benthos is an important link in supporting a detritus based fishery, the dead particulate matter upon decomposition (by bacteria and fungi) is used by detritivores directly (the process may be furthered by reingestion and coprophagy), these organisms alongwith detritivores are fed upon by fishes. Thus the energy of dead particulate organic matter passes to the plankton and nekton of water body, to be cropped later by human beings as fishes.

Nekton (other than prawns and fishes) includes insects and other aquatic organisms which are functional links in important food chains in the water body.

From amongst the biota inhabiting this stream, prawns, crabs, fishes and tortoises are edible and information needs to be obtained regarding

their food habits, reproduction and diseases. Biota interact with their abiotic environment, thereby necessitating a great scientific insight into the physico-chemical factors in relation to biota, as has been realized in course of present investigations. Therefore, in this direction due consideration is paid to the detailed investigations of soil and water (in relation to the supported biota).

The suitability and productive potential of soil is determined by its physical and chemical properties. In case of an aquatic ecosystem, (where the bottom sediments remain in contact with flowing water) the mineral nutrients released by the soil are added to the water and become readily available to the biota of the column. The bottom sediments of Gadigarh stream therefore, have been investigated for colour, texture, pH, conductivity, total soluble salts, bicarbonates, available phosphates, total nitrogen and carbon (organic); all of which are known to enhance productivity.

Most of the previous workers dealing with aquatic organisms have regarded substrate composition as a fundamental factor in controlling

biotic distribution. The role of water too, is no less important, it is the environment for aquatic organisms and functions as the medium for the circulation of nutrients. Thus, the water of Gadigarh stream has been analysed for temperature, depth, suspended matter, transparency and chemical composition particularly for dissolved oxygen, free carbon dioxide, pH, carbonates, bicarbonates, chlorides, water soluble phosphate, calcium, and magnesium. All these factors in their own intent, singly or collectively, determine aquatic productivity.

It may be pointed out that in an aquatic ecosystem the primary producers are trophically linked to primary consumers which in turn are connected with secondary and tertiary consumers and ultimately culminating in top carnivores. All this results in the formation of a complex food web. Knowledge of food web in a water body is, therefore, basic to any scheme in aquaculture. Important food chains and food web operating in Gadigarh stream have been projected in proper perspective.

Thus the studies dealing with seasonal changes in physico-chemical conditions of soil and water, planktonic abundance, food of

culturable forms, reproductive behaviour of some animals, diseases and predators would serve as a basic source material for species introduction and establishment, to exploit every available ecological niche so as to form a basis of composite aquaculture in this part of the country. The present studies thus aim at greater production from limited aquatic resources, through scientific enquiry into various finer components of interacting abiotic and biotic factors as incorporated in the present thesis.

HISTORICAL RESUME

BOTTOM SEDIMENT

The available information on physico-chemical factors of river and stream bottom is inadequate. Soil nitrogen in relation to productivity has been studied by Boyd (1970) and Sumitra - Vijayaraghavan (1973); while Isirimah and

Keeney (1973) studied nitrogen accumulation in soil under water logged and aerobic conditions. Bollag and Drzymala (1973) observed predominance of nitrate decomposition in acidic soil under sterile and non-sterile conditions, but observed very little decomposition of nitrate in neutral and alkaline soils. They attributed the disappearance of nitrates under anaerobic non-sterile conditions to the microbial activity.

Kuznetov (1975) compared decomposition of organic substances in terrestrial soil and lake bottom; while Sorokin Jr. (1975) observed sulphate reduction in lake bottom as related to organic pollution, eutrophication and number of bacteria.

Adams and Honeysetts (1964) concluded that water logged conditions raised the total uptake of cobalt but not of copper by plants. Karanth, Lokabharathi and Nair (1975) observed that the origin and chemistry of phenolic acids is related to the processes involved in the degradation of organic matter of mangrove swamps. Jones (1975) observed that the exchange of potassium was higher in slack than in dune soils.

BENTHOS

Information on the benthic organisms of Indian waters is scanty. Srivastava (1956) studied

the variation of oligochaetes, Chironomus, molluscs, ostracods and leeches in a fish tank in Lucknow; while in 1959 he observed seasonal variations in relative abundance of different benthic organisms of lake Martiniere and Kathauta in the same area. Macrobenthic fauna of the Tungabhadra reservoir has been investigated by Krishnamurthy (1966).

Mandal and Moitra (1975) while studying variations of benthic organisms in a fresh water fish pond at Burdwan observed the occurrence of oligochaetes, Chironomus, molluscs, and leeches attaining their peak during August. Raman, Ghosh and Chatterjee (1975) observed greater number of benthos in unstocked (as compared to stocked) part of fish ponds at Cuttack and Bhubaneswar.

PHYSICO-CHEMICAL FACTORS AND PLANKTON

Perusal of literature has revealed that compared to lentic waters the limnology of lotic waters has received a very little attention in India. Chacko and Ganapati (1949), Chacko, Srivivasan and Evangeline (1953) provided some information on

physico-chemical and planktonic composition of Adyar and Malamphaza rivers respectively. Iyenger and Venkataraman (1951) described the ecology and seasonal succession of the algal flora of river Cooum in Madras. Chacko and Srinivasan (1955); While investigating river Godavari for seasonal variations of physico-chemical and biotic parameters, observed a predominance of zooplankton during flooding and of phytoplankton in the non flooding season.

Chakrabarty, Roy and Singh (1959) on investigating the seasonal variations in physico-chemical and biological parameters of river Jamuna at Allahabad have brought into focus the impact of these factors on the growth of plankton and discussed zooplanktonic-phytoplanktonic relationship. Rajan(1963) in his study on ecology of river Pykara and Moyar (Nilgiri) observed that altitude, physical barriers, and temperature substantially influence the distribution of fishes in the length and column of these rivers.

Ray, Singh and Sehgal (1966), and Pahwa and Mehrotra (1966) investigated various hydrobiological features of the River Ganga. Venkateswarlu (1966, 1969) studied the effect of various physico-chemical factors on algal development in river Moosi.

little information

A number of workers have contributed informations on the physico-chemical and biotic parameters of Indian lentic waters. Pruthi (1933) and Sewell (1934) studied bionomics of some fresh water organisms from Indian Museum Compound at Calcutta. Ganapati (1943) worked out interrelationships between the environmental conditions and animals in a garden pond in Madras. Das and Srivastava (1956a,b) studied quantitative planktonic variations of some fresh water bodies in Lucknow. Later in 1959 they undertook studies on qualitative planktonic composition of two lakes in Lucknow.

Zafar (1964) observed diatoms to constitute the dominant algal populations in two fish ponds of Hyderabad. Hussainy (1966), while investigating the population dynamics of plankton in Vihar lake, observed the dominance of copepods and cladocera.

Sreenivasan (1967) concluded that limnological data can be used to predict relative productivity of an aquatic biotope. In 1968, he found that in alkaline reservoirs (Sathnaur and Krishnagiri) turbidity limits phytoplankton production. Sreenivasan(1972) observed a low productivity of Odathuri tank as due to

(i) absence (throughout the year) of free carbon dioxide, (ii) prevalence of high alkalinity and, (iii) constant turbidity caused by wind action.

Verma and Shukla (1968) observed that algal bloom hampers development and management of fisheries; subsequently in 1970 (while working on Kamla Nehru tank, Muzzafarnagar) they observed that biological fluctuations cannot be correlated with any single factor.

Vasisht (1968) described the limnological conditions of Sukhna lake, Chandigarh; while Vasisht and Dhir (1970) studied seasonal fluctuations in physico-chemical factors and zooplanktonic abundance in four fish farm tanks of Chandigarh. Vasisht and Sharma (1976) observed correlation between the physico-chemical characteristics and plankton density of a pond near Ambala.

Saha, Sehgal, Mitra and Nandy (1971) found identical annual mean values for planktonic groups existing in different layers. Tandon and Singh (1972) studied the effect of physico-chemical conditions on the plankters of Nangal lake. Moitra and Mukherji (1972) discussed composition and seasonal fluctuations in plankters from a fish pond in Kalyani and concluded

that the pond in comparison to North Indian lentic waters is poorer in plankton population. Khan and Siddiqui (1974) discussed the relationships between various physico-chemical parameters, sources of major ions, seasonal variations and relationships of phyto- and zooplankton in a perennial fish pond at Aligarh.

DIURNAL STUDIES

Studies on diurnal variations in physico-chemical and biotic parameters in Indian waters have been initiated only recently. The available data (Ganapati, 1949, 1955; George, 1961; George, 1966; Khan and Siddiqui 1970; Sumitra - Vijayaraghavan 1971b; Misra, Bhargava and Bohra 1975, and Kant and Kachroo 1975) pertain mainly to lentic waters in India.

BIOLOGY OF PRAWNS

The literature on biology of prawns is quite extensive and has been extensively reviewed by Kurian and Sebastian (1976). It may, however, be added that bulk of this work, is related to the marine than to fresh water forms.

Das (1935) appears to have initiated the work on biology of Indian fresh water

prawns by studying the developmental stages of Palaemon lamarrei. Ayer (1949) described the embryology of Palaemon idae. Rajayalakshmi (1968) suggested possibility of culturing Macrobrachium mulcolmsonii and M. rosenbergii in tanks; and observed that former species from River Godavari (inhabiting soft bottom in the region of vegetation) is a bottom feeder in which spawning takes place in July and extends upto September. Koshy and Tiwari (1975) pointed out a positive correlation between the number of eggs carried by females and their body size of Macrobrachium dayanum and M. lamarrei.

Biological details of Macrobrachium rosenbergii investigated so far (from Indian waters) are available on larval stages (Menon, 1938) and maturation, fecundity, age and growth Rajayalakshmi (1961, 1964) and Rao (1965, 1967). Observations on the life history and bionomics have been made by John (1957) and location of nursery grounds (in Kerala) by Raman (1964).

FOOD AND FEEDING HABITS OF FISHES

Sen (1937) studied food of Panchax panchax, Barbus stigma, Esomus danrica and

Trichogaster fasciatus from Bengal. Chacko, Venkataraman and Ranganathan (1946) found that Chela argentea inhabiting Madras feeds on algae, crustaceans (daphnids and cyclops), diatoms and desmids, insect parts, sand particles and other organic matter. Chacko and Kuriyan (1948a) studied food composition of nine species of Barbus from Madras; while in 1948b they recorded Catla catla as an omnivore surface and mid-feeder, occasionally browsing along marginal substratum.

Mookerjee, Gupta and Choudhury (1946) analysed the food composition of 19 fish species from Bengal and classified them into various groups on the basis of the food they consume. Motwani and Karamchandani (1958) stated that Clupisoma garua is a non-selective carnivore, marginal- and bottom-feeder; while Eutropiichthys vacha is a somewhat selective surface- and marginal-feeder. Das and Moitra (1955) studied the food and feeding habits of 25 fish species from U.P and classified them as herbivore, carnivore and omnivore, and also grouped them as surface, column and bottom feeders. During his studies on biology of Barilius bendelisis, Grover (1971) observed it to be an omnivore surface and column feeder. Natarajan, Ramakrishnan and Khan (1975) have worked out the food

composition of thirteen species of fishes inhabiting Konar and Tilaiya reservoir (Bihar).

Saigal (1964) recorded that Mystus aor is a carnivore showing qualitative feeding variations from juveniles to adults, the latter, however, suspends feeding during breeding season. On the contrary, Pandian (1966) reported a marked decrease in feeding intensity of Mystus gulio during spawning period. Desai (1970) observed that young of Tor tor (in Narbada waters) are insectivorous while their adults are herbivorous reducing food intake during breeding season. Jyoti and Malhotra (1975) observed that Nemacheilus kashmiriensis a herbi-omnivore fish, continues voracious feeding even during breeding season.

Chakrabarty and Singh (1963) observed that Cirrhina mrigala does not show a significant difference in the composition of diet of different size groups. Bhatnagar (1963) found that in Puntius kolus adults are mainly bottom feeders; while juveniles are plankton feeders. Parameswaran, Radhakrishnan, and Selvaraj (1971) observed that in Osteobrama cotio fishes of 21 mm in length subsist predominantly on plankton; and individuals larger in size feed on aquatic

insects, worms, detritus and mud in addition to plankton. Shah (1975) mentioned that Salmo trutta (inhabiting Beas) an insectivore (larval and adult stages) feeding actively from April - June; monsoons being a lean period in this regard.

Availability of food in the environment has been discussed in relation to feeding of Labeo rohita, L. calbasu, Catla catla and Cirrhina mrigala by George (1965).

FISH DISEASES AND PREDATORS

The literature on fish diseases in general is extensively reviewed by Van Dujin Jr. (1967), and Sinderman (1970). But very limited literature is available on disease causing parasites (in Indian waters) observed during the course of present investigations viz. Myxobolus , Hennequya, Argulus, and Ergasilus and Saprolegnia. Southwell (1915) described Myxobolus and Argulus foliaceus from the skin of Rasbora daniconus and Labeo rohita respectively. Southwell and Prasad (1918) presented a description of Myxobolus rohitae, M. seni, M. nodularis, Ergasilus bengalensis and E. hamiltoni infecting various fish hosts in Bengal.

Ray (1933) listed Myxobolus and Henneguya parasites infecting ovary, liver, gills and muscles of various fishes inhabiting Calcutta waters.

Infection of Myxobolus fatal to fry and fingerlings of Catla is reported by Chakrabarty (1943). Sarkar (1946) suggested the control measures against Myxobolus, Argulus, and some fungal diseases in fresh water fishes.

MATERIALS AND METHODS

1. SAMPLING AND ANALYSIS OF BOTTOM SEDIMENTS

1.1. Collection: Random shoreline soil samples were collected fortnightly and stored in polythene bags after proper labelling. The samples were initially dried in the sun and thereafter, ½ kg of each sample was finally dried to a constant weight in an oven at 60°C and stored in air tight containers for further analysis.

1.2. Colour: The colour of sample was recorded and interpreted according to the Soil Survey Manual of U. S. Department of Agriculture Hand Book No. 18 (1969), and Munshell soil colour charts (1954).

1.3. Consistency: Consistency of the wet soil samples was determined in terms of stickiness to the thumb and index finger between which it was pressed. The soil was treated as non-sticky when it did not adhere to the digits after the release of pressure. The soil material which remained stuck to the digits but fell off upon slight disturbance was regarded as slightly sticky, whereas, if it continued adhering, the soil was regarded as sticky. Whenever, the soil material adhered strongly and continued to stick even after the stretching of digits, it was labelled as very sticky.

Non-coherent dry soil has been termed as loose while weakly-coherent soil which crumbled to a powder even under slight pressure between the digits has been regarded as soft. The soil which was moderately or considerably resistant to such pressure was labelled as slightly hard or hard respectively. Soil which was highly resistant to the digital pressure but could be broken in hands was regarded as very hard and the soil which could not be broken down even then was termed as extensively hard.

1.4. Textural components: Textural determination of the soil samples was done according to the textural triangle method of the U. S. Department of Agriculture Hand Book No. 18 (1969), after ascertaining the percentage of various soil components viz. coarse sand, fine sand, silt, clay and loam. These components were separated by sieving the sample through an electrically operated sieve set (Geological Syndicate make) having sieves of Nos. 35, 60, 120 and 320. 100 g of oven dried soil sample was placed in the top sieve No. 35 and subjected to a continuous shaking for half an hour. At the termination of the sieving, only coarse sand remained in sieve No. 35 whereas fine sand, silt and clay got collected in sieve No. 60, 120 and 320 respectively. The receiver below sive No. 320 contained only loam. All these fractions were carefully collected and weighed separately (to an accuracy of 1 mg) for ascertaining their respective percentage content in the soil sample.

1.5. pH determination: pH of the soil samples was determined by dissolving 20 g of oven dried sample in 40 ml of distilled water. The supernatant was decanted and both the glass and the calomel electrodes of an initially standardized pH meter (Philips make) were dipped in it and the readings taken.

1.6. Conductivity: For determining the conductivity of the various soil samples, aqueous sample solution obtained through dissolving 20 g of a soil sample in 40 ml of distilled water (1:2, wt/v), was filled in a thoroughly cleansed cell of a conductivity bridge (Prince make, cell constant = 1). The current was adjusted and when the eye of the conductivity bridge showed full deflection, the readings were taken directly from the bridge scale. Values thus obtained were multiplied by the cell constant to arrive at the final soil conductivity values represented in micromhos per cm.

1.7. Estimation of water soluble salts: To determine the water soluble salt content of the soil, 100 g of oven dried soil sample was dissolved in 500 ml of distilled water through vigorous shaking in a flask. Thereafter, allowing the heavier soil particles to settle down by leaving the flask undisturbed for sometime, the supernatant was decanted out into another container and was left undisturbed so as to allow the fine soil particles to settle down. The process was repeated till all the insoluble soil particles were removed. The final supernatant was consecutively filtered through cotton wool and Whatman filter paper No. 44. Initial 30 to 50 ml of the filterate was rejected and the remaining used as follows.

100 ml of clear aliquot was taken in a pre-weighed china dish and evaporated over a water bath till only 5 - 10 ml were left. Thereafter, 2 ml of hydrogen peroxide was added to aliquot to oxidize the soluble organic matter. The mixture was further evaporated, dried in an oven, cooled in a desiccator and finally weighed along with the container. Difference between the initial and final weights multiplied by a factor of 5 gave the soluble salt content per 100 g of the soil sample.

1.8. Estimation of carbonates and bicarbonates: For the determination of carbonate and bicarbonate content of a soil sample, 100 ml of soil aliquot (refer section 1.7) was taken in a titration flask and to this were added 5 drops of 1 % phenolphthalein indicator prepared in 50 % alcohol. Appearance of pink colour in the flask indicated the presence of carbonates. This mixture was then titrated against 0.1N H_2SO_4 (Eq. wt. 36) standardized against 0.1N $NaCO_3$ using methyl orange as indicator). The volume (V_1) of acid required to achieve the end point i.e. disappearance of pink colour was noted. Subsequently, the mixture was titrated against 0.1N H_2SO_4 using few drops of methyl red indicator. The volume (V_2) of acid utilized to affect the colour change from yellow to rose red was noted. A blank was also run with 100 ml of distilled water to serve as a check.

Amount of carbonates and bicarbonates per 100 g of soil sample were calculated as under:

$$-CO_3 = \left[2(V_1) \times 5\right] \times 0.003$$

$$HCO_3 = \left[(V_2 - V_1) \times 5\right] \times 0.0061$$

Note: 1 ml of 0.1N H_2SO_4 is equivalent to 0.003 g of CO_3 and 0.0061 g of HCO_3

1.9. Estimation of organic carbon: Determination of organic carbon in a soil sample was done according to Walkley - Black's method (c.f. Black, 1965). Various procedural steps followed are as under.

10 g of oven dried, finely ground soil sample was taken in a titration flask to which were then added 10 ml of 1N potassium dichromate (Eq. wt. 49) solution and 20 ml of concentrated H_2SO_4 (Sp. gr. 84). The mixture was shaken and left undisturbed for half an hour on an asbestos pad. Thereafter, 200 ml of distilled water, 10 ml of phosphoric acid (85 %) and 1 ml of diphenylamine indicator (0.5 g in a mixture of 100 ml of Conc. H_2SO_4 + 20 ml distilled water) were added to the mixture. Subsequently, the mixture was titrated against 0.5N ferrous ammonium sulphate solution (Eq. wt. 392, with a little of conc. H_2SO_4 added to it). The volume (V_1) of ferrous ammonium sulphate solution utilized to affect

the colour change from deep violet to green, was noted. Simultaneously, a blank with 100 ml of distilled water was also run and the volume (V_2) of ferrous ammonium sulphate thus utilized noted. The amount of organic carbon per 100 g of soil sample was calculated as under.

$$\left[\frac{(V_2 - V_1)}{2} \times 10\right] \times 0.003 = \text{percent of organic carbon in the sample}$$

Note: 1 ml of 1N $K_2Cr_2O_7$ is equivalent to 0.003 g of carbon

1.10. Estimation of organic matter: Determination of organic matter content of the soil sample was done according to the method of Wilde et al. (1972). Various procedural steps followed are as under.

10 g of soil sample was sieved through a 2 mm mesh and dried for 2 hr in a pre-weighed crucible kept in an oven maintained at 110°C. Thereafter, the sample was cooled in a desiccator, weighed (wt_1) and ignited over the low flame of a blow lamp. The flame was gradually increased and ignition continued for 30 minutes with occasional stirring of the sample by means of a platinum wire, till there was no evidence of unburnt carbon. The sample was cooled and after the addition of a few drops of 30 % H_2O_2 it was reignited to bring about the oxidation of organic matter. Complete oxidation, however, was achieved by keeping the soil

sample at 600°C for 3 hr in an electric muffle furnance. Subsequently, the sample was cooled in a desiccator and reweighed (wt_2). Amount of organic matter per 100 g of the soil sample was calculated as ($wt_1 - wt_2$) x 10.

1.11. Estimation of nitrogen: The nitrogen content of a soil sample was determined according to Kjeldahl's method (Bramner, 1965). Reagents used and the procedural steps followed are as under.

The reagents were prepared in nitrogen free distilled water in the following manner. Sulphuric acid - Salicylic acid mixture was prepared by dissolved 10 g of salicylic acid in 300 ml of conc. H_2SO_4; sodium thiosulphate powder was prepared by grinding the crystals in moisture free conditions; digestion accelerator or the catalyst was prepared by mixing $CuSO_4.5H_2O$, $FeSO_4.7H_2O$ and K_2SO_4 in a ratio of 1:4:10 by weight respectively and stored in a dark coloured bottle; 40 % sodium hydroxide solution was prepared by dissolving 40 g of NaOH pellets in distilled water and final volume raised to 100 ml; Morray zinc was prepared by boiling granulated zinc for few minutes in 20 % NaOH followed by a thorough washing in distilled water and then dried 0.1N H_2SO_4 was prepared by dissolving 3.6 ml of H_2SO_4 (conc. H_2SO_4 is approximately 36N) in distilled water

and final volume raised to 1 liter followed by standardization against 0.1N $NaCO_3$; 0.1N NaOH was prepared by dissolving 40 g of NaOH (Eq. wt. 40) in distilled water and the final volume raised to 1 liter followed by standardization against 0.1N succinic acid.

10 g of soil sample was taken in a thoroughly cleaned and dried Kjeldahl flask to which were then added 50 ml of H_2SO_4 - salicylic acid mixture and 5 g of sodium thiosulphate powder. The mixture was left undisturbed for half an hour and then subjected to digestion in a heating mantle at comparatively low temperature. As the mixture started fuming, 8 - 10 g of the catalyst was added to it and the temperature of the heating mantle raised. Complete digestion of the sample was achieved after 2 to 3 hr when the mixture acquired a clear blue-green tinge. Thereafter, the mixture was cooled before it was transferred to the distillation flask and distillation started only after making the mixture alkaline by adding 150 ml of 40 % NaOH and 5 g of sodium thiosulphate to it, along with few glass beads to prevent bumping. The distillate was collected in a titration flask containing known volume of 0.1N H_2SO_4; the collection was continued as long as the presence of ammonia was revealed (by conventional HCl test) in the trickling distillate. Subsequently the contents of the titration

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flask were titrated against 0.1N NaOH solution using methyl red as indicator. The volume of NaOH used (V) to achieve the end point i.e. the disappearance of pink colour was recorded and the amount of nitrogen per 100 g of soil sample calculated as under.

(V x 10) x 0.0014 = percent of nitrogen in sample

Note: 1 ml of 0.1N NaOH is equivalent to 0.0014 mg of nitrogen

1.12. Estimation of phosphorus: Phosphorus content of the soil sample was determined according to the method of Olsen et al. (1954). Various reagents and procedural steps employed are described as under.

0.5M sodium bicarbonate solution was prepared by dissolving 42 g of $NaHCO_3$ in distilled water and the final volume raised to 1 liter after which the pH of the solution was adjusted to 8.5 by adding requisite quantity of 10 to 20 % solution of NaOH; ammonium molybdate - sulphuric acid solution was prepared by dissolving 25 g of ammonium molybdate in 200 ml of warmed distilled water to which were then added 275 ml of conc. H_2SO_4 gradually and the final volume raised to 1 liter; stannous chloride solution was prepared by first dissolving 10 g of $SnCl_2.2H_2O$ in 25 ml of conc. HCl and then diluting it with distilled water in the proportion

of 1:132 (v/v) as and when required; activated carbon black (Darco G 60) was used after it was washed with $NaHCO_3$ solution to remove all traces of phosphate.

For plotting the standard curve the requisite stock solution from which various dilutions (indicated below) were obtained, was prepared by dissolving 0.2195 g of KH_2PO_4 in a small quantity of distilled water and the final volume raised to 1 liter by adding 0.5 M $NaHCO_3$ aqueous solution. The concentration of phosphate in this stock solution was 50 ppm.

Standard fequired (ppm)	Stock solution to be taken (ml)	Volume to be made up (ml)
1.0	2.0	100.00
2.5	5.0	100.00
5.0	10.0	100.00
10.0	10.0	50.00
20.0	20.0	50.00
40.0	20.0	25.00

5 ml each of the standard dilutions mentioned above were taken in separate volumetric flasks to which were added 5 ml of molybdate reagent and 1 ml of dilute $SnCl_2$ solution and the final volume raised to 25 ml with the addition of distilled water. The contents of the flask were thoroughly mixed and immediately subjected to colorimetery (red filter 660nm) to obtain O. D. values needed for plotting the standard curves.

For actual estimation, to 5 g of soil sample in a conical flask were added, a teaspoonful of activated carbon and 150 ml of 0.5 M $NaHCO_3$ solution. The mixture was filtered after thoroughly shaking through a Whatman filter paper No. 40 to obtain a colourless filterate. To 5 ml of the filterate in a titration flask were added 5 ml of ammonium molybdate and 1 ml of dilute stannous chloride solutions and the final volume was raised to 25 ml by adding distilled water. The solution was immediately subjected to colorimetery. The O. D. values thus obtained, were read in ppm after comparing them with the standard curves.

1.13. Estimation of potassium content of the soil sample was determined according to the method of Pratt (1965). Various reagents needed and the procedural steps followed are as under.

Neutral solution of 1N ammonium acetate was prepared by dissolving 0.82 g of the chemical in distilled water and final volume raised to 1 liter followed by adjustment of its pH to 7 by the addition of either acetic acid or ammonium hydroxide; stock solution of potassium was prepared by dissolving 0.953 g of dried KCl in distilled water and the final volume raised to 1 liter containing 500 ppm of potassium which was utilized for obtaining the following standard dilutions.

Standard required (ppm)	Stock solution to be taken (ml)	Volume to be made with neutral amm. acetate (ml)
5	0.5	100
10	1.0	100
15	1.5	100
20	2.0	100

For the standard curves, the flame photometer (Systronics make) was standardized by coinciding 0 to 20 ppm range of the dilutions with 0 to 100 range of the instrument's scale and the readings taken.

For actual determination, 5 g of the soil sample was taken in a conical flask and dissolved in 25 ml of ammonium acetate solution which was added with the help of a multiple dispenser. The contents were filtered and to the filterate were added 2 drops of butyl alcohol before it was subjected to flame photometery. The values thus obtained were read in ppm after comparing them with the standard curves.

2. SAMPLING AND ANALYSIS OF WATER

2.1. Collection: Water samples from different experiment stations along the 'nallah' were obtained and analysed at the spot for their dissolved oxygen, free carbon dioxide, carbonate and bicarbonate content. For the determination

of of pH, phosphate, chloride, calcium, magnesium and suspended matter content, the samples, were, however, analysed in the laboratory. During diurnal studies all analyses except for phosphates were done in the field. Physical parameters like transparency, depth and temperature were also determined in the field.

2.2. Transparency: Transparency of water was determined with the help of a Secchi disc (Welch, 1948) of 20 cm diameter using the formula $T = \frac{X + Y}{2}$,

wherein T, X and Y represents transparency in cm; depth at which the disc could not be discerned while lowering the thread and depth at which the disc was discernable while raising the thread respecitively. An average of four readings was taken whithin the limits of each station.

2.3. Depth: Depth measurements were obtained at a fixed point in each experiment station by the conventional method of lowering a depth measuring chain and data recorded in centimeters.

2.4. Temperature: The air and water temperature was measured by means of a centigrade mercury thermometer having an accuracy of $0.1^{o}C$. Air temperature was measured by keeping the thermometer in shade. Water temperature was recorded at a depth of 10 cm at three different spots viz. the entrance, centre and exist of

each experimental station. The data on water temperature are tabulated as the mean of three separate readings.

2.5. Suspended matter: For the determination of suspended matter content, 500 ml of a water sample was filtered through a pre-weighed thoroughly dried Whatman filter paper No. 42. Subsequently, the filter paper was kept in an oven at 80°C for 48 hr after which it was cooled in a desiccator and weighed again. The difference between the initial and the final weight multiplied by a factor of 2 indicated the quantity of suspended matter per liter of a water sample.

2.6. pH: pH of the water sample was determined by using standardized pH meter (Philips make).

2.7. Estimation of dissolved oxygen: Oxygen was estimated according to Alsterberg's sodium azide method(Lagler 1971). Reagents used and the procedural steps followed are as under:

The reagents were prepared from A. R. grade chemicals and distilled water, in the following manner. Manganous sulphate solution was prepared by dissolving 36.4 g of $Mn.SO_4 . 2H_2O$ in a small quantity of water after which the solution was filtered and the volume raised to 100 ml. Alkaline iodide-sodium azide solution was prepared by dissolving 700 g of KOH and 150 g of KI together and to 10 g of sodium azide

separately in small quantities of distilled water, the two solutions were mixed and the final volume raised to 1 liter through distilled water. Potassium fluoride solution was prepared by dissolving 40 g of potassium fluoride in distilled water and the final volume raised to 100 ml. the solution was stored in polythene bottle to prevent fluoride glass reaction. 1 % starch solution was prepared by dissolving 1 g of starch powder in a small quantity of distilled water the slurry w thus obtained was gradually added to boiling distilled water and the final volume raised to 100 ml. 0.025N sodium thiosulphate solution was prepared by dissolving 6.205 g of sodium thiosulphate (Eq. wt. 248.18) in 100 ml of distilled water and the final volume raised to 1 liter followed by its standardization against 0.025N $K_2Cr_2O_7$ (Eq. wt. 49) solution. 0.025N potassium dichromate solution was prepared by dissolving 1.225 g of preheated potassium dichromate (Eq. wt. 49) in distilled water and the final volume raised to 1 liter. Sulphuric acid used was of sp. gr. 84.

How the sample is collected

To 250 ml of water sample in a flask were added 1 ml of potassium fluoride, 2 ml of manganous sulphate and 2 ml of alkaline iodide-sodium azide solution each at intervals of a few minutes and just beneath the surface layer. The flask was stoppered

and gently rotated to allow the precipitate to settle at the bottom. Thereafter, 0.5 - 1 ml of concentrated sulphuric acid was added to the contents and the mixture transported to the laboratory for further analysis. Subsequently, 200 ml of this mixture was titrated against 0.025N $Na_2S_2O_3$ using 2 - 3 drops of starch solution as indicator. Volume of $Na_2S_2O_3$ thus utlized to achieve the end point, directly indicated the dissolved oxygen content in mg per liter of the water sample.

2.8. Estimation of free carbon dioxide: The estimation was done according to the method suggested by Lager (1971). Various reagents used and the steps followed are described below:

N/44 sodium hydroxide solution was prepared by dissolving 0.9 g of sodium hydroxide (Eq. wt.40) in one liter of carbon dioxide free distilled water and was standardized against N/44 solution of succinic acid using few drops of 1 % phenolphthalein as indicator. The acid solution was prepared by dissolving

1.34 g of succinic acid (Eq. wt 59.04) in a liter of pre-heated but cooled distilled water 1 % indicator solution was prepared by dissolving 1 g of phenolphthalein in 100 ml of 50 % alcohol.

100 ml of the water sample was titrated against N/44 NaOH using few drops of 1 % phenolphthalein as indicator. Volume of NaOH required to neutralize the sample multiplied by a factor of 10 directly gave the quantity of free carbon dioxide per liter of sample.

2.9. Estimation of carbonates and bicarbonates: Estimation of of carbonates and bicarbonates was done according to Indian standard methods (1968). The reagents required and procedural steps followed have already been described at page 26 . For actural analysis, 100 ml of water sample was titrated against 0.05N sulphuric acid. The volume of acid required to neutralize CO_3 (V_1) and HCO_3 (V_2) were recorded. V_1 multiplied by a factor of 30, and V_2 minus V_1 multiplied by a factor of 30.5 gave the quantity of CO_3 and HCO_3 in mg per liter of the water sample, respectively.

2.10. Estimation of chlorides: The estimation was done according to Mohr's titration method. Preparation of needed reagents and the procedural steps followed are

N/35.5 silver nitrate solution was prepared by dissolving 4.789 g of silver nitrate (Eq. wt 170) in 100 ml of distilled water and the final volume raised to one liter followed by its standardization against N/35.5 solution of NaCl using 5 % potassium chromate solution as indicator. NaCl solution was prepared by dissolving 1.648 g of the salt in a small quantity of distilled water and the final volume raised to one liter. 5 % indicator solution was prepared by dissolving 5 g of potassium chromate in 100 ml distilled water.

100 ml of water sample was titrated against N/35.5 $AgNO_3$ solution using 3 to 4 drops of potassium chromate as indicator. The volume (V_1) of $AgNO_3$ used was noted. Simultaneously the volume (V_2) of $AgNO_3$ used for a blank was also noted. Calculations were made as under:

$$\text{Milli-equivalent of chloride per liter} = \frac{V_1 - V_2}{\text{Vol. of water sample taken}} \times 1000 \times \text{Normality of } AgNO_3$$

$$\text{Milligram of chloride per liter} = \text{Milli-equivalent per liter} \times \text{Eq. wt of chloride (35.46)}$$

2.11. Estimation of calcium: Calcium content of the sample was estimated according to Versenate method (c.f. Kanwar and Chopra, 1967). Preparation of reagents used and the procedural steps followed are given below.

0.01N calcium carbonate solution was prepared by dissolving 0.5g of anhydrous calcium carbonate (Eq.wt. 50) in a small quantity of 0.2N HCl and distilled water; the solution was boiled to drive off carbon dioxide, cooled and then raised to a final volume of 1 liter . 0.01N solution of ethylene diamine tetra acetic acid (E.D.T.A) was prepared by dissolving 2 g of the chemical in distilled water and the final volume raised to 1 liter followed by its standardization against 0.01N calcium carbonate solution. Murexide indicator was prepared by grinding and mixing .2 mg of murexide and 40 g of potassium sulphate crystals. 16 % aqueous solution of sodium hydroxide and crystals of sodium diethyl dithio carbamate were also used for the estimation.

To 100 ml of water sample were added a few crystals of sodium diethyl dithio carbamate, a few ml of 16 % solution of sodium hydroxide (to adjust the pH to 12) and 50 mg of murexide indicator. This mixture was titrated against standard 0.01N E.D.T.A solution and the volume of acid thus consumed was noted. Calculations were made as under:

$$\text{Milli-equivalent of calcium per liter} = \frac{\text{Vol. of acid consumed}}{\text{Vol. of sample taken}} \times 1000 \times \text{Normality of E.D.T.A}$$

$$\text{mg of calcium per liter} = \text{Milli-equivalent of calcium} \times \text{Eq. wt. of calcium (20.05)}$$

2.12. Estimation of magnesium: Magnesium content of the sample was estimated according to the Versenate method (c.f. Kanwar and Chopra, 1967). Preparation of the reagents used and the procedural steps followed are as under.

Standard 0.01N E.D.T.A was prepared as described for calcium estimation. Ammonium chloride-ammonium hydroxide buffer (pH) was prepared by dissolving 67.5 g of ammonium chloride in 100 ml of distilled water to which was then added 570 ml of concentrated ammonium hydroxide solution and the final volume raised to 1 liter by the addition of distilled water. Erichrome black-T indicator was prepared by dissolving 0.5 g of the indicator in a mixture containing 100 ml of ethyl alcohol plus 4.5 g of hydroxylamine hydrochloride. Sodium diethyl dithio carbamate crystals were also used in the estimation.

To 100 ml of water sample were added a few crystals of sodium diethyl dithio carbamate, a few drops of ammonium chloride ammonium hydroxide buffer (to adjust its pH to 10) and a few drops of Erichrome black-T indicator. The mixture was then titrated against 0.01N solution of E.D.T.A. The volume of E.D.T.A required to affect the change in colour from red to violet

in the mixture was noted and the quantity of magnesium in the water sample calculated as under:

$$\text{Milli-equivalent of calcium + magnesium per liter} = \frac{\text{Vol. of EDTA used}}{\text{Vol. of the sample taken}} \times 1000 \times \text{normality of EDTA} \quad ..(A)$$

$$\text{Milli-equivalent of magnesium per liter} = (A) - \text{milli-equivalent of calcium} \quad ..(B)$$

$$\text{Quantity of magnesium per liter of the sample (mg per liter)} = (B) \times \text{Eq.wt. of magnesium (12.15)}.$$

2.13. Determination of water soluble phosphates: Water soluble phosphate content of the sample was determined according to the method of Schwoerbel (1970). Prepration of the reagents used and the procedural steps followed are as under:

Solution was prepared by mixing 10 % amm. molybdate solution 50 % sulphuric acid in the proportion of 1:3 by volume. $SnCl_2$ solution was prepared by dissolving 0.27 g of tine foil in 7.5 ml of fuming HCl which was subsequently diluted to 50 ml with distilled water. Standard curve was prepared by using potassium dihydrogen orthophosphate (KH_2PO_4) as already discussed at page .

To 50 ml of a filtered water sample were added 5 ml of amm.molybdate-sulphuric acid solution and 0.15ml of $SnCl_2$ solution. The intensity of colour thus developed in the sample was determined in a Bauch and Lomb colorimeter. The values so obtained were interpretted in terms of u mg of phosphate per liter of the sample after comparing them with the standard curve.

3. SAMPLING AND ANALYSIS OF BENTHOS

Sampling of benthos was made by dredging (hand operated) on four different places within each station. The samples thus obtained were mixed together. Molluscs were obtained by washing the entire sample through a sieve of 80 mesh per cm. For enumeration of Chironomids and annelids only 1/10 th of the mixed sample was sieved. In all cases animals were retained by the sieve and enumerated in the laboratory. The results are represented number per dredge.

4. SAMPLING AND ANALYSIS OF ZOOPLANKTON

Zooplankton were collected by a haul net (572 meshes per square cm. Indian Linen(cloth, [redacted] collecting tube 20 cc, net mouth diameter 11.5 cm as per specifications Lagler, 1971). A total of five hauls, two horizontal and three verticals, each running through one meter for one to two minutes were made. Sampling tube was then entied and the lower end of net was washed by immersion in a beaker. Plankton thus obtained (in the tube and beaker) were fixed in 5 % formaldehyde and stored. They were later enumerated for different components by diluting

contents of each sample to 25 cc, shaking thoroughly and transferring 1 cc of diluted sample to a counting cell (4 cm x 2 cm x 0.1 cm, marked with 5 mm squares as specified by Schwoerbel, 1970). Two such observations were recorded in seasonal studies and one during diurnal studies. The results were converted n into number of animals per haul (Jillet, 1971). In diurnal studies the results are represented as number per sample.

5. SAMPLING AND ANALYSIS OF FISHES

5.1. Collection: Fishes were collected with a net of 2.5 ft diameter at mouth hauled at each station, both through the rooted vegetation and in open water zone. These fishes were scanned immediately for ectoparasites, and later fixed in 10 % formaldehyde for laboratory studies.

5.2. Food: Preserved fishes were blotted, both externally and internally so as to avoid weight of free water; and their weight was recorded in grams. Their total length was recorded in cms.

Next the alimentary canal was removed and weighed first along with its contents and later when all its contents had been removed.

The difference between the two weights was recorded as the weight of gut contents. In case of fishes of smaller size, the alimentary canals of all available specimens were collectively weighed and average values were calculated. While evacuating the alimentary canal, the contents of the stomach and anterior part of the alimentary canal were separated from contents of the rest of intestine. Enterosomatic index was calculated for studying the quantitative variations in the food according to the formula:

$$\text{Enterosomatic index (E. S. I)} = \frac{\text{Wt. of alimentary canal contents}}{\text{Wt. of fish}} \times 100$$

For qualitative analysis, contents of the stomach or of the anterior part of the alimentary canal were mounted in glycerine, and studied under microscope for determining the individuals components as percentage of total fish dietary. Later these samples were mounted permanently (in Reyne's mountant, chloral hydrate 50 gm, gum arabic 30 gm, water 50 ml and glycerine 12.5 ml). Percentage values were determined by the visual point method (Pearse, 1915, and Job, 1940).

Enterosomatic Index and percental qualitative variations were recorded. Average for each month has been calculated.

6. SAMPLING AND ANALYSIS OF PRAWNS

6.1. Collection: Prawns were collected through haul net (specifications as per fish net), and fixed in 5 % famaldehyde.

6.2. Food: Total length from the tip of rostrum to the tip of telson of preserved specimens was recorded along with the total weight. Due to the small size of animals and stomach, only qualitative percental composition of their food contents was made (because of small size of animals and its stomach). Food was sampled and mounted as already described (for fishes).

6.3. Fecundity: Gravid females were isolated and their total lengths and weights recorded. The eggs were removed from brood pouch and counted.

For calculating the mathematical relationship of total length to fecundity, and total weight to fecundity, the females were arranged

into various size groups (with a class interval of 0.5 cm); and mean lengths, mean weights and mean fecundity for each group was calculated. Mean data obtained were used for obtaining a regression line (by the methods of least squares). Correlation coefficient was calculated (after methods advocated by Pearse [illegible] and described by Gupta (1976). Test of significance of regression coefficient (t test) was also applied.

RESULTS AND DISCUSSION

TOPOGRAPHY OF THE STREAM

Gadigarh stream is situated at a distance of 12 km from Jammu city; at 74° 50' E longitude and 32° 40' N latitude at an elevation of 304.8 meters above sea level. It originates in the area itself from natural springs. Additional water

supply comes from the Ranbir canal distributary, rain, run off from Siwalik hills and from the adjoining irrigated fields.

The stream flows through the agricultural land with village Gadigarh on one side and Giddar - Gallian and Rohian villages on the other side (Fig. 1).

The stream is a slow running pool, 2½ km long. In order to have a thorough understanding of the physico-chemical and biological conditions, seven study stations were raised along the course of the stream. For other details reference may be made to Table 1 and Figs. 1 - 8.

Table 1. Observations on topographical features at Stations I to VII of Gadigarh stream (Figs. 1 - 8).

S.No.	Parameters	STATIONS I	II	III	IV	V	VI	VII
1.	Length (ft.)	200	378	471	262	245	69	172
2.	Width (ft.) Min.	8	6	6	3	8	6	6
	Max.	18	45	53	30	76	122	31
3.	Source of water supply	Natural springs occasionally from DRC*	Subterranean natural springs.	In addition a few springs along the intermediate portions between Station II and III.	Natural springs overflown water of DRC from irrigated fields.	Continuity from Station IV and occasionally from irrigated fields.	Continuous supply from Station V.	DRC* in the middle of Stations VI and VII being an occasional source.
4.	Nature of surrounding area	Low level, open grazed land on western side with low embankment of cultivated fields on eastern side.	Embankment of Karan Bagh on western side; a low overgrazed land followed by cultivated fields on eastern side.	Puddles, cultivated rice fields, undergrazed land on northern side and embankment of cultivated fields on western side.	Plain area.	Plain overgrazed, cremation ground on northern side with embankment and cultivated fields on southern side.	Large outspread water body, on northern and western side with embankment of bridge.	Open land. Stream at this station confluences with Ballole Nallah.
5.	Nature of vegetation growing along the banks	Typha and Ipomea form thick population at the beginning of the station with a few grasses.	Scattered Accacia bushes on raised banks; Typha and Ipomea grow densly with few grasses.	Scattered vegetation of Typha.	Thick vegetation of Typha with localized Ipomea plants. A few trees of Salix have also been observed growing along the banks.	Typha is scarcly present.	Thick population of Typha Ipomea and a few grasses.	Thick population of Typha.
6.	Nature of biotic interference	Cattle bathing.	Cattle bathing.	Human and cattle bathing.	Cattle bathing.	Washing of trucks and tongas, clothes, and human bathing; cremation of dead bodies.	Cattle bathing and grazing.	Cattle and human bathing.

*DRC = Distributary from Ranbir canal.

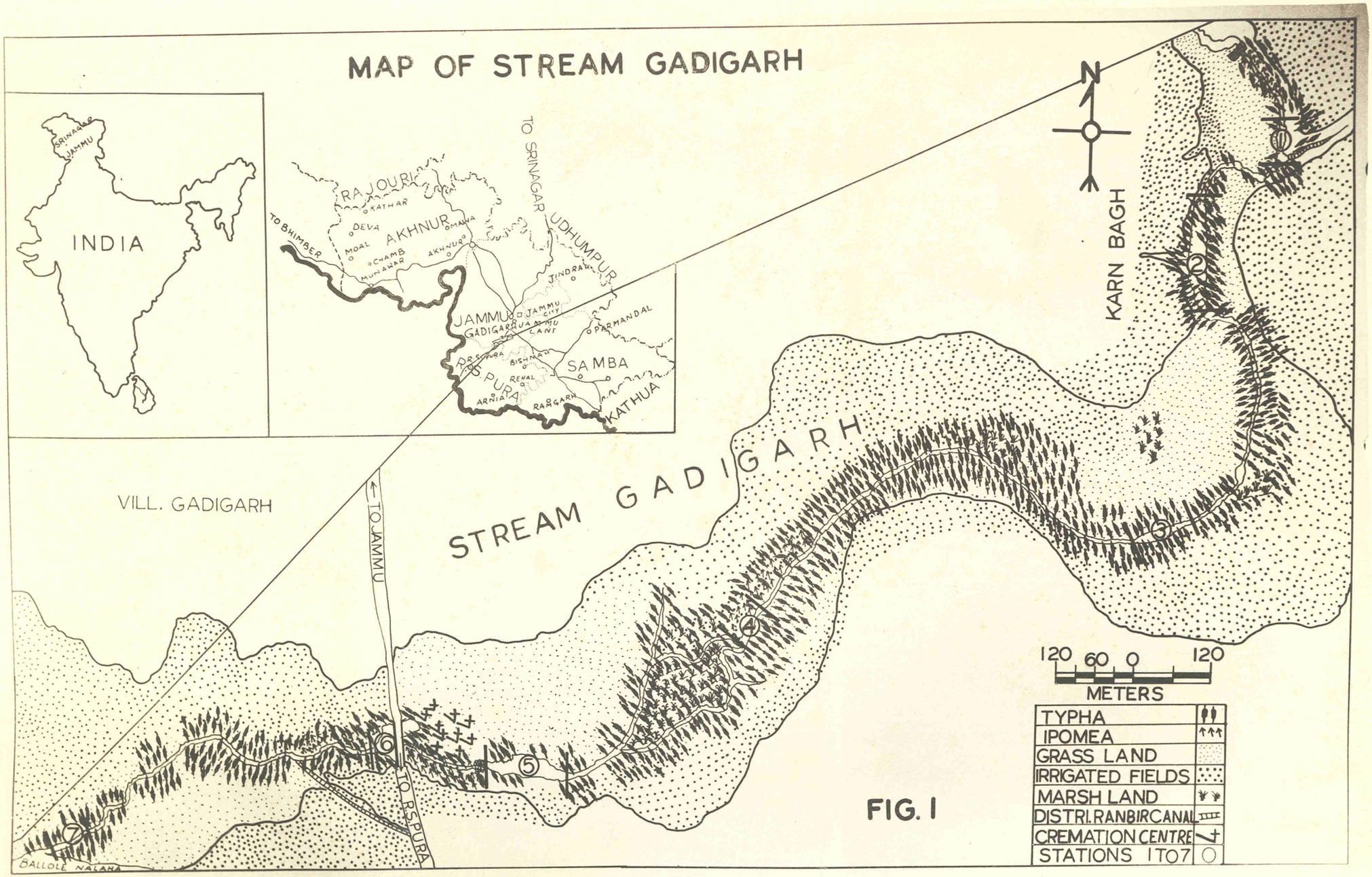

MAP OF STREAM GADIGARH
INDIA
SRINAGAR
JAMMU
TO SRINAGAR
UDHUMPUR
RAJOURI
KATHAR
DEVA
MOAL
AKHNUR
CHAMB
MUNAHAR
AKHNUR
OMANA
TO BHIMBER
JINDRAH
JAMMU
GADIGARH
JAMMU CITY
CANT
PARMANDAL
R.S. PURA
BISHNAH
RENAL
ARNIA
SAMBA
RARGARH
KATHUA
N
KARN BAGH
VILL. GADIGARH
TO JAMMU
STREAM GADIGARH
TO R.S.PURA
BALLOLE NALANA
120 60 0 120
METERS
TYPHA
IPOMEA
GRASS LAND
IRRIGATED FIELDS
MARSH LAND
DISTRI. RANBIR CANAL
CREMATION CENTRE
STATIONS 1 TO 7

FIG. 1

Figs. 2A, 3, 4A,
5, 6, & 7. - Showing the general view of Stations I - VII of Gadigarh stream.

Fig. 2B . - Ranbir canal distributary at Station I, during monsoons.

Fig. 4B . - Soil erosion at the exict of Station III, during monsoons.

Fig. 8 , - General view of Station VII confluencing with Ballole nallah.





PHYSICO-CHEMICAL
AND
BIOTIC STUDIES OF THE STREAM

SEASONAL STUDIES

A. BOTTOM SEDIMENTS

Ancient Indians (2,500 B.C. to 600 A. D.) recognized two types of soils viz. Urvara (fertile) and Unurvara or Ushara (barren). [redacted], Raychaudhuri (1964) classified the Indian terrestrial soils into eight categories viz. alluvial, black, red, desert soils, saline and alkaline soils, peaty soils,

laterite and lateritic soils. Later, he (Raychaudhuri, 1966) came forth with a more comprehensive system of soil classification in which he classified Indian soils into 28 major groups on the basis of morphological and physico-chemical properties and suggested equivalent names for the sub-orders of various soil groups. Using Raychaudhuri's classification, the bottom sediments of Gadigarh stream fall under the category of alluvial soils.

I. Physical:

I.1. Nature: The bottom sediments of Gadigarh stream have been observed undergoing considerable changes. The sediments composed mainly of fine clay, become loose, the top remaining more or less in a viscuous suspension state above the hard bottom. The depth of loose mud increases gradually from the shore to the centre where it is maximum. Towards the periphery of each station the depth as well as percentage of fine particle fraction of the mud gets reduced.

I.2. Colour: The colour of the bottom sediments is indicative of soil composition although it has not been discussed by limnologists in the past. The present work indicates that as in terrestrial soils so also in bottom sediments colour is indicative of the drainage pattern and composition. The colour of bottom mud has been

observed to vary from October, 1974 to June, 1976. The colour varies all the way from yellow to grey; the 5 YR and 10 YR hues being most representative (Munshell soil, colour charts 1954 (ed.), Munshell soil colour company Inc. U. S. A). The colour values of mud samples from different stations along Gadigarh stream (Tables II - VII) range from 1 to 6 i.e. brownish to yellowish-grey, which indicates silt-loam or sandy-silt texture. The dominance of greyish colour of the bottom mud is attributed to the presence of detritus and is the result of oxidation and reduction of the decaying plant and animal material at the stream bottom.

I.3. Texture: The data recorded in Tables II - VII, indicate particle size distribution of sand, silt, clay and loam; and also the sand/silt ratio and clay/loam ratio in the bottom sediment for the period October, 1974 to June, 1976.

The total sand content shows marked variation at all the studied stations. Maximum total sand content (82.99 %) was observed at Station IV during January, 1975 and the minimum (3.10 %) at Station III in the month of August, 1975. Fine-sand content of the total sand constituted the major portion and dominated in samples drawn from all stations.

The maximum fine sand fraction (65.33 %) was observed at Station II in March, 1975 and minimum (2.824 %) at Station III during August, 1975.

The silt and clay fractions of the bottom sediment did not show as much variation except that the silt content declined to 2.37 % at Station IV during April, 1975. The sand/silt ratios do not exhibit significant variation but run almost constant (Tables II - VII; Figs. 9 - 14). Earlier, Boyd (1976) reported that the deeper parts of the fish pond that he investigated showed smaller proportion of sand and gravel and larger proportion of clay and silt. During the course of present investigation also it has been observed that the finer fraction represented by clay and loam predominate at Stations I, II, III, and IV but the sand fraction is proportionately low (Tables II - VII; Figs. 9 - 14). At Station V and VII on the contrary, the proportion of sand is higher because of continued biotic interference increased water velocity due to the stream gradient and the fact that the latter station represents the confluence between this stream and Ballol nallah (Fig. 8). The water from 'nallah' Ballol churns the bottom sediment of Gadigarh stream and maintains it in a colloidal state.

The rushing water washes down the finer clay particles and results in the deposition of sand at the bottom of the stream (Tables II - VII; Figs. 9 - 14). A similar observation has been made by Ordway (1974) also on the bottom sediments of the various rivers of U. S. A.

The proportion of sand particles increases during the monsoon and winter rains. This is because, the water flow in the stream gets increased during this period with the consequence that much of the finer material is washed off; the proportion of sand decreases gradually as the energy of stream gets exhausted in the transportation of its bed load. The dominance of sand (heavy particle fraction) fraction during winter showers at all stations is caused by the washing off of all floating vegetation so that all blockades get removed and the water speed increases. Running water erodes the stream margins by dissolving the mud and carrying away finer particles in a state of suspension. This also results in the deposition of heavier or coarser particles along the edges. Boyd (1976) made similar observation on fish ponds of Alabama, U.S.A.

2. Chemical

2.1. Hydrogen ion concentration (pH): Hydrogen ion concentration or pH is an important property of the soil

which determines the growth of plants, indicates the availability of nutrients and the microbial and biodegradation and physical conditions of the soil. Growth and survival of plant species requires an optimum pH range. Bear (1965) pointed out the importance of humus, alumino-silicates, hydrous oxides and soluble salts im determining the soil acidity in general. Among all these factors, the role of humus is particularly pertinent to the present investigations. Humus possesses several types of functional groups which alter or dissociate hydrogen ions. A few of these are carboxylic, phenolic and amino groups. The strength of the acid produced is determined by the nature of the predominant group. Humus may also react with iron and aluminium ions to form complexes which may subsequently undergo hydrolysis to yield hydrogen ions. During the breakdown and mineralization of organic matter, water, carbon dioxide and various salts and organic acids are produced. The increased concentration of carbon dioxide, hydrolysis of acid salts and accumulation of organic acids add to the acidity of soil.

Welch (1952) has pointed out that the pH of bottom sediments depends on several factors some of which have been described and discussed below:

(i) Water level and salt concentration: Bottom mud is

rich in humic substances which fluctuate because of the fluctuating level of water column. Increased water level caused by rains induces alkalinity. Rains increase, (a) dilution due to increased volume of water, (b) raise input of soluble salts from surrounding areas, and (c) release mineral products of humus such as soluble salts and carbon dioxide, which otherwise lie burried in the bottom mud.

Bear (1965) states that as a soil suspension becomes more dilute the pH of acid soil rises through what he called "suspension effect". He explains the impact of dilution in increasing pH by stating "thicker the paste in which the glass electrode is placed, ..., and lower the pH values. As more water is added to the paste, the ion layer would become more diffused, until finally the electrodes would be measuring pH of the liquid phase of the suspension".

The effect of dilution of the bottom sediments of Gadigarh stream by rain water is somewhat similar to the suspension effect described above. According to this concept as the volume of water in the stream increases through early monsoon showers, the dilution effect operates to kick up the pH. At Stations I, II, III and V, however, the pH decreases

from 8.6 to 8.2 (Tables VIII - XIII; Figs. 9 - 14) probably on account of the release of nutrients and acidic salts accumulated on the shoreline of the stream during the prolonged premonsoon period. With continued rainfall the quantity of water added to the stream is so much that it causes dilution as a consequence of which the pH rises from 8.4 to 8.6 at all stations (Tables VIII - XIII; Figs. 9 - 14). Stations IV and VII do not register any decline in pH with early-monsoon showers. However, with continuous raining the pH values increased from 8.2 to 8.4 at Station IV and 8.2 to 8.6 at Station VII. The increase in pH at the two stations is attributed to the merger during summer months of the distributaries of Ranbir canal with Gadigarh stream at these two sites (Fig. 1). The addition of water causes a greater dilution at these stations as compared to others (I, II, III and V) and the pH therefore, never registers a fall instead it rises directly to 8.6.

Change in pH cannot be attributed exclusively to dilution because several other factors such as the quantity of dissolved salts, carbon dioxide etc. act simultaneously and interact in effecting the ultimate pH value of the stream bottom.

Usually, with the increase in salt concentration the pH is lowered. The presence of

electrolytes has the same effect on soil pH in neutral and alkaline range (Bear, 1965). As pointed out above, monsoon showers change the water level. This is associated with an increase in the concentration of nutrients because the incoming waters from neighbouring fields import some nutrients into the stream. Changes in nutrient concentration alter conductivity and total soluble salt content of the bottom muds of the Gadigarh stream (Tables VIII - XIII; Figs. 9 - 14). In general, there is an increase in the total dissolved solids and conductivity of the bottom sediment (Tables VIII - XIII; Figs. 9 - 14) resulting in the decline of pH from 8.4 to 8.2 at Station I; 8.5 to 8.3 at Station II and 8.4 to 8.2 at Station III; the pH registerd no change at Station V although it increased from 8.2 to 8.4 and 8.2 to 8.6 at Stations IV and VII respectively during December, 1974 to January, 1975. Similarly, from June to July, 1975 the conductivity and soluble salt concentration increased at Stations I, II, III and IV but a decline was marked at Stations IV and VII (Tables VIII - XIII; Figs. 9 - 14). Increase in conductivity and soluble salt concentration was attributed to Bear's suspension effect and to the continuous addition of water from Ranbir canal distributaries. It is an accepted fact that increase in salt concentration is directly related to increase

in conductivity and lowering of pH. In this respect the present finding is in line with that of Bear (1965).

Certain sulphide ions get oxidized to form sulphate which render the soil acidic. Ammonia and ammonium salts are acted upon by bacteria converting them to nitric acid. In the process the pH is lowered. Boyd (1976) has observed that with highest pH values the nitrogen concentration in the shallow areas of the pond is reduced. On the contrary in deeper layers the lowest pH values correspond to the highest nitrogen concentration. In the present investigation on Gadigarh stream, an inverse relationship holds between pH and nitrogen concentration at all stations except during a few months of the year. The highest pH values, 8.5, 8.6, 8.7, 8.6, 8.7 correspond to nitrogen concentration 0.0028, 0.0476, 0.0896, 0.0308, 0.098 at II, III, IV, V, and VII station respectively. At Station I pH of 8.2 corresponds with nitrogen concentration of 0.966. This inverse correlation of pH with nitrogen concentration has also been reported by Sumitra-Vijayaraghavan (1973). She states that pH and phosphate concentration show direct correlation; while phosphate and nitrogen concentration show an inverse relationship. A similar observation suggesting direct relationship between phosphate and pH has also been made during the course of present investigation$.

(ii) Carbon dioxide and bicarbonate: A number of workers have pointed out that pH of the soil containing calcium carbonate or appreciable quantity of bicarbonate ions in soil solution is related to carbon dioxide pressure, concentration of bicarbonates and ionic strength of the soil solution (Bear, 1965). Gasser (1969) reported that with each tenfold increase in carbon dioxide concentration in aqueous solution, the pH falls by half a unit. The fraction of carbon dioxide, bicarbonate and the ionic strength are interrelated in accordance with the equation:

$$pH = pK_1 - \sqrt{0.5\mu} + \text{Log} \quad \frac{(HCO_3)}{(CO_2)}$$

In the relationship, pK_1 is the negative logarithm of the first dissociation constant of carbonic acid (6.26 at 24°C) and $\sqrt{\mu}$ the ionic strength of the soil solution. Bear (1965) pointed out that the pH of soil is reduced in proportion to the logarithm of the carbon dioxide pressure of soil air. Jhingran (1975) states that bicarbonates are reduced at higher pH values, at pH lower than 8.3 but more than 4.5, practically no carbonate is present but free carbon dioxide and bicarbonates may be present. In the present investigations, the pH values in general correspond inversely to the

bicarbonate concentration of the bottom mud except for some intervals. At Stations I, III and V the pH values 8.3, 8.2 and 8.4 - 8.5 corresponded with bicarbonate values of 0.042 %, 0.179 % and 0.0732 - 0.271 % during the months of November, 1974, May, 1975, June 1975 and September 1975 respectively, while at Stations II, IV and VII pH values showed inverse relationship with bicarbonate content (Tables IX, XI and XIII; Figs.10,12 & 14).

Recently, Dhar (1976) pointed out that when a plant is burnt in air, alkali carbonates are left as residues. On the soil surface, similar oxidation reaction takes place but on a smaller scale. The carbonateous and nitrogenous substances of the plant are steadily oxidized leaving behind only alkaline mineral residues. Obviously therefore, the plants and their residues present in the soil contribute alkali to it. Green manure is known to increase soil alkalinity (Dhar, 1976). Dhar (1976) has also pointed out that as a result of the slow oxidation of organic matter in soil, carbonic acid and organic acid such as lactic, acetic, citric, maleic and propionic acids are produced which neutralize soil alkalinity. Carbonic acid produced by the decomposition and oxidation of organic matter plays an important role in neutralizing soil alkalinity. It is a weak acid having a dissociation constant which

according to Dhar (1976) is represented as:

$$\frac{H^+ \times HCO_3^-}{H_2CO_3} = 3 \times 10^{-7} \text{ (1st dissociation constant)}$$

$$H^+ \times CO_3^- = 6 \times 10^{-11} \text{ (2nd dissociation constant)}$$

During the process of decomposition the concentration of CO_2 may also be increased through the dissociation of bicarbonate ions as:

$$2HCO_3 \longrightarrow CO_2 + CO_3 + H_2O \text{ or}$$
$$HCO_3 \longrightarrow CO_2 + OH$$

OR

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$
$$Ca(HCO_3)_2 \longrightarrow Ca^{++} + 2HCO_3^-$$
$$H^+ + HCO_3^- \longrightarrow H_2CO_3 \rightleftharpoons H_2O + CO_2$$

Increase in carbon dioxide concentration sometimes results in the depletion of oxygen associated with the bottom mud carbon dioxide. Hydroxyl ions thus liberated are responsible for causing fluctuations in the pH values of the bottom mud. Thus, during summer months when the proportion of organic matter is maximum (0.192 - 4.012 % at Station I), the rate of decomposition gets enhanced through bacterial

activity, which in all probability accounts for the decline of pH from 8.5 - 8.2 recorded during 1975 and from 8.4 - 8.1 observed in 1976 at Station I. Similar observations were made at other stations too (Tables IX - XIII; Figs. 10 - 14). Banerjea (1967) has attempted to correlate pH with productivity of a fresh water fish pond. He classified ponds into five types and observed that highly acidic and alkaline bottom soils of the ponds is undesirable for fish productivity; slightly alkaline and acidic pH is favourable for production.

2.2. Organic matter: Soil organic matter is contributed by the living and dead organisms of the ecosystem through microbial activity. The soil organic matter contains most of the naturally occurring organic compounds like carbohydrates and their derivatives, proteins and other organic compounds. Under several biological and physico-chemical influences, the organic matter of Gadigarh stream showed variations from 0.192 % during December, 1974 to 4.597 % during December, 1975 at Stations I, IV (Tables VIII, XI; Figs. 9-12) It has been observed that increase in the percentage of fine particles, clay and loam, boosted the quantity of organic matter. On the contrary, with the increase in percentage of coarse particles the quantity of organic matter got reduced at all the stations (Tables VIII - XIII; Figs. 9 - 14).

This is in all probability due to the adsorption of dissolved organic matter on fine clay particles as has been reported by Odum (1971). Sander (1956) stated that all clay minerals except Kaolin, bind organic matter; further the organic matter is predominantly bound by fine particle fraction and to a lesser degree by silt and coarse sand (Russel, 1950). The minimum percentage of organic matter bears a relation with fine particle percentage in clayey soil. Boyd (1976) while studying the fish ponds of Alabama (U. S. A.) and Damodaran (1973) in his investigation of the Keral Coast (India) have observed that the lowest organic matter content corresponds with high percentage of coarse particles.

During the course of present investigations the organic matter content has been found to be proportional to the total nitrogen content and percentage of organic carbon (Tables VIII - XIII; Figs. 9 - 14). This observation is in conformity with that of Boyd's (1976).

Jhingran (1975) has stated that organic matter occurring at the bottom of the stream at different stations is decomposed by microbial activity into end product like water, carbon dioxide, ammonia etc. Further changes in ammonium salts and nitrates occur by

the process of nitrification. It is well known that organic matter has to be reduced to simple nitrogen compounds to make it available for plant growth and for food chain.

2.3. Phosphorus: The total available phosphate in the bottom sediments of Gadigarh stream is highly variable; it varies from a minimum of 4.5 ppm at Station IV (October, 1974) to a maximum of 89 ppm at Station VII (January, 1975). It has been observed that no quantitative uniformity exists in the available phosphate content at various stations during the same month or at the same station during different months in a year (Tables VIII - XIII; Figs. 9 - 14). A similar observation has been made by Raychaudhuri (1966) for terrestrial soils. This variability in available phosphates is due to variability in organic combination in which phosphate available (Raychaudhuri, 1966; Jhingran, 1975).

It has been observed that during summer months there is a higher average phosphate content in the bottom sediments, while during the winter months the average phosphate content of soil is low at all stations except I and VII (Table XIV). This seasonal fluctuation in average available phosphate content suggests an interesting relationship between phosphate

content and environmental temperature. Such a relationship has not been reported by any past investigator. Higher phosphate content of the soil during summer months may be due to greater microbial activity resulting in the release of phosphate ions from the detritus of the preceding peak of biomass. This activity of the microbes gets considerably reduced during winter when the phosphate content records every time low. During this period, phosphate remains locked up in detritus. Generally low phosphate values during monsoons can be attributed to greater soil washings through abundant rains. Higher values at Station III even during monsoon can be attributed to greater depth and gentle water flow. Depth and calm flow absorb the fury of the force of rains, thereby, preventing bottom washings.

The available phosphate content of the soil bears a direct correlation with the pH of bottom sediments (Tables VIII - XIII; Figs. 9 - 14) except for a few months. This has been discussed earlier on page 61 . During the course of present investigation it has been observed that rise in available phosphate content is always preceded by a rise in pH (Table VIII - XIII; Figs. 9 - 14).

Banerjea (1967) grouped the ponds that he studied into four categories on the basis of the phosphate content available in the bottom sediment and stated that available phosphate is more important than total phosphate in determining the productivity of an aquatic system. The available phosphate content in the four categories of pond was (i) 30 ppm, (ii) 30 - 60 ppm, (iii) 60 - 120 ppm, and (iv) 120 ppm and above. He pointed out that soils with 30 ppm of phosphate are more suitable for production, those with 30 - 60 ppm favour average production and soils with more than 60 ppm support maximum fish production.

Present studies have revealed a range of 25 - 35 ppm of available phosphate at Stations II, III and IV which favours the growth and production of rooted vegetation and submerged plants. At Stations I, V and VII such a correlation between available phosphate content of bottom sediments and the productivity of plants is lacking (Tables VIII, XII & XIII; Figs. 9, 13 & 14) probably on account of greater biotic interference at these stations.

Available phosphate content in the bottom sediment bears a direct relationship with the available potassium content of the bottom soil. This is

particularly clear at Stations II, III, IV, V and VII (Tables IX - XIII; Figs. 10 - 14). At Station I the two are inversely correlated in the first few months of the year which may be due to the simultaneous release or assimilation of phosphate and potassium in decomposition and production of primary producers.

2.4. Nitrogen: In the first half of the 19th century it was established that most of the plants obtain their nitrogen requirement from the soil. According to the Stevenson's Geochemical theory (1965) nitrogen found in the atmosphere now was originally present in the form of ammonium compounds and nitrides in the solid matters of earth. With the development of heat in the earth, nitrogen was driven off into the atmosphere, where it existed mostly as ammonia. When the atmosphere got enriched with oxygen produced through photosynthesis, the atmospheric ammonia got oxidized to elemental nitrogen. Bear (1965) states that although nearly 80 % of air consists of nitrogen yet only 2 % of the total nitrogen present in plants is contributed by atmospheric nitrogen.

Black (1965) stated that the nitrogen content decreased with the increase in annual temperature sometimes reaching even zero. During the course of present work it has been observed that the average total nitrogen content shows an increase from 0.058 - 0.113 % from October to February (1974 - 1975) and from

0.099 - 0.229 % during the same period in 1975 - 1976 (Tables VIII - XIII, and XV). The average total nitrogen content obviously bears an inverse relationship with temperature; lower temperatures being associated with increased nitrogen content.

With the onset of summer (March - June) the average total nitrogen content showed a decline to 0.042 % during 1975 and to 0.067 during 1976 at Station II (Table XV). Although the range of values for total nitrogen content was large, most of the values were, however, within much narrower ranges and similar relationship between temperature and nitrogen content was obtained at all other stations too (Tables VIII - XIII; Figs. 9 - 14)

During early showers of monsoons in June, the nitrogen content of the bottom sediment of Gadigarh stream registered a slight increase at all stations (Tables VIII - XIII ; Figs. 9 - 14). Jhingran (1975) pointed out that ammonium salts and nitrates are highly soluble compounds and are therefore, easily leached out. Most part of soluble nitrogen content is added during first monsoon showers by the water contributed by the surrounding cultivated fields. This soluble

nitrogen becomes available to the bottom sediment of the stream along with other nutrients. Saha (1969) observed that increase in water level brought about a remarkable increase in available nitrogen, which he attributed to the reduction of oxidized mud layer due to a rise in water level whereby the nutrients get released. This release of nutrients encourages the activity of ammonifying bacteria which cause an increase in nitrogen content. Further increase in monsoon showers causes a remarkable change in water level which reduces the nitrogen content of the bottom sediment. Since Gadigarh stream represents a lotic water body, the floods invariably cause the bottom sediment to drift with the running water. In this way much of the bottom sediment is replaced by fresh sediment. This causes a change in nitrogen content since the microbial activity is insignificant (Tables VIII - XIII; Figs. 9 - 14). In the following months when the monsoon rains become scarce the water body offers a congenial habitat for microbial activity leading to the production of plants and algae along with several types of bacteria. At this time many nutrients like calcium, phosphate, manganese and ammonia are released which encourage bacterial activity (Saha, 1969). This marks the beginning of gradual rise in the total nitrogen content. Edward and Rolley (1965) reported that

nitrate reduction by mud is increased, when either oxygen consumption by the mud or nitrate concentration of overlying water is high.

Bear (1965) pointed out that organic nitrogen added to soils in the form of plant and animal residues is largely proteinaceous in nature. These nitrogen constituents undergo numerous transformations like biological mineralization and immobilization. At Station I, such transformations of organic matter take place in the bottom sediment as a consequence of which the total nitrogen content is very high (0.966 %). Station I is very shallow (only 6 - 14" deep) and therefore, microbial activity at the station is high. Saha (1969) pointed out that release of nitrogen along with other minerals from soil colloids, decomposition of organic matter and conversion of insoluble to soluble salts appears to have contributed to a rise in nitrogen concentration to a smaller extent than rain washing.

The lowest total nitrogen values (0.0028 %) at Station II in January, 1975 can be attributed to the maximum inflow of water from the adjoining fields and nearby Karan Bagh (Fig. 1) which prevents fertile material from becoming available to the bottom and its inhabitants. Further, the nitrogen

already present in the "stream" remains locked up (Gasser, 1969) during this period and is not also available until a particular type of bacterium brings about its conversion into simpler forms of nitrogen compounds. Bear (1965) has pointed out that, bulk of nitrogen exists in the soil in the form of decaying plant and animal residues, including the microbes Bear (1965), Gasser (1969) and Saha (1969) have pointed out that some amount of soluble nitrogen reaches the stream after the application of urea (fertilizers) to the adjoining cultivated fields. In addition to nitrogen from organic sources, the bottom mud contains small amount of nitrogen in inorganic form mainly as nitrate and ammonical compounds. Nitrogen content from the two sources, organic and inorganic, varies greatly from one station to another, although the area under investigation lies within the same climatic zone and geological formation. While working on terrestrial soils, Raychaudhuri (1966) advocated the view that there is variability in the nitrogen content of agricultural soils. Many workers like Mann and Barners (1951), Broadbent and Stojanovic (1952), Verhoeven (1952), Arnold (1954), Wallace and Smith (1954) and Widler and Delwiche (1954) support the view that significant loss of nitrogen from soil may occur by processes of

denitrification. Below the pH of 4.8 denitrification is slow; with an increase in pH, denitrification increases and at a pH 8 it becomes rapid. The total nitrogen value in January, 1975 and February, 1976 at 8.1 pH at Station I was 0.1176% and 0.2915%. Similarly, the lowest total nitrogen content of 0.0028 % (January, 1975), 0.0546% (April, 1975), 0.0378 % (June, 1975) and 0.024 % (May, 1975) at Station II correspond to the pH value 8.5; the highest nitrogen value of 0.248 % during January, 1976 corresponds to pH 8.1. Although the range of values for total nitrogen content was large, most of the values were within a narrow range and a similar pattern of rise or decline in nitrogen values corresponded to the maximum or minimum pH values at all these stations (Tables VIII - XIII; Figs. 9 - 14). At certain intervals the unexpectedly high or low values of nitrogen are thought to be caused by unusual biological activity, biotic interference, influence of the inflow of water from distributaries and the effect of certain other physical and chemical parameters prevailing along the course of the stream.

During the present investigations too, an inverse relationship has been found to operate between the total nitrogen content and available

phosphate content of the bottom sediment of Gadigarh stream. The nitrogen values 0.0406 %, 0.186 % and 0.241 % for the period October, 1974 and November and December, 1975 corresponded to highest phosphate values 43.2 ppm, 55 ppm and 44 ppm at Station I. At Station II the nitrogen values of 0.1471 % in December, 1975 and 0.0721 % in April, 1976 corresponded to the highest phosphate values of 55 ppm and 46 ppm during the period. Similarly, lowest nitrogen values 0.0451 % and 0.0643 % during April, 1976 at Station III and IV corresponded to 44.5 ppm and 32.5 ppm of phosphate respectively. Similarly 0.0564 % of nitrogen in May, 1976 and 0.0588 % in January, 1975 corresponded to 53 ppm and 89 ppm of phosphate values at Stations V and VII. Similarly, the highest nitrogen values of bottom sediment corresponded to the lowest phosphate values. An inverse correlation between nitrogen and phosphate confirms the earlier findings of Mortimer (1941, 1942) and Sumitra - Vijayaraghavan (1971).

Table II. Monthly values of particle size distribution (sand, silt, clay and loam), colour and consistency of bottom sediments at Station I in Gadigarh stream.

S.No.	Period	Munshell colour	Texture	Coarse sand	Fine sand	Total sand	Silt	Clay	Loam	Sand: silt	Clay: loam	Consistency of soil Wet	Dry
	1974												
1.	October	5YR 6/1	Sandy-silt	7.157	32.903	40.06	31.855	7.302	20.783	1.257	0.351	Sl*st**	Soft
2.	November	5YR 4/2	Sandy-silt	7.327	46.042	53.369	38.629	0.466	7.536	1.381	0.061	Sl.St.	Soft
3.	December	5YR 7/1	Sandy-silt	8.027	52.019	60.046	34.240	1.922	3.772	1.753	0.509	Sl.st.	Soft
	1975												
4.	January	2.5YR 6/2	Silty-loam	2.413	18.371	20.784	28.410	24.351	26.455	0.7315	0.92	St.	Soft
5.	February	2.5YR	Sandy-silt	7.301	49.029	56.33	31.015	2.175	10.879	1.816	0.731	Sl.st.	Sl.hard
6.	March	5YR 7/1	Silty-loam	1.019	21.46	22.479	37.271	11.341	28.909	0.603	0.392	St.	Sl.hard
7.	April	5YR 7/1	Sandy-silt	3.549	33.325	36.874	32.811	12.908	16.407	1.123	0.786	St.	Sl.hard
8.	May	10YR 6/2	Sandy-silt	8.411	31.318	39.729	29.913	4.123	26.235	1.328	0.157	St.	Sl.hard
9.	June	10YR 7/1	Sandy-silt	23.135	43.439	66.574	18.341	10.271	4.814	3.629	2.133	Sl.st.	Sl.hard
10.	July	5YR 6/4	Silty-loam	5.501	10.323	15.824	32.112	20.780	31.282	0.492	0.664	Very st.	Hard
11.	August	5YR 6/4	Silty-loam	7.411	10.360	17.771	31.841	7.621	42.767	0.558	0.178	Very st.	Hard
12.	September	10YR 6/6	Silty-loam	10.081	8.142	18.223	32.740	18.678	30.359	0.556	0.615	Very st.	Hard
13.	October	5YR 7/1	Silty-sand	18.241	14.215	32.456	33.229	8.761	25.554	0.976	0.342	Very st.	Hard
14.	November	5YR 6/1	Sandy-silt	15.470	19.621	35.091	32.621	14.141	17.174	1.075	0.823	Very st.	Hard
15.	December	5YR 6/1	Silty-sand	18.213	13.761	31.974	34.206	16.410	17.410	0.934	0.942	Sl.st.	Hard
	1976												
16.	January	5YR 5/2	Sandy-silt	13.751	18.142	31.893	30.054	18.591	19.462	1.061	0.955	Sl.st.	Hard
17.	February	5YR 6/3	Sandy-silt	4.154	38.241	42.395	31.143	8.032	18.43	1.361	0.435	Sl.st.	Hard
18.	March	5YR 7/3	Sandy-silt	6.514	42.12	48.634	34.140	8.421	8.805	1.424	0.856	Sl.st.	Hard
19.	April	10YR 7/1	Sandy-silt	9.217	32.123	41.340	33.104	11.591	13.965	1.248	0.83	Sl.st.	Hard
20.	May	5YR 6/3	Sandy-silt	13.521	31.479	45.00	28.451	4.471	21.808	1.581	0.217	Sl.st.	Sl.hard
21.	June	5YR 6/3	Sandy-silt	23.941	30.014	53.955	21.492	10.21	14.343	2.5104	0.711	Sl.st.	Sl.hard

* Sl. = Slightly; ** st. = sticky

Table III. Monthly values of particle size distribution (sand, silt, clay and loam), colour and consistency of bottom sediments at Station II in Gadigarh stream.

S.No.	Period	Munshell colour	Texture	Coarse sand	Fine sand	Total sand	Silt	Clay	Loam	Sand: silt	Clay: loam	Consistency of soil Wet	Dry
	1974												
1.	October	5YR 7/1	Loamy-sand	12.659	16.287	28.946	28.859	13.001	29.194	1.003	0.445	Very st**	Hard
2.	November	5YR 7/1	Sandy-silt	10.287	32.016	42.303	26.445	13.617	17.635	1.599	0.772	Sl* st.	Hard
3.	December	5YR 5/3	Loamy-clay	11.680	15.490	15.452	15.900	23.880	33.050	0.997	0.722	Very st.	Hard
	1975												
4.	January	10YR 6/2	Sandy-silt	14.108	56.931	71.039	18.211	5.394	4.756	3.900	1.134	Non st.	Loose
5.	February	10YR 7/1	Sandy-silt	8.465	31.291	39.756	38.742	14.213	7.229	1.024	1.975	Sl. st.	Sl.loose
6.	March	10YR 7/1	Sandy	16.271	65.336	81.606	14.121	1.493	2.779	5.775	0.551	Non st.	Loose
7.	April	10YR 6/2	Sandy-silt	4.239	51.329	55.568	28.617	8.719	7.636	1.941	1.071	Sl.st.	Loose
8.	May	10YR 6/3	Sandy-loam	8.108	29.759	37.867	20.910	8.742	32.481	1.81	0.269	Sl.st.	Sl.hard
9.	June	10YR 6/2	Sandy-silt	25.779	42.491	68.27	19.712	9.879	2.139	3.463	4.61	Sl.st.	Sl.Hard
10.	July	5YR 6/3	Silty-sand	4.05	29.128	33.178	34.514	6.943	25.365	0.961	0.271	Sl.st.	Sl.hard
11.	August	5YR 6/3	Loamy-silt	5.886	9.450	15.336	23.250	11.612	49.802	0.659	0.233	Very st.	Sl.hard
12.	September	5YR 5/3	Loamy-silt	9.421	10.261	19.682	23.096	21.780	35.436	0.852	0.614	Very st.	Sl.hard
13.	October	5YR 6/3	Silty-sand	13.451	14.914	28.365	30.125	17.401	24.109	0.941	0.721	St.	Sl. hard
14.	November	5YR 6/3	Sandy-silt	18.214	21.517	39.758	31.201	16.257	12.784	1.274	1.271	St.	Sl. hard
15.	December	5YR 6/6	Clayey-sand	12.970	15.421	28.391	19.310	32.145	20.154	1.47	1.594	St.	Sl. hard
	1976												
16.	January	5YR 6/3	Sandy-silt	18.21	32.967	51.177	28.24	8.219	12.364	1.812	0.664	St.	Sl. hard
17.	February	5YR 6/2	Sandy-silt	12.012	31.291	43.303	34.951	18.214	3.532	1.238	5.156	St.	Sl.hard
18.	March	5YR 6/1	Sandy-silt	14.792	42.41	57.202	24.721	8.643	9.434	2.313	0.916	Sl.st.	Sl.hard
19.	April	5YR 6/1	Sandy	16.172	56.614	72.786	10.523	8.141	8.55	6.916	0.952	Non st.	Loose
20.	May	5YR 5/2	Sandy-silt	22.74	40.491	63.231	28.121	4.211	4.437	2.48	0.949	Non st.	Soft
21.	June	5YR 7/1	Sandy-silt	15.105	38.41	53.515	42.135	1.471	2.879	1.270	0.510	Sl. st.	Soft

* Sl. = Slightly; ** st. = sticky.

Table IV. Monthly values of particle size distribution (sand, silt, clay and loam), colour and consistency of bottom sediments at Station III in Gadigarh stream.

S.No.	Period	Munshell colour	Texture	Coarse sand	Fine sand	Total sand	Silt	Clay	Loam	Sand: silt	Clay: loam	Consistency of soil Wet	Hard
	1974												
1.	October	5YR 7/1	Loamy-silt	5.866	9.450	15.336	23.250	11.612	49.802	0.659	0.233	Very st**	Hard
2.	November	10YR 7/2	Silty-loam	2.996	21.298	24.348	34.560	16.160	24.986	0.704	0.646	Very st.	Hard
3.	December	5YR 6/2	Sandy-silt	7.801	51.043	58.844	34.997	1.550	4.609	1.681	0.338	Sl* st.	Soft
	1975												
4.	January	5YR 6/3	Clayey-loam	4.167	10.614	14.781	13.177	42.134	29.008	1.121	1.452	Sl. st.	Hard
5.	February	7.5YR 6/4	Sandy-silt	12.091	24.142	36.233	33.650	19.714	11.003	1.076	1.791	Sl. st.	Hard
6.	March	7.5YR 7/0	Clayey-loam	8.416	15.879	24.295	36.451	19.321	29.753	0.66	0.64	Sl. st.	Hard
7.	April	10YR 7/2	Sandy-silt	13.402	21.842	35.244	35.152	17.111	12.491	1.002	1.369	Sl. st.	Hard
8.	May	10YR 7/1	Sandy-loam	11.523	43.015	54.538	12.141	6.232	27.109	4.492	0.299	Sl. st.	Soft
9.	June	10YR 5/3	Silty-sand	4.198	25.682	29.88	37.211	8.259	24.650	0.802	0.335	Sl. st.	Soft
10.	July	5YR 5/3	Loamy-clay	5.170	5.470	10.64	11.287	27.993	50.078	0.942	0.558	Very st.	Hard
11.	August	10YR 6/2	Silty-clay	0.279	2.829	3.103	46.731	32.574	17.592	0.666	1.851	Very st.	Hard
12.	September	7.5YR 7/2	Silty-sand	4.215	20.119	24.334	39.513	18.54	17.613	0.615	1.05	Very st.	Hard
13.	October	7.5YR 7/2	Silty-sand	8.157	28.21	36.367	42.46	6.741	14.432	0.856	0.467	Very st.	Hard
14.	November	7.5YR 6/0	Silty-sand	9.729	21.451	31.18	38.459	14.794	15.567	0.81	0.95	Very st.	Hard
15.	December	5YR 6/4	Sandy-silt	2.581	18.476	21.057	34.249	22.514	22.18	0.6	1.015	Very st.	Hard
	1976												
16.	January	5YR 6/3	Silty-loam	6.791	10.441	17.232	32.047	24.145	26.576	0.567	0.908	Very st.	Sl.hard
17.	February	5YR 6/3	Sandy-loam	18.781	20.914	39.695	18.15	16.781	25.374	2.187	0.616	Very st.	Sl.hard
18.	March	5YR 6/4	Sandy-clay	5.75	42.21	47.96	12.781	29.914	9.345	3.752	3.202	Very st.	Sl.hard
19.	April	5YR 5/1	Sandy-clay	19.148	13.473	32.62	22.749	30.145	14.486	1.433	2.080	Very st.	Sl.hard
20.	May	5YR 7/1	Sandy-silt	12.561	18.641	31.202	30.24	14.641	23.871	1-031	0.612	Very st.	Sl.hard
21.	June	5YR 7/2	Sandy-loam	2.781	30.14	32.921	29.72	10.561	26.798	1.107	0.394	Very st.	Sl.hard

* Sl. = Slightly; ** st. = sticky.

Table V. Monthly values of particle size distribution (sand, silt, clay and loam), colour and consistency of bottom sediments at Station IV in Gadigarh stream.

S.No.	Period	Munshell colour	Texture	Coarse sand	Fine sand	Total sand	Silt	Clay	Loam	Sand: silt	Clay: loam	Consistency of soil Wet	Hard
	1974												
1.	October	5YR 5/1	Silty-sand	4.606	21.195	25.862	41.262	9.105	23.768	0.626	0.382	St*	Sl**hard
2.	November	5YR 6/2	Sandy-silt	9.250	49.834	59.084	34.706	1.560	4.650	1.702	0.335	Sl.st.	Soft
3.	December	5YR 6/1	Silty-sand	10.245	21.725	31.970	34.718	9.348	23.963	0.921	0.390	Sl.st.	Soft
	1975												
4.	January	5YR 7/1	Sandy	32.845	50.151	82.996	4.136	8.709	4.159	20.059	2.049	Sl.st.	Loose
5.	February	5YR 6/2	Silty-loam	0.478	18.741	19.219	45.315	2.517	32.949	0.424	0.07	Sl.st.	Hard
6.	March	5YR 5/2	Silty-sand	2.798	27.295	30.093	50.569	6.647	12.691	0.595	0.523	Sl.st.	Hard
7.	April	5YR 5/1	Silty-sand	14.552	18.849	33.40	42.07	6.817	17.751	0.782	0.384	Sl.st.	Very hard
8.	May	5YR 7/3	Loamy-silt	2.112	14.521	16.633	33.512	6.125	43.530	0.493	0.4	Sl.st.	Very hard
9.	June	5YR 6/4	Silty-sand	7.211	16.391	23.602	41.302	14.671	20.425	0.571	0.718	Sl.st.	Very hard
10.	July	5YR 5/6	Clayey-loam	3.125	7.103	10.218	18.581	49.740	21.48	0.549	2.319	Sl.st.	Hard
11.	August	5YR 6/4	Loamy-silt	5.058	17.851	22.909	27.553	12.561	36.969	0.831	0.339	Sl.st.	Hard
12.	September	5YR 6/4	Silty-sand	7.14	27.099	34.247	39.039	10.7	16.016	0.877	0.668	Sl.st.	Hard
13.	October	10YR 5/3	Sandy-silt	11.851	31.214	43.065	38.19	8.742	10.003	1.127	0.873	Sl.st.	Hard
14.	November	10YR 5/3	Sandy-silt	14.14	42.257	56.397	36.145	6.21	1.24	1.56	5.00	Sl.st.	Soft
15.	December	10YR 6/1	Silty-sand	8.21	21.25	29.46	42.41	18.21	9.92	0.694	1.835	Sl.st.	Soft
	1976												
16.	January	10YR 7/1	Sandy-silt	11.46	32.149	43.609	33.75	16.21	6.431	1.292	2.52	Sl.st.	Soft
17.	February	10YR 6/3	Sandy-silt	25.45	21.091	46.541	31.411	11.721	10.319	1.481	1.136	Sl.st.	Sl.hard
18.	March	10YR 6/3	Silty-sand	17.252	16.397	33.646	40.78	6.14	19.431	0.825	0.315	Sl.st.	Sl.hard
19.	April	10YR 6/3	Loamy-sand	21.341	12.75	34.091	2.37	16.24	47.3	14.38	0.343	Sl.st.	Sl.hard
20.	May	10YR 6/3	Silty-sand	18.64	10.891	29.531	31.21	18.23	21.029	0.946	0.866	Sl.st.	Sl.hard
21.	June	10YR 6/3	Silty-clay	12.80	5.78	18.58	32.40	21.62	27.40	0.573	0.789	Sl.st.	Sl.hard

* St. = Sticky; ** Sl. = Slightly.

Table VI. Monthly values of particle size distribution (sand, silt, clay and loam), colour and consistency of bottom sediments at Station V in Gadigarh stream.

S.No.	Period	Munshell colour	Texture	Coarse sand	Fine sand	Total sand	Silt	Clay	Loam	Sand: silt	Clay: loam	Consistency of soil Wet	Hard
	1974												
1.	October	10YR 4/2	Silty-sand	1.482	14.693	16.175	57.627	12.011	14.187	0.28	0.846	Sl.* st.**	Soft
2.	November	10YR 5/1	Loamy-sand	13.325	14.199	25.524	18.185	15.575	40.616	1.403	0.385	St.	Sl.hard
3.	December	10YR 5/1	Sandy-silt	6.327	49.029	55.356	31.415	13.423	10.076	1.77	0.339	Sl.st.	Soft
	1975												
4.	January	10YR 6/1	Silty-sand	5.192	37.123	42.315	47.407	9.507	0.771	0.89	12.33	Sl.st.	Sl.hard
5.	February	10YR 5/2	Silty-loam	11.319	13.527	24.846	31.761	17.450	25.940	0.784	0.67	sl.st.	Sl.hard
6.	March	10YR 5/2	silty-sand	3.361	33.366	36.727	50.272	7.750	6.251	0.73	1.239	Sl.st.	Sl.hard
7.	April	10YR 6/2	Loamy-sand	0.912	31.331	32.303	27.573	2.467	37.777	1.17	0.06	Sl.st.	Sl.hard
8.	May	10YR 6/2	Silty-loam	4.129	18.351	22.48	41.971	2.521	33.018	0.535	0.076	St.	Hard
9.	June	10YR 6/4	Sandy-clay	6.371	25.273	31.644	18.671	24.911	24.779	1.69	1.005	Sl.st.	Sl.hard
10.	July	2.5YR 6/4	Silty-loam	5.501	10.323	15.824	32.112	20.780	31.284	0.492	0.664	St.	Sl.hard
11.	August	2.5YR 6/6	Silty-loam	7.913	13.171	21.084	49.734	4.372	24.810	0.423	0.176	St.	Hard
12.	September	2.5YR 6/6	Loamy-silt	6.650	18.066	24.716	28.727	19.667	28.896	0.924	0.6	St.	Sl.hard
13.	October	10YR 6/4	Sandy-silt	8.941	23.72	32.661	31.27	14.87	21.199	1.044	0.701	Sl.st.	Sl.hard
14.	November	10YR 6/4	Silty-sand	10.241	26.27	36.511	42.19	12.4	8.899	0.865	1.393	Sl.st.	Sl.hard
15.	December	10YR 6/4	Sandy-silt	16.7	31.7	48.4	31.27	10.781	9.549	1.547	1.29	Sl.st.	Sl.hard
	1976												
16.	January	10YR 6/1	Silty-sand	20.75	18.41	39.16	39.27	4.159	17.411	0.997	0.238	Sl.st.	Sl.hard
17.	February	10YR 5/2	Sandy-loam	21.2	33.4	54.6	21.78	2.145	21.475	2.50	0.099	Sl.st.	Sl.hard
18.	March	10YR 5/4	Silty-loam	10.24	16.415	26.655	41.21	2.546	29.589	0.646	0.086	St.	Sl.hard
19.	April	10YR 6/1	Loamy-sand	6.41	20.2	26.61	22.400	8.21	42.780	1.18	0.19	St.	Sl.hard
20.	May	10YR 6/1	Sandy-silt	8.721	19.45	28.171	26.79	10.461	10.461	1.051	1.00	Sl.st.	Sl.hard
21.	June	10YR 6/1	Sandy-loam	6.726	25.62	32.246	18.24	24.241	25.173	1.77	0.96	Sl.st.	Sl.hard

* Sl. = Slightly; ** st. = sticky.

Table VII. Monthly values of particle size distribution (sand, silt, clay and loam), colour and consistency of bottom sediments at Station VII in Gadigarh stream.

S.No.	Period	Munshell colour	Texture	Coarse sand	Fine sand	Total sand	Silt	Clay	Loam	Sand : silt	Clay : loam	Consistency of soil Wet	Hard
	1974												
1.	October	10YR 6/2	Silty-sand	3.008	27.191	30.199	46.515	7.666	15.417	0.649	0.497	Sl* st**	Sl. hard
2.	November	10YR 6/2	Silty-sand	6.602	22.109	28.315	38.412	10.394	22.979	0.737	0.542	Sl. st.	Sl. hard
3.	December	10YR 5/2	Sandy-silt	7.308	44.623	51.931	35.015	2.175	10.879	1.483	0.199	Non st.	Soft
	1975												
4.	January	10YR 5/1	Sandy-silt	2.909	29.130	32.039	31.204	8.634	28.103	1.026	0.307	Sl. st.	Soft
5.	February	5YR 5/1	Silty-sand	2.789	20.219	23.008	39.107	18.517	19.371	0.588	0.955	Sl. st.	S. hard
6.	March	5YR 5/2	Loamy-sand	14.594	17.508	32.102	15.500	7.466	44.832	2.07	0.166	Sl. st.	S. hard
7.	April	5YR 5/2	Silty-sand	7.204	18.320	25.524	49.121	5.609	17.751	0.519	0.315	Sl. st.	S. hard
8.	May	10YR 5/2	Silty-sand	0.571	22.741	23.312	46.442	8.721	21.525	0.501	0.405	Sl. st.	S. hard
9.	June	5YR 6/4	Clayey-loam	0.391	19.706	20.09	18.513	40.171	21.279	1.085	1.893	Sl. st.	S. hard
10.	July	5YR 6/2	Silty-sand	4.414	23.043	27.457	48.165	9.039	15.339	0.57	0.589	Sl. st.	S. hard
11.	August	5YR 6/2	Silty-loam	2.68	10.337	13.003	37.142	22.472	27.381	0.35	0.82	St.	Hard
12.	September	5YR 6/4	Silty-sand	18.215	9.520	27.735	35.631	15.873	19.371	0.778	0.819	Sl. st.	S. hard
13.	October	2.5YR 6/4	Sandy-silt	20.21	16.178	36.388	29.21	14.1	20.302	1.245	0.694	Sl. st.	S. hard
14.	November	2.5YR 5/2	Sandy-silt	23.21	16.89	40.10	24.12	12.729	23.051	1.662	0.552	Sl. st.	S. hard
15.	December	5YR 6/4	Sandy-loam	25.258	20.291	45.549	16.781	8.785	28.885	2.714	0.304	Non st.	Soft
1	1976												
16.	January	5YR 6/4	Silty-sand	18.7	13.72	32.42	42.78	6.421	18.379	0.757	0.349	Sl. st.	Sl. soft
17.	February	5YR 6/3	Silty-loam	14.15	10.21	24.36	32.14	18.56	24.94	0.757	0.744	Sl. st.	Sl. soft
18.	March	10YR 6/4	Silty-sand	13.51	16.571	30.081	30.241	21.45	18.255	0.995	1.176	Sl. st.	Sl. soft
19.	April	10YR 6/1	Clayey-loam	2.24	14.25	16.49	18.61	34.24	30.66	0.886	1.116	St.	Sl. hard
20.	May	10YR 6/1	Clayey-loam	1.79	12.78	13.959	22.29	40.14	23.611	0.626	1.7	St.	Sl. hard
21.	June	10YR 6/1	Clayey-silt	2.245	18.2	20.445	30.2	32.4	16.955	0.676	1.91	St.	Sl. hard

* Sl. = Slightly; ** st. = sticky

Table VIII. Monthly values of physico-chemical parameters of bottom sediments at Station I in Gadigarh stream.

S.No.	Period	pH	Conductivity μ mho per cm	Total soluble salts (%)	Bi-carbonates (%)	Organic matter (%)	Available potassium (ppm)	Available phosphates (ppm)	Total nitrogen (%)	Organic carbon (%)	C : N
	1974										
1.	October	8.3	0.55	0.1925	0.422	1.8	14.5	43.2	0.0406	0.044	1.083
2.	November	8.3	0.54	0.189	0.042	1.428	22.5	27.5	0.0238	0.828	38.82
3.	December	8.3	0.42	1.47	0.146	0.192	14.0	15.4	0.09	0.6914	6.953
	1975										
4.	January	8.1	0.29	1.595	0.067	2.141	21.4	17.6	0.1176	1.541	10.55
5.	February	8.4	0.41	0.1422	0.103	4.012	28.0	20.0	0.2016	1.927	11.54
6.	March	8.5	0.23	1.265	0.1403	3.72	15.0	25.0	0.1162	2.1577	18.568
7.	April	8.3	0.23	0.112	0.042	0.681	23.0	26.0	0.0228	0.395	14.100
8.	May	8.2	0.28	0.134	0.1769	1.821	11.5	21.0	0.966	1.056	10.93
9.	June	8.4	0.28	0.1124	0.0732	1.51	25.0	17.0	0.0252	0.6676	26.49
10.	July	8.2	0.4	0.22	0.487	1.65	25.5	14.0	0.0784	0.8497	27.58
11.	August	8.2	0.2	0.105	0.124	0.619	18.5	14.2	0.0308	0.359	11.65
12.	September	8.5	0.23	0.1265	80.271	1.06	9.7	13.5	0.0406	0.614	15.12
13.	October	8.5	0.45	0.2425	0.301	1.01	13.5	23.00	0.068	0.5858	8.614
14.	November	8.6	0.26	0.091	0.429	2.12	22.5	55.0	0.186	1.2296	6.61
15.	December	8.8	0.22	0.077	0.121	2.147	27.5	44.0	0.241	1.245	5.165
	1976										
16.	January	8.3	0.32	0.112	0.213	2.74	12.5	19.5	0.261	1.5893	6.089
17.	February	8.1	0.42	0.147	0.035	3.7	18.0	23.0	0.2915	2.146	7.364
18.	March	8.4	0.28	0.098	0.318	1.8	21.0	33.5	0.1247	1.044	8.372
19.	April	8.4	0.23	0.0805	0.289	1.3	24.0	25.5	0.082	0.154	9.195
20.	May	8.1	0.22	0.077	0.092	3.61	11.5	21.5	0.0251	1.0939	43.73
21.	June	8.1	0.2	0.07	0.103	1.385	19.0	18.5	0.0641	0.8033	12.531

Table IX. Monthly values of physico-chemical parameters of bottom sediments at Station II in Gadigarh stream.

S.No.	Period	pH	Conductivity μ mho per cm	Total soluble salts (%)	Bi-carbonates (%)	Organic matter (%)	Available potassium (ppm)	Available phosphates (ppm)	Total nitrogen (%)	Organic carbon (%)	C : N
	1974										
1.	October	8.0	0.4	0.22	0.3037	1.07	12.2	11.5	0.0658	0.6206	9.431
2.	November	8.6	0.13	0.071	0.0366	1.14	20.0	6.0	0.0756	0.6612	8.74
3.	December	8.2	0.22	0.1121	0.1037	1.421	10.5	11.5	0.0602	0.8242	13.691
	1975										
4.	January	8.5	0.32	0.176	0.048	0.143	16.0	14.5	0.0028	0.0829	29.6
5.	February	8.2	0.22	0.182	0.1037	2.14	17.5	15.0	0.1596	1.2412	7.776
6.	March	8.3	0.22	0.146	0.1281	1.031	28.0	21.0	0.0308	0.598	19.415
7.	April	8.5	0.46	0.253	0.0732	1.821	21.0	18.0	0.0546	1.056	19.34
8.	May	8.1	0.12	0.066	0.1647	1.231	21.0	28.0	0.0448	0.714	15.937
9.	June	8.5	0.46	0.241	0.0427	1.231	22.5	27.0	0.0378	0.714	18.80
10.	July	8.3	0.21	0.1155	0.217	2.84	19.5	27.0	0.147	1.6473	11.206
11.	August	8.5	0.22	0.121	0.221	4.271	13.5	12.4	0.090	2.4773	9.917
12.	September	8.6	0.23	0.1265	0.236	1.06	10.5	9.5	0.0658	0.6148	6.273
13.	October	8.6	0.4	0.22	0.428	1.81	18.5	11.5	0.0941	1.0498	15.954
14.	November	8.1	0.23	0.0805	0.024	2.147	20.0	17.0	0.0984	1.245	13.23
15.	December	8.3	0.28	0.098	0.251	2.749	41.5	55.0	0.1471	1.594	16.199
	1976										
16.	January	8.1	0.14	0.049	0.129	1.89	21.5	10.5	0.2478	1.0962	7.452
17.	February	8.1	0.23	0.0809	0.109	2.96	21.0	14.5	0.213	1.7169	9.06
18.	March	8.6	0.24	0.084	0.374	1.2	34.0	31.5	0.114	0.696	6.1052
19.	April	8.4	0.40	0.14	0.239	1.26	55.0	46.0	0.0721	0.7308	10.135
20.	May	8.5	0.40	0.14	0.389	2.641	19.5	28.0	0.024	1.2319	51.329
21.	June	8.2	0.22	0.077	0.154	2.641	21.5	34.5	0.0561	1.5319	29.403

Table X. Monthly values of physico-chemical parameters of bottom sediments at Station III in Gadigarh stream.

S.No.	Period	pH	Conductivity μ mho per cm	Total soluble salts (%)	Bi-carbonates (%)	Organic matter (%)	Available potassium (ppm)	Available phosphates (ppm)	Total nitrogen (%)	Organic carbon (%)	C : N
	1974										
1.	October	8.4	0.26	1.43	0.2732	2.612	12.0	9.2	0.1848	1.515	8.198
2.	November	8.3	0.55	0.3025	0.0366	4.2	18.0	17.5	0.1568	2.4361	15.53
3.	December	8.1	0.12	0.066	0.1037	1.231	24.0	15.0	0.0578	0.714	12.35
	1975										
4.	January	8.4	0.46	0.253	0.0366	1.01	21.5	14.5	0.0168	0.5858	34.86
5.	February	8.3	0.32	0.176	0.1281	3.01	15.5	12.0	0.147	1.745	11.87
6.	March	8.5	0.30	0.165	0.1159	1.091	16.0	26.0	0.952	0.6328	6.647
7.	April	8.1	0.40	0.221	0.0671	1.245	23.5	27.0	0.0672	0.7221	10.745
8.	May	8.1	0.22	0.121	0.1281	2.37	14.0	10.5	0.0433	1.374	31.658
9.	June	8.4	0.23	0.1265	0.0427	2.653	16.5	16.0	0.1876	1.538	8.198
10.	July	8.2	0.24	0.132	0.216	2.258	46.0	28.0	0.1624	1.309	8.06
11.	August	8.5	0.34	0.242	0.147	4.01	27.25	25.5	0.2576	2.325	9.025
12.	September	8.6	0.23	0.1126	0.189	1.81	12.2	18.25	0.0476	1.098	22.054
13.	October	8.4	0.26	0.165	0.041	1.31	12.5	8.5	0.0923	0.759	8.241
14.	November	8.1	0.28	0.098	0.201	3.01	20.0	12.0	0.117	1.745	14.924
15.	December	8.6	0.24	0.084	0.212	3.641	13.5	12.0	0.0671	2.111	31.46
	1976										
16.	January	8.3	0.12	0.042	0.138	2.797	33.5	29.5	0.0841	1.627	19.286
17.	February	8.3	0.42	0.147	0.129	4.549	21.5	28.5	0.1813	2.638	14.55
18.	March	8.1	0.42	0.147	0.091	2.17	35.5	30.0	0.0942	1.258	13.354
19.	April	8.2	0.36	0.126	0.24	2.56	63.0	44.5	0.451	1.484	32.904
20.	May	8.5	0.32	0.112	0.226	3.74	18.5	25.0	0.2212	2.169	9.8
21.	June	8.4	0.24	0.0875	0.085	4.14	19.0	15.5	0.0443	2.401	54.19

Table XI. Monthly values of physico-chemical parameters of bottom sediments at Station IV in Gadigarh stream.

S.No.	Period	pH	Conductivity μ mho per cm	Total soluble salts (%)	Bi-carbonates (%)	Organic matter (%)	Available potassium (ppm)	Available phosphates (ppm)	Total nitrogen (%)	Organic carbon (%)	C : N
	1974										
1.	October	8.1	0.4	0.23	0.422	1.42	13.5	4.5	0.0728	8.23	11.304
2.	November	8.2	0.21	0.1155	0.1037	1.845	14.0	18.2	0.0756	1.0701	14.154
3.	December	8.7	0.15	0.0825	0.0854	1.263	12.0	20.0	0.0896	0.732	8.169
	1975										
4.	January	8.5	0.88	0.484	0.0429	1.368	18.5	16.0	0.0196	0.7935	40.48
5.	February	8.5	0.3	0.165	0.1281	1.217	24.0	14.5	0.0336	0.7059	21.008
6.	March	8.2	0.2	0.110	0.1037	4.26	21.0	28.0	0.2968	2.47	8.3221
7.	April	8.5	0.3	0.164	0.1281	3.027	13.5	11.5	0.1168	1.7558	11.197
8.	May	8.5	0.26	0.143	0.0854	1.051	12.7	16.2	0.0574	0.6096	10.62
9.	June	8.2	0.26	0.143	0.244	3.12	21.2	14.5	0.2296	1.8097	7.881
10.	July	8.4	0.41	0.2255	0.481	2.468	36.5	27.0	0.1234	1.4315	11.60
11.	August	8.6	0.23	0.1265	0.321	1.24	31.5	23.0	0.672	0.719	10.699
12.	September	8.1	0.2	0.115	0.214	2.417	14.5	10.0	0.1778	1.4019	7.884
13.	October	8.1	0.4	0.235	0.281	2.14	27.5	24.5	0.0843	1.2412	14.723
14.	November	8.6	0.42	0.147	0.429	2.74	21.5	10.5	0.134	1.5893	11.860
15.	December	8.1	0.12	0.042	0.184	4.597	15.5	12.5	0.101	2.666	26.396
	1976										
16.	January	8.5	0.40	0.14	0.246	3.17	14.5	21.5	0.0938	1.838	19.59
17.	February	8.5	0.28	0.094	0.283	2.727	26.5	32.0	0.0821	1.3178	16.05
18.	March	8.2	0.42	0.147	0.127	2.31	24.5	26.5	0.1092	1.359	12.273
19.	April	8.2	0.26	0.091	0.138	1.76	37.5	32.5	0.0643	1.02	15.863
20.	May	8.4	0.26	0.091	0.318	2.10	18.0	26.0	0.0257	1.218	48.72
21.	June	8.1	0.12	0.042	0.124	4.14	18.0	21.5	0.0821	2.401	29.244

Table XII. Monthly values of physico-chemical parameters of bottom sediments at Station V in Gadigarh stream.

S.No.	Period	pH	Conductivity µ mho per cm	Total soluble salts (%)	Bi-carbonates (%)	Organic matter (%)	Available potassium (ppm)	Available phosphates (ppm)	Total nitrogen (%)	Organic carbon (%)	C : N
	1974										
1.	October	8.3	0.23	0.0775	0.2793	1.12	9.5	18.5	0.1008	0.6496	6.44
2.	November	8.6	0.13	0.0455	0.854	0.621	20.0	12.0	0.0308	0.360	11.6
3.	December	8.1	0.23	0.0805	0.0732	3.299	24.0	15.0	0.1498	1.913	12.77
	1975										
4.	January	8.3	0.23	0.0846	0.0427	1.368	32.0	27.0	0.0476	0.7935	16.67
5.	February	8.5	0.3	0.105	0.1464	3.191	6.0	10.0	0.114	1.85	16.114
6.	March	8.1	0.28	0.098	0.0854	2.14	20.0	35.0	0.1596	1.241	7.775
7.	April	8.3	0.54	0.189	0.1403	1.243	10.5	14.0	0.067	0.720	11.450
8.	May	8.1	0.40	0.140	0.1037	0.964	22.00	50.0	0.0168	0.5591	33.2797
9.	June	8.3	0.66	0.231	0.426	1.26	14.5	18.0	0.0518	0.730	14.092
10.	July	8.3	0.28	0.098	0.136	2.66	78.0	62.0	0.1834	1.5475	8.43
11.	August	8.6	0.25	0.192	0.167	1.212	13.5	23.0	0.0616	0.703	11.412
12.	September	8.7	0.15	0.0875	0.431	2.472	13.0	15.5	0.1736	1.4338	8.2592
13.	October	8.3	0.23	0.0805	0.293	1.12	12.4	7.0	0.1041	0.6496	6.2401
14.	November	8.1	0.42	0.147	0.0349	2.01	13.5	23.5	0.0843	1.1658	13.829
15.	December	8.1	0.66	0.231	0.081	1.46	18.5	21.5	0.1291	0.8468	6.559
	1976										
16.	January	8.6	0.24	0.084	0.189	1.79	27.0	24.5	0.0209	1.0382	49.67
17.	February	8.2	0.40	0.14	0.0427	2.54	12.5	10.5	0.127	1.484	11.685
18.	March	8.5	0.32	0.112	0.172	1.477	21.5	36.0	0.271	0.8567	3.161
19.	April	8.3	0.12	0.042	0.128	0.8	18.0	25.5	0.104	0.464	4.461
20.	May	8.3	0.24	0.084	0.108	2.34	34.5	53.0	0.0564	1.3573	24.065
21.	June	8.3	0.22	0.077	0.0461	1.92	8.5	13.5	0.0821	1.113	13.55

Table XIII. Monthly values of physico-chemical parameters of bottom sediments at Station VII in Gadigarh stream.

S.No.	Period	pH	Conductivity μ mho per cm	Total soluble salts (%)	Bi-carbonates (%)	Organic matter (%)	Available potassium (ppm)	Available phosphates (ppm)	Total nitrogen (%)	Organic carbon (%)	C : N
	1974										
1.	October	8.5	0.25	0.0875	0.2549	1.821	32.5	22.25	0.0686	1.0562	15.39
2.	November	8.5	0.25	0.0785	0.0793	3.681	44.5	50.0	0.1162	2.135	18.373
3.	December	8.4	0.51	0.1785	0.0671	1.681	27.0	20.0	0.0336	0.975	29.017
	1975										
4.	January	8.2	0.23	0.0805	0.0732	1.271	50.0	89.0	0.0588	0.737	12.534
5.	February	8.4	0.58	0.203	0.1586	2.757	31.0	18.8	0.175	1.599	9.137
6.	March	8.1	0.12	0.03	0.0549	1.18	14.5	17.5	0.091	0.684	7.516
7.	April	8.6	0.28	0.098	0.2074	1.687	55.0	49.0	0.0896	0.978	10.915
8.	May	8.5	0.25	0.091	0.0488	1.21	24.0	35.0	0.0196	0.701	35.765
9.	June	8.2	0.42	0.147	0.269	1.46	40.0	27.0	0.0644	0.664	10.31
10.	July	8.6	0.28	0.0965	0.129	0.728	63.0	46.0	0.0168	0.4222	25.1309
11.	August	8.4	0.25	0.0785	0.167	1.01	7.25	9.0	0.1218	0.5858	4.8095
12.	September	8.45	0.17	0.0595	0.174	4.74	39.2	29.0	0.3696	2.749	7.4377
13.	October	8.5	0.25	0.0785	0.391	2.37	36.5	27.0	0.249	1.3747	5.520
14.	November	8.6	0.28	0.098	0.272	3.157	46.0	28.0	0.1411	1.831	12.9766
15.	December	8.1	0.40	0.14	0.154	4.301	33.5	23.5	0.0472	2.494	52.83
	1976										
16.	January	8.3	0.28	0.098	0.249	2.41	39.0	49.5	0.127	1.397	11.0
17.	February	8.5	0.12	0.042	0.051	4.415	34.0	24.5	0.237	2.560	10.8
18.	March	8.2	0.44	0.154	0.245	2.1	11.5	6.0	0.191	1.218	6.376
19.	April	8.2	0.64	0.224	0.059	2.18	42.5	63.5	0.0471	1.2645	26.845
20.	May	8.1	0.23	0.0805	0.241	1.385	36.5	24.0	0.139	0.8033	5.77
21.	June	8.7	0.34	0.119	0.0856	2.182	18.25	23.5	0.098	1.2656	12.91

Table XIV. Average of available phosphate contents during different seasons at Stations I - VII in Gadigarh stream.

Station	Season				
	Winter		summer		Monsoon
	1974-75	1975-76	1975	1976	1975
I	24.2	31.0	22.2	24.7	14.0
II	11.7	21.7	23.5	34.9	16.1
III	13.6	18.0	15.0	29.0	24.0
IV	14.6	20.0	17.5	25.5	20.0
V	16.5	17.3	29.2	32.0	30.0
VII	40.0	31.3	32.1	17.7	28.0

Table XV. Average total nitrogen content during different seasons at Stations I - VII in Gadigarh stream.

Station	Season				
	Winter		Summer		Monsoon
	1974-75	1975-76	1975	1976	1975
I	0.0958	0.2295	0.0575	0.0764	0.0438
II	0.0728	0.124	0.042	0.067	0.0852
III	0.113	0.108	0.098	0.1012	0.1638
IV	0.0582	0.099	0.2001	0.0703	0.1495
V	0.0887	0.113	0.0606	0.074	0.1176
VII	0.0904	0.1602	0.0661	0.1185	0.1432

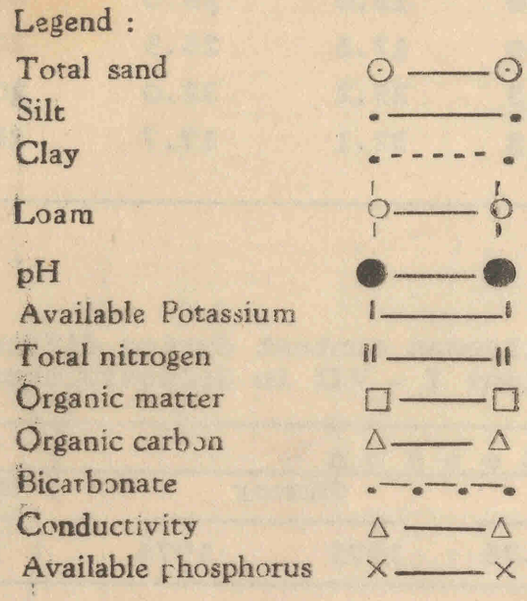


Fig. 9. Seasonal changes in physico-chemical parameters of bottom soil at Station No. I during October, 1974 to June, 1976.

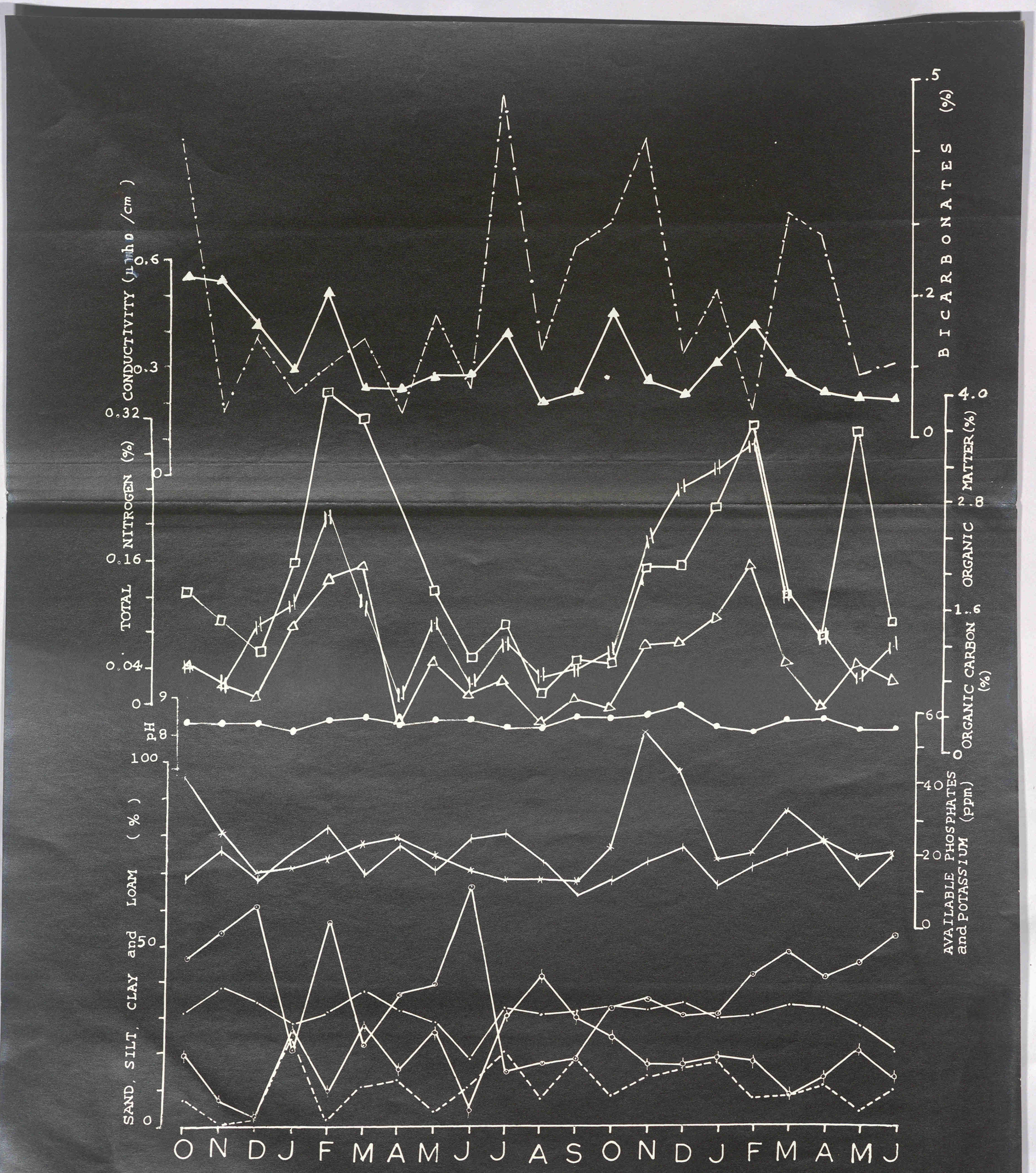

CONDUCTIVITY (µmho /cm)
0.6
0.3
0
BICARBONATES (%)
.5
.2
0
TOTAL NITROGEN (%)
0.32
0.16
0
ORGANIC MATTER (%)
4.0
2.8
1.6
0
pH
9
8
SAND, SILT, CLAY and LOAM (%)
100
50
0
AVAILABLE PHOSPHATES and POTASSIUM (ppm)
60
40
20
0
ORGANIC CARBON (%)
O N D J F M A M J J A S O N D J F M A M J

FIG. 9

Fig. 9

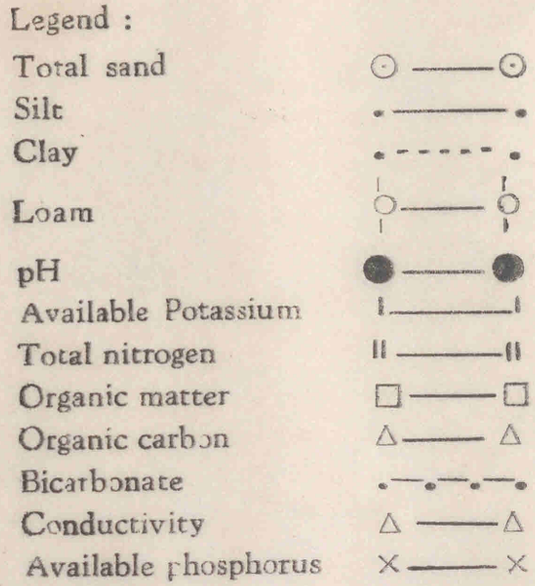


Fig. 10. Seasonal changes in physico-chemical parameters of bottom soil at Station No. II during October, 1974 to June, 1976.

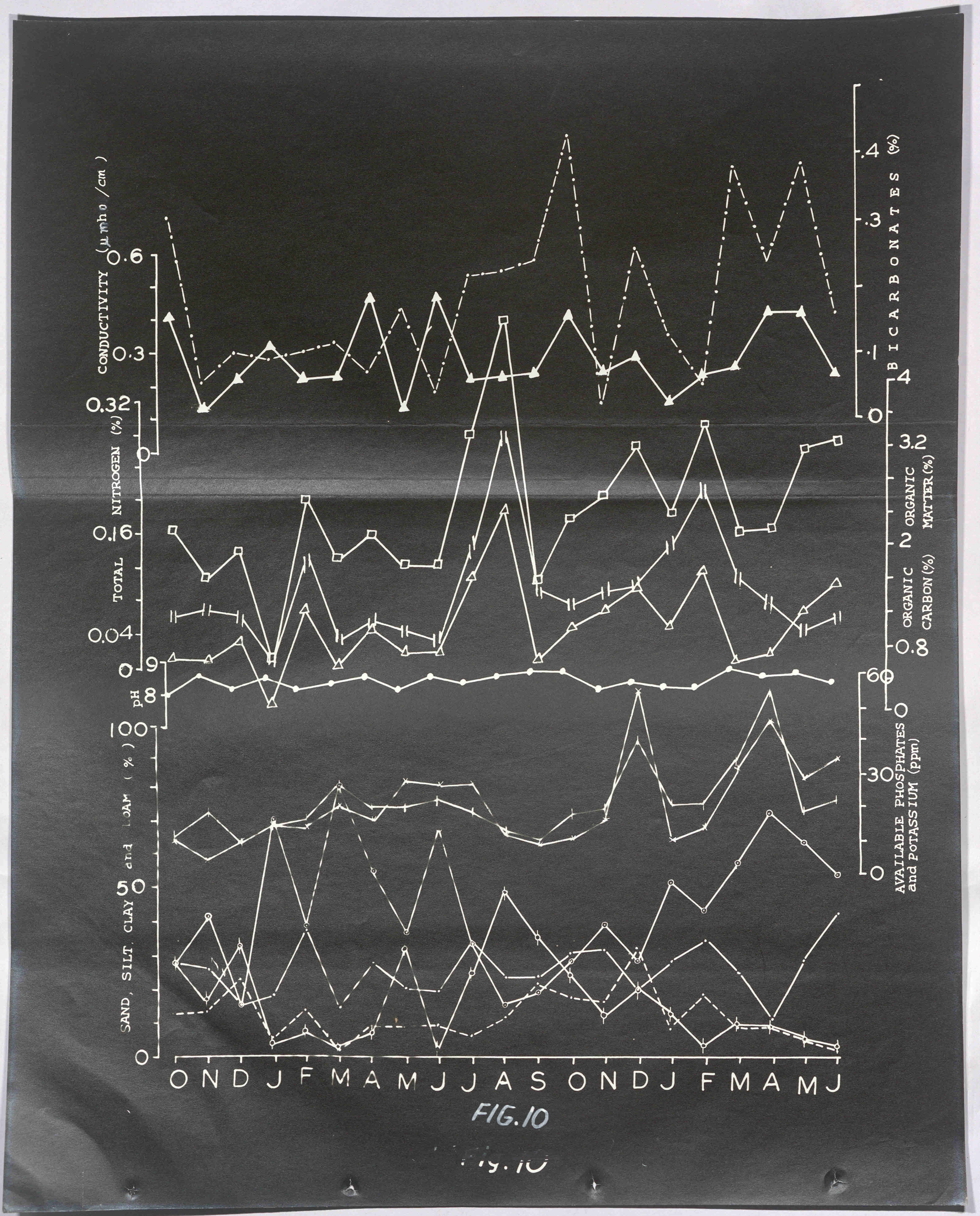

CONDUCTIVITY (µmho/cm)
0.6
0.3
0
TOTAL NITROGEN (%)
0.32
0.16
0
0.04
pH
9
8
SAND, SILT, CLAY and LOAM (%)
100
50
0
BICARBONATES (%)
.4
.3
.2
0
ORGANIC CARBON (%)
2
0
ORGANIC MATTER (%)
3.2
0.8
AVAILABLE PHOSPHATES and POTASSIUM (ppm)
60
30
0
O N D J F M A M J J A S O N D J F M A M J

FIG.10

Fig.10

Legend :

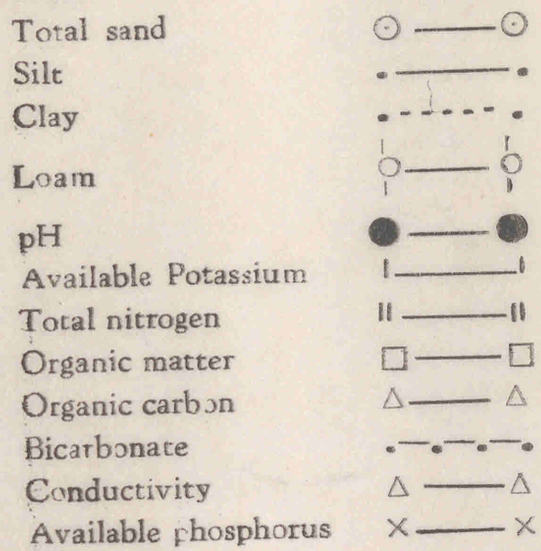


Fig. II. Seasonal changes in physico-chemical parameters of bottom soil at Station No. III during October, 1974 to June, 1976.

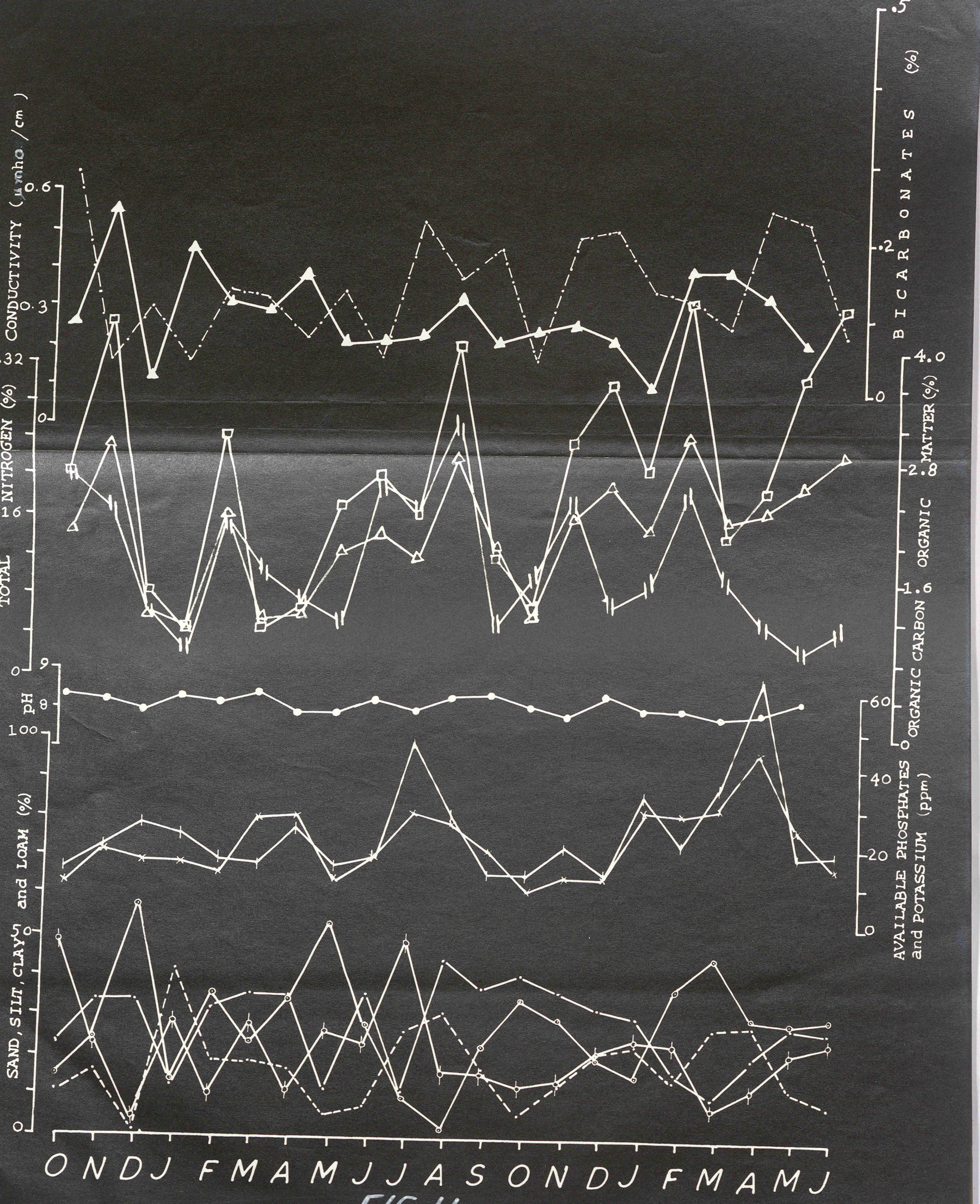

CONDUCTIVITY (µmho /cm)
0.6
0.3
0
TOTAL NITROGEN (%)
0.32
0.16
0
pH
9
8
SAND, SILT, CLAY & LOAM (%)
100
50
0
BICARBONATES (%)
5
2
0
ORGANIC MATTER (%)
4.0
2.8
1.6
0
AVAILABLE PHOSPHATES and POTASSIUM (ppm)
60
40
20
0
ORGANIC CARBON
O N D J F M A M J J A S O N D J F M A M J

FIG. 11

Fig. 11

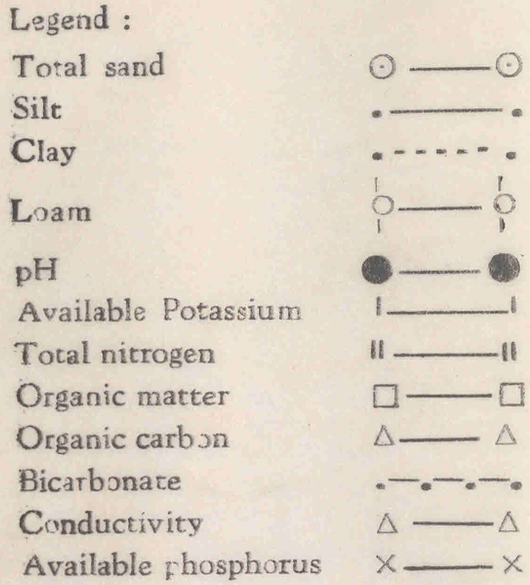


Fig. 12. Seasonal changes in physico-chemical parameters of bottom soil at Station No. IV during October, 1974 to June, 1976.

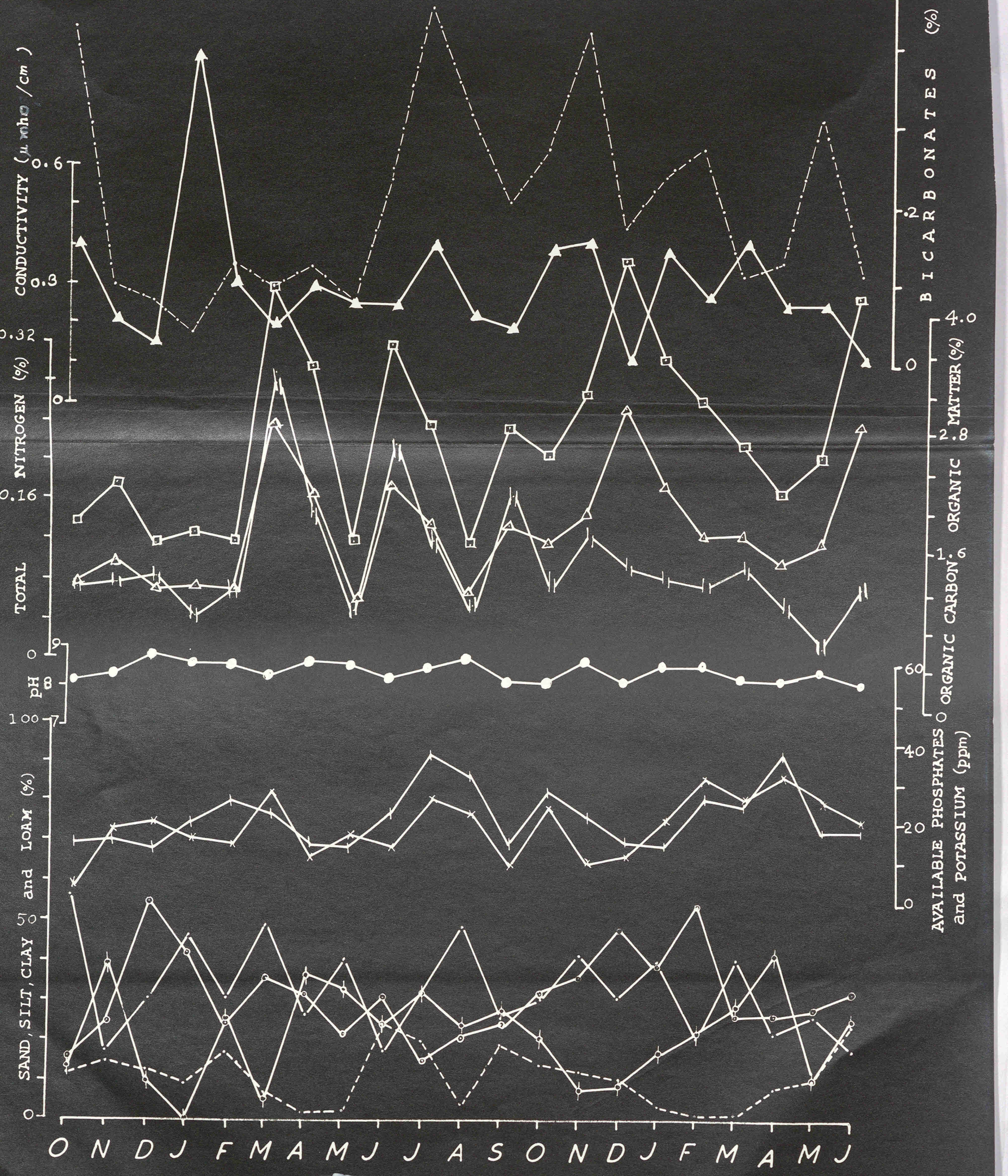

CONDUCTIVITY (μ mho /cm)
0.6
0.3
0
TOTAL NITROGEN (%)
0.32
0.16
0
pH
9
8
7
SAND, SILT, CLAY and LOAM (%)
100
0
BICARBONATES (%)
.5
0
ORGANIC MATTER (%)
4.0
2.8
1.6
0
AVAILABLE PHOSPHATES and POTASSIUM (ppm)
60
40
20
0
ORGANIC C
O N D J F M A M J J A S O N D J F M A M J

FIG. 12

Fig. 12

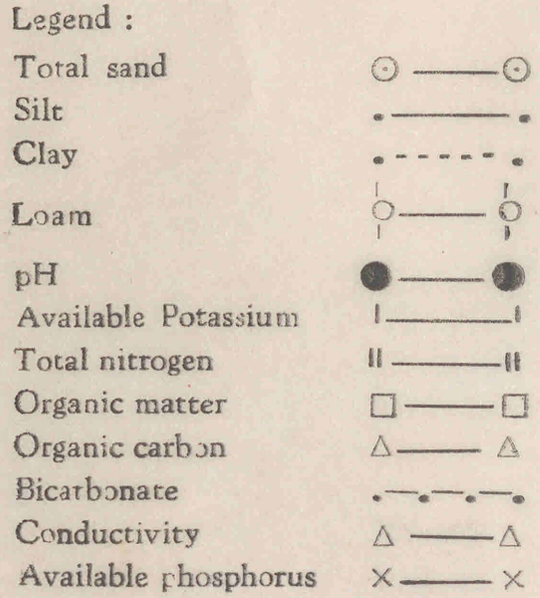


Fig. 13. Seasonal changes in physico-chemical parameters of bottom soil at Station No. V during October, 1974 to June, 1976.

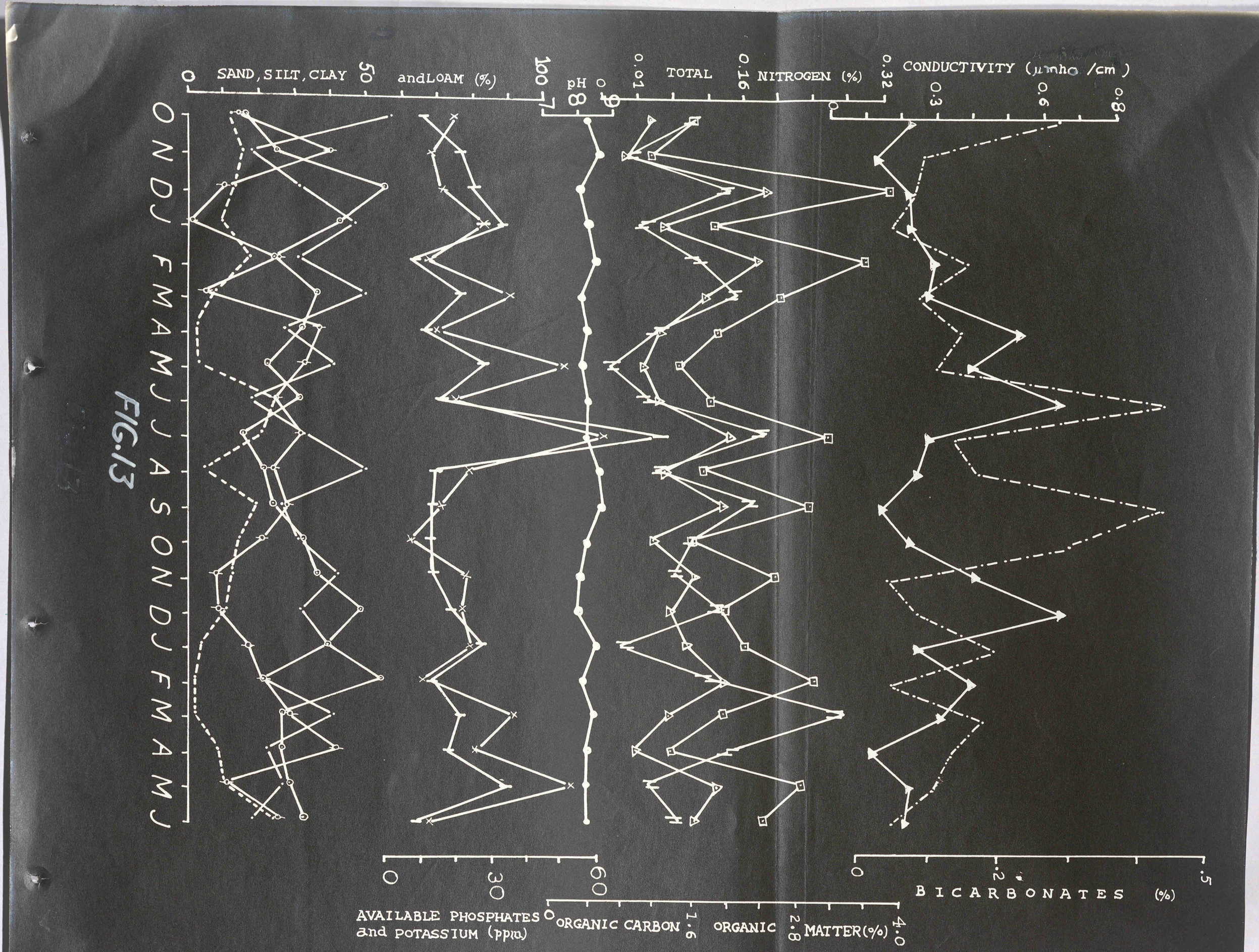

SAND, SILT, CLAY and LOAM (%)
0
50
100
pH
7
8
9
TOTAL NITROGEN (%)
0.01
0.16
0.32
CONDUCTIVITY (µmho /cm)
0.3
0.6
0.8
O N D J F M A M J J A S O N D J F M A M J J
AVAILABLE PHOSPHATES and POTASSIUM (ppm)
0
30
60
ORGANIC CARBON
0
1.6
ORGANIC MATTER (%)
2.8
4.0
BICARBONATES (%)
0
.2
.5

FIG. 13

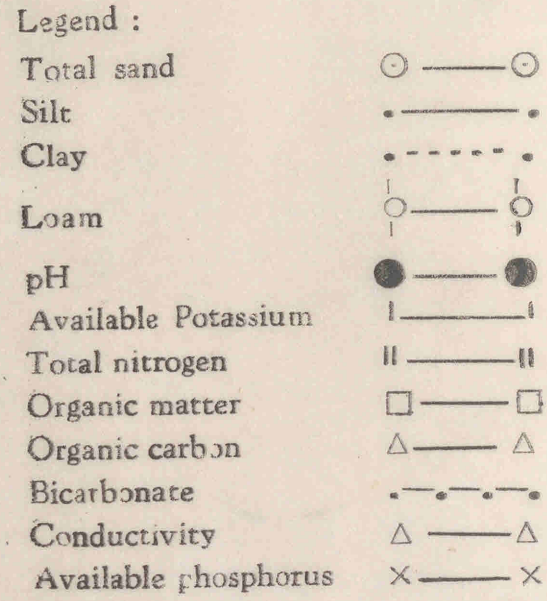


Fig. 14. Seasonal changes in physico-chemical parameters of bottom soil at Station No. VII during October, 1974 to June, 1976.

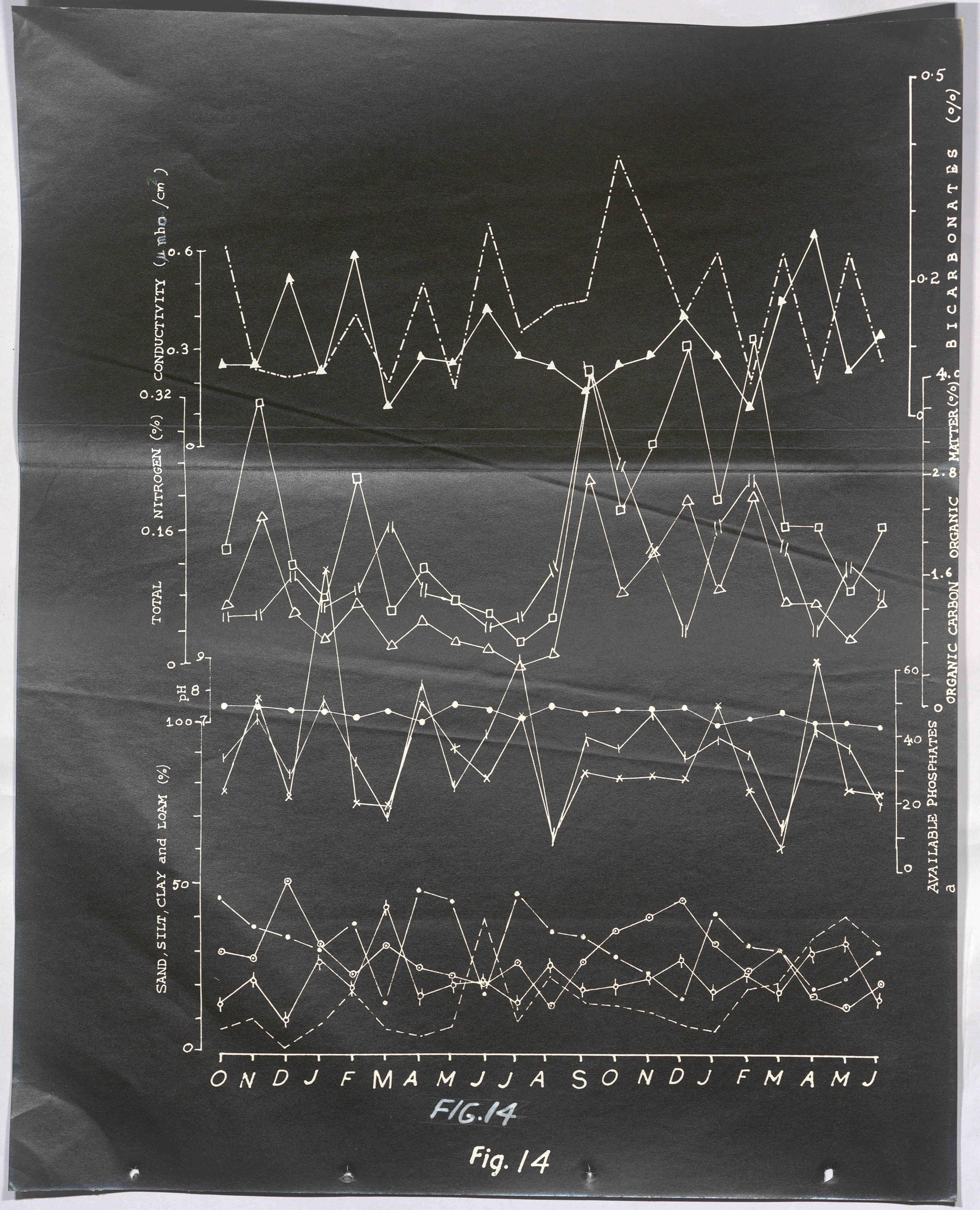

SAND, SILT, CLAY and LOAM (%)
0
50
pH
9
8
7
TOTAL NITROGEN (%)
0.32
0.16
0
CONDUCTIVITY (μ mho /cm)
0.6
0.3
0
AVAILABLE PHOSPHATES
60
40
20
0
ORGANIC CARBON & ORGANIC MATTER (%)
4
2.8
1.6
BICARBONATES (%)
0.5
0.2
O N D J F M A M J J A S O N D J F M A M J

FIG.14

Fig. 14

B. WATER

1. Physical:

1.1. Depth: Study on this parameter of the stream has been carried out from September, 1974 to March, 1976. During this one and half year period, it has been observed that the water flow increased and the stream got fully swollen only during the rainy season lasting a little over two months (July - August and a part of September). The stream attained maximum depth in the month of July at all stations (Figs. 15 - 21) except I, II and VII.

Comparative study of the various stations raised along the stream has revealed a great seasonal variation in depth at Station I. The change in depth was more prominent after the heavy monsoons of 1975 which caused heavy soil erosion and reduced the depth.

Minor variations in depth recorded during the months other than July and August are caused by the inflow of water from adjoining fields, entry of Ranbir canal distributaries and change in the number and rate of flow of the subterranean source springs.

1.2. Transparency: Transparency is a measure of light penetration in water and in lotic waters is affected mostly by such inorganic suspended matter as sand, silt and clay. At Gadigarh, the minimum transparency has been recorded during the month of July when monsoon rains are at the peak (Tables XXVI - XXXII; Figs. 15-21). Although the area also receives winter rains from December to March, yet the quantity and the speed of the down pour is insufficient to cause any substantial erosion with the result that the transparency of the stream is not impaired significantly. Slight loss in the transparency of Gadigarh stream observed in seasons other than rains is caused collectively by the inflow of turbid waters from the Ranbir canal and biological disturbances caused by bathing of animals, anglers and poachers etc.

1.3. Suspended matter: Analysis of the suspended matter of stream waters has revealed its maximum value (283 mg per liter) in July, at Station III and minimum (10 mg per liter) at Stations IV in April, 1975. Comparative data on suspended matter at different stations along the stream have been summarized in the Table XVI.

Tables XXVI - XXXII; Figs. 15 - 21 indicate that maximum suspended matter appeared in the

Table XVI. Details of suspended matter at different stations in Gadigarh stream.

Station	Suspended matter mg/lit	
	Min.	Max.
I	13.0	234.0
II	12.0	249.0
III	11.0	264.0
IV	10.0	232.0
V	12.0	262.0
VI	14.0	232.0
VII	13.0	283.0

stream water during monsoon rains (June - August) with the peak reaching in July at all stations. Similar correlation between suspended matter and incessant rains has also been recorded by Chakrabarty et al.(1959), Reed (1962), Verma and Shukla (1967), and Jhingran(1975).

Compared to monsoon, winter rains are not of much consequence in causing any prominent change in suspended matter of the stream. This is either because the winter rains are scanty or that the vegetation which is dense in winter months keeps the soil bound and does not permit it to get washed away with water.

The suspended matter present in water during the remaining period has its source in, (i) the inflowing waters from Ranbir canal, (ii) agitation of bottom sediments by movement of water or biotic interference, and (iii) fluctuations in planktonic populations.

1.4. Temperature: The temperature of water and atmosphere at Gadigarh stream show great seasonal fluctuations. Maximum air temperature of 41.0°C has been recorded at Stations IV and V during May, 1975. Minimum air temperature recorded is 14.5°C at Station III during December, 1974 and at Station II during February, 1976. Water registered maximum temperature of 32.35°C and minimum temperature of 14.65°C in the month of June, 1975 and January, 1976 at Stations V and IV respectively. Comparative figures for air and water temperature at different stations of the stream have been tabulated in the following table.

Table XVII. Temperature index* of the Stations I - VII of Gadigarh stream.

Station	Temperature C°			
	Water		Atmospheric	
	Min.	Max.	Min.	Max.
I	16.0	29.5	15.0	39.0
II	16.5	28.0	14.5	39.0
III	15.9	30.5	14.5	38.5
IV	14.65	31.45	15.0	41.0
V	14.85	32.35	16.3	41.0
VI	15.1	31.65	16.5	37.9
VII	15.0	31.0	17.5	40.5

*Temperature index is the maximum and minimum recorded value over the year at any given station.

Present observations have revealed that the water temperature follows air temperature almost all the year round. Slight variations have,

however, been noticed during certain months. The positive correlation between air and water temperature is attributed to slow movement of stream water. During the lean period the adjoining stations become almost cut off from one another (Stations I and II in May, 1975, Fig. 30) and in this way simulate lentic water conditions.

Along Gadigarh stream both atmospheric and water temperatures indicated a decline from September to November, 1974. In the corresponding months in other years too, a similar decline was observed both in water and atmospheric temperatures. October, 1975 was, however, exceptional during which month water temperature registered a unexplainable increase at Stations I, III and VI. Temperature variability observed during the months of December, January and February is possibly induced by chilly winter of the area.

During winter months (December, 1974, January and Feb. 1975, and February, 1976) the water temperature during the day has been observed to exceed the atmospheric temperature at some stations. This situation was more frequent at Stations I, II and III where it can be attributed to the presence of

subterranean springs, either at stations I and II or in the intermediate segments of stations II and III. A similar correlation between air and water temperature for a spring water was recorded by Macan (1963). Temperature stability was even enforced by the variant morphic conditions at Station II. The station is protected from the eastern and western sides by mud embankments (Fig. 31 A, B) and on the northern side by aquatic vegetation. It is therefore, exposed by only on the southern side for wind action, which could cause temperature fluctuations.

A gradual rise in atmospheric and water temperature was observed from February to May (Tables XXVI - XXXII; Figs. 15 - 21) perhaps on account of increased solar radiation due to comparatively longer day length. Temperature fluctuations observed in the months of July and August are caused by active monsoon in the area.

Wide temperature variations (between minimum and maximum observed throughout the study) at stations other than I and II are due to the absence or paucity of source springs and other topographic conditions. It could further be argued that shallowness of the stream segments connecting

nearby stations also contributes to temperature variations; these parts are exposed to prompt heating and cooling caused by weather conditions.

The maximum water temperature recorded at Station V is in all probability due to complete absence of source springs and comparatively exposed morphic conditions.

2. Chemical:

2.1. Dissolved oxygen: Perusal of Tables XXXIII - XXIX; Figs. 22 - 28 reveals seasonal fluctuations of dissolved oxygen at all the seven stations recognized along the whole length of the stream. 11.10 mg per liter is the seasonal maximum recorded value (in February, 1976 at Station VI) and 1.92 mg per liter is the seasonal minimum recorded value (in June, 1975 at Station I) in the stream. The minimum and maximum values of oxygen concentration vary a good deal during different seasons at different stations and are tabulated in the Table XVIII.

A bimodal rise in dissolved oxygen content is observed at most of the study stations (Figs. 22 - 28). The first annual rise in 1974 extended

from September to December. The second rise was prevalent during February to April in 1975 and February to March in 1976 (variations marked here and there were rather insignificant).

Table XVIII. Minimum and maximum concentration of dissolved oxygen at different stations.

Station	Dissolved O_2 mg/lit	
	Min.	Max.
I	1.92	7.88
II	2.64	7.65
III	2.93	9.03
IV	3.16	8.88
V	3.60	9.50
VI	3.20	11.10
VII	2.80	9.50

The first annual rise observed during the two years may be related to post-monsoon algal growth in the stream. Butcher et al. (1930) pointed out that oxygen produced by algae goes into solution more rapidly than the oxygen produced by macrophytes, because most of the oxygen produced by macrophytes is lost from the water through bubbling. Biological demand for oxygen is also reduced during these months because of the considerable decline in the number of aquatic animals during monsoon, and due to the reduced decomposition of detritus.

Second rise in oxygen concentration observed from February to April, at one or the other station may be induced by increased density of algae and macrophytes (at some stations and at the intermediate segments connecting them, algal growth was great reaching even upto the bottom of the stream). Welch, (1952) and Ganning, (1971) state that the amount of oxygen derived from plants depends upon the density of latter in a given area and the duration of effective light, therein. The study of present stream has revealed that biological oxygen demand during February to April is comparatively higher since plankton (Tables IIIL - LIII; Figs. 41 - 47) and nekton are both available in plenty. Despite this demand the value of dissolved oxygen concentration is quite high which suggests that oxygen is produced in very large quantities during this period. The higher concentration may also be due to prevalence of the optimum temperature which favours retention of oxygen by water.

A decrease in oxygen concentration recorded at most of the stations during May and June, 1975 (except at Stations IV and VII in June) may be due to reduced vegetation and higher consumption by decomposing detritus; as also pointed out earlier by

Schneller (1955), Slack (1955), Chase and Ferullo (1958), and Hynes (1960). Higher temperature of May and June (hottest months) may also contribute to impoverished oxygen content observed in the stream, when the decomposition of organic matter is accelerated (Macan, 1963). Moreover, higher temperatures significantly lower the oxygen retention capatity of water (Welch, 1952 and Verma and Shukla, 1970). Reduced photosynthesis on account of increase in suspended matter due to rains, as observed in second fortnight of June may yet be another factor responsible for lowering of oxygen tension in the stream water. A similar decrease of oxygen observed in July at all stations (except at Stations I - III) may be due to heavy monsoon whereas photosynthesis is interfered by turbid water as has also been reported earlier by Chakrabarty et al. (1959), Pahwa and Mehrotra (1966) and Ray et al. (1966). Decreased photosynthesis caused by reduction in light hours leads to lower oxygen concentration as observed during December, 1974 and January, 1975 at all stations (except at Stations V - VII) and in January, 1976 (except stations V and VI).

Compared to all other stations, the difference between maximum and minimum values of

oxygen (as observed at different stations) is least at Station II which may be due to inflow of spring water at this station; and may also be furthered by raised embankments preventing agitation of water by winds. Similar cases of lowering of oxygen by mixing of spring waters has been made by Ganapati (1943), and Welch (1952).

2.2. Free carbon dioxide: During the course of present investigations, carbon dioxide concentration has been observed to exhibit great variation at different stations along the stream (Tables XXXIII - XXXIX; Figs. 22 - 28). A minimum value of 2.25 mg per liter of free carbon dioxide in water during April, 1975 has been recorded from Station VI and a maximum of 14.85 mg per liter at Station II in March, 1976.

The values of free carbon dioxide fluctuated as is depicted by the following table.

Table XIX. Minimum and maximum concentration of carbon dioxide at different stations in Gadigarh stream.

Station	CO_2 mg / lit.	
	Min.	Max.
I	4.40	10.26
II	5.50	14.85
III	4.50	13.25
IV	4.00	11.25
V	3.00	10.63
VI	2.25	9.45
VII	3.00	11.45

The enrichment of carbon dioxide in Gadigarh water during February, March 1975 - 1976, and July, August and September, 1975 may be due to the inflow of rain water rich in carbon dioxide. Such an enrichment has earlier been suggested by Chakrabarty et al. (1959), Verma and Shukla (1968), Schwoerbel (1970) and Jhingran (1975). Increase in number and flow of subterranean springs in the stream is another factor responsible for increase of carbon dioxide concentration during and after the rains. Ganapati (1943), Welch (1952), Bombowna (1965) and Schwoerbel (1970) have also reported richness of spring waters in carbon dioxide content. Yet one more contributary factor to higher concentration of carbon dioxide (during February and March) is the increased respiratory activity of zooplankton and nekton which occur in higher number during this period. Increase of carbon dioxide in June, 1975 may be attributed to decomposition of aquatic vegetation and pre-monsoon showers. Such a increase of carbon dioxide in water due to decomposition has been recorded earlier by Welch (1952), Schneller (1955), Slack (1955), and Jhingran (1975).

Moderate carbon dioxide content in water (observed from October to December, 1974; October, 1975 and December 1975 at most of the stations) may be caused by the increased flow of subterranean waters from the springs, which increase during this period.

Carbon dioxide decrease during April, 1975 may be related to increased photosynthesis due to longer days (increased photoperiod) and abundance of aquatic vegetation.

Minimal concentration in the maximum and minimum recorded values of free carbon dioxide at Station VI is attributed to the agitation of water caused by flow from Station V. Earlier Welch (1952) has also suggested that agitation of water reduces carbon dioxide concentration. Similarly highest concentration in the maximal and minimal carbon dioxide observed at Station II may be due to a large number of springs present at this station which add carbon dioxide rich water from soil.

2.3. Bicarbonate: Perusal of Tables XXXIII - XXXIX; Figs. 22 - 28, indicates that like other elements, bicarbonates too undergo great seasonal fluctuations.

A maximum concentration of 442.25 mg per liter in the month of March, 1975 has been recorded from Station I and a minimum of 185.44 mg per liter for Station II in July, 1975. Comparative study of different stations for bicarbonate availability has revealed that the concentration varies from station to station and is summarized in table given below:

Table XX. Minimum and maximum concentration of bicarbonate at different stations in Gadigarh stream.

Station	HCO_3^- mg/lit.	
	Min.	Max.
I	195.20	442.25
II	185.44	381.25
III	231.80	353.80
IV	230.89	381.25
V	230.89	355.50
VI	240.65	353.80
VII	230.89	347.70

Bicarbonate concentration is higher in Gadigarh waters as compared to all other known lotic water bodies in India. The bicarbonate values recorded for River Godavari vary from 0.458 - 1.922 pmm, for River Cauvery 0.0 - 0.24 ppm (Chacko and Srinivasan, 1955) and for River Ganga 72.0 - 212.0 ppm (Ray et al. 1966). Bicarbonate values of Gadigarh waters are even higher than the alkalinity values of 85.0 - 270.0 ppm recorded from River Jamuna (Chakrabarty et al. 1959) and 84.0 - 220.0 ppm in River Gandak (David, 1963).

Filipovic (1966) who conducted limnological investigation of Lisinski potok source area on Kopaonik mountains has recorded bicarbonate concentrations of the magnitude (376.89 - 449.57 mg per liter) estimated in Gadigarh waters.

Higher bicarbonate values in Gadigarh stream can be attributed to subterranean water that oozes from the springs present in the stream bed. Subterranean waters are known to contain larger quantities of bicarbonate as compared to the surface drainage (Welch, 1952; Bombowna, 1965b; Barnes, 1965 and Slack, 1967). The higher bicarbonate concentration in subterranean waters is due to the presence of large quantities of bicarbonates present in the bottom sediments.

Welch (1952) states that water charged with free carbon dioxide is an active agent in converting soil carbonates into bicarbonates. Further, for purposes of the maintenance of stability of bicarbonates, presence of free carbon dioxide is essential (Welch, 1952; Jhingran, 1975). Both diurnal and seasonal studies have revealed constant presence of free carbon dioxide in the stream water which also speaks of the presence of higher bicarbonate.

Seasonal variations in bicarbonate (Tables XXXIII - XXXIX; Figs. 22 - 28) suggests that increase flow of water from stream bed springs result in the increase of bicarbonate concentration (after monsoon) and enrich water with bicarbonates (during and after winter rains) as observed in March, 1975 at all stations (except at Stations III, VI and VII). Bicarbonate may also be released through decomposition of organic matter (Hays and Anthony, 1958) which thus accounts for its slight increment in June, 1975 at Stations I and II. Soil erosion into stream may be yet another cause of increase during monsoon in Gadigarh stream.

Decrease of bicarbonate may be a consequence of increased photosynthesis as suggested by Reid (1961) who stated that phytoplanktonic bloom in sluggish streams after depleting free carbon dioxide, obtain their further supply (of carbon dioxide) from bicarbonates. Such a situation is observed at all stations (except at III and VI) in Gadigarh stream during April, when a decrease in carbon dioxide has also been observed.

Dilution is another factor causing bicarbonate decline (Chakrabarty et al. 1959) and Verma

and Shukla, 1967) and has been observed in Gadigarh stream during July and September, 1975 at most of the stations caused by monsoon; and at all stations (except VI and VII) in May, 1975, and at Stations IV - VII in June, 1975 due to inflow from Ranbir canal distributary.

2.4. Chloride: Present investigations have shown that chloride show a maximum concentration of 21.13 mg per liter at Station V in the month of March, 1976, and a minimum 6.99 mg per liter at Stations II - VII in November, 1974. The exact variability of minimum and maximum concentration of chloride is given in the following table.

Table XXI. Minimum and maximum concentration of chloride at different stations in Gadigarh stream.

Station	$Cl^{'}$ mg/lit.	
	Min.	Max.
I	7.99	16.45
II	6.99	18.48
III	6.99	20.88
IV	6.99	18.48
V	6.99	21.13
VI	6.99	19.48
VII	6.99	16.99

Soil, springs and animal excreta as an important sources of chloride (in a normal water body) have been considered by Ganapati (1942),

Hussainy (1965) and Chanlet (1973). All these sources have also been observed as the main contributors of chloride in Gadigarh stream. Bleaching powder used by poachers accounts for an occasional increase in chloride content of Gadigarh stream, as observed in February, 1976 at Station III (just a month before and after the addition of bleaching powder in the stream, the chloride concentration at this station was as much as recorded at other stations in the stream). Increase of chloride content at Stations II and III observed during December, 1974 and January, 1975, Stations I and III in June, 1975, may similarly be attributed to use of bleaching powder. Springs along the bottom of the stream may also increase the chloride content of water during February and March, 1975.

Biotic disturbances (caused by animals at Station V) may yet be another factor leading to chloride enrichment.

2.5. Water soluble phosphates : Concentration of phosphate in stream water during the present study varied from a maximum of 122.5 µ mg per liter (Station VI in March, 1976) to a minimum of 2.0 µ mg per liter

(at Station VII in October, 1975). Comparative values (minimum and maximum) of water soluble phosphate at various stations have been tabulated in the table given below.

Table XXII. Minimum and maximum values of water soluble phosphate at various stations in Gadigarh stream.

Station	Phosphate µ mg/lit	
	Min.	Max.
I	5.0	60.0
II	7.5	29.0
III	6.5	47.5
IV	4.0	57.5
V	2.5	70.5
VI	2.5	122.5
VII	2.0	40.5

The increase of phosphate at Stations I, III, V and VI in May, 1975 and at Stations I, II and VII in June, 1975 (Tables XXXIII - XXXIX; Figs. 22 - 28) may be due to the liberation of phosphate by decomposition of aquatic vegetation as has also been discussed by Ganapati (1942), Welch (1952), Chakrabarty et al. (1959), Kramer et al. (1972) and Jhingran (1975). Monsoons by eroding soil add salts to the water which accounts for increase of phosphate at some stations in August, 1975.

Higher phosphate content in February to April (Period for growth of vegetation) may

by argued along the lines proposed by Ganapati (1942) and Chakrabarty et al. (1959), who attribute such an increase to the release of more phosphate through death and decomposition of vegetation; while this phosphate is simultaneously incorporated in the growing vegetation. As zooplankton and other aquatic animals are in abundance during this period, they also increase phosphate concentration in water through their excreta or decomposition of carcases. Water from springs may yet be another augmenting factor of phosphate during this period.

Minimum concentration of phosphate at most of the stations has been observed during October, 1975 (Tables XXXIII - XXXIX). This may be due to the utilization of phosphate by abundant algae in post-monsoon period. Einsele (1941) observed experimentally that some phytoplankton can store even ten times the amount of phosphorus present in the water. Another possibility of decline may be the scarcity of detritus, and phosphate may remain locked up in vegetable matter.

2.6. Calcium: Concentration of calcium in Gadigarh water has been observed to vary from a minimum of 33.20 mg per liter at Station VI in June, 1975 to a

maximum of 81.61 mg per liter in February, 1975 at Station VII. The exact variability observed at the seven stations is tabulated below.

Table XXIII. Minimum and maximum concentration of calcium at different stations in Gadigarh stream.

Station	Ca++ mg/lit. Min.	Max.
I	35.22	69.78
II	42.01	74.29
III	39.22	73.39
IV	40.45	73.14
V	36.33	73.42
VI	33.20	76.95
VII	36.28	81.61

One of the causes of higher values of calcium observed in the stream may be the inflow of spring waters into the stream as suggested by Welch (1952), Barnes (1955), Bombowna (1965[a,b]) and Schwoerbel(1970). This principle of upwelling is exhibited in Gadigarh stream following rains in November, 1974 and October, 1975, February and March, 1975 and February, 1976 which are the periods following monsoon, and during and after winter rains, when out-flow from spring increases considerably. Greater quantities of calcium (as suggested by Welch, 1952; Rao 1971; Bombowna 1965[a,b] and Jhingran 1975), may be due to excess of carbon dioxide which converts calcium of the marls what

into soluble and stable calcium bicarbonate. Such an effect may be observed in calcium of (i) soil, and (ii) from marls produced by aquatic plants such as members of Myxophyceae, Chara sp., and Potamogeton sp. which produce marls externally or internally, as also observed at Stations II and V in April, 1975. This finding derives support from earlier observations of Welch (1952) and Jhingran (1975). In order to support this view point a direct relationship between bicarbonates and calcium (as pointed by Cushing, 1964), should exist in the ecosystem; which,however, has also been observed in Gadigarh stream.

Macan (1963) and Egglishaw et al. (1967) attributed recession in calcium concentration to detritus decomposing bacteria. This may be illustrated in the present stream at all stations in the months of May (except at Stations VI and VII) and June, when due to higher temperature decomposing activity is at its maximum. Another factor leading to calcium depletion may be reduction in marl forming aquatic vegetation and increase in calcium consuming molluscan population during May and June, 1975. Dilution due to the inflow of Ranbir canal waters into Gadigarh stream may yet be another cause of calcium decline.

2.7. Magnesium: Concentration of magnesium varies from a maximum of 27.46 mg per liter (October, 1974 at Station VII) to a minimum 5.07 (October, 1975 at Station I). Stationwise concentration of magnesium is presented in the following table.

Table XXIV. Minimum and maximum concentration of magnesium at different sations in Gadigarh stream.

Station	Mg+ mg/lit.	
	Min.	Max.
I	5.07	23.51
II	7.59	25.22
III	9.11	23.02
IV	7.08	22.18
V	6.56	24.70
VI	7.08	22.16
VII	10.13	27.46

Higher concentration of magnesium observed at stations other than Station VII from February to April may be due to increased flow of magnesium rich spring waters, as pointed out by Welch (1952) and Bombowna (1965). Further Welch (1952) suggested that marls are salts of calcium and magnesium which may be precipitated by aquatic plants. Such a precipitation occurs from February to April in Gadigarh stream and thus becomes another source of magnesium enrichment during these months.

Dilution by flow of water from Ranbir canal may impoverish magnesium concentration

per liter in Gadigarh waters, at all the Stations other than III and VII in May, 1975 and I and III in June, 1975. Further, magnesium being an important constituent of chlorophyll its decrease at Stations I, III, IV and VII (during November, 1974) and at all stations (except V) in October, 1975 may be due to incorporation of magnesium soluble salts in algae whose production is fairly high during this post-monsoon period.

pH: Studies have revealed that the water of stream Gadigarh is alkaline. Although pH varies from station to station yet values range between 7.2 - 8.35.

Table XXV. Minimum and maximum pH values at Station I - VII in Gadigarh stream.

Station	pH	
	Min.	Max.
I	7.75	8.2
II	7.2	8.3
III	7.7	8.35
IV	7.7	8.3
V	7.6	8.35
VI	7.7	8.35
VII	7.75	8.35

An observation of Tables XXXIII - XXXIX indicates that pH fluctuations in Gadigarh stream are not significant when compared with other ecological factors. In water bodies pH values are regulated by

carbon dioxide, bicarbonate and carbonate system (Hutchinson, 1957), but carbonates being completely absent in Gadigarh stream (Tables XXXIII - XXXIX) the chain of sequence in this stream may be governed by carbon dioxide, bicarbonate chain. Such a carbon dioxide-bicarbonate system, according to Hutchinson (1957) operates only when the pH values do not go much above 8.0. In Gadigarh stream both the range of fluctuation in pH (7.2 - 8.35) and complete absence of carbonates substantially support this assumption. Similar narrow pH variations reported by Welch (1952) and Jhingran (1975) however, have been attributed to the buffering effect in the water bodies.

An overall study has revealed highest values of pH in the month of April, 1975 at all stations except Station I. Such an increase in pH during this period may be due to high photosynthetic activity of aquatic vegetation (which as already discussed is abundant) which utilizes carbon dioxide, the latter has be also been observed to show a maximum decrease in this month (Tables XXXIII - XXXIX). Pierce (1947) has also observed a similar increase of pH due to high photosynthesis in St. Johns river (North Florida).

Decrease in pH concentration recorded from July to September, 1975 at most of the stations is due to the dilution effect and increased carbon dioxide concentration.

Table XXVI. Mean values of temperature (air & water), transparency, depth and suspended matter at Station I in Gadigarh stream.

S.No.	Period	Temperature (C°) Air	Temperature (C°) Water	Transparency (cm)	Depth (cm)	Suspended matter (mg/lit)
	1974					
1.	September	30.0	27.0	90.0	100.0	18.8
2.	October	26.0	23.0	90.0	92.5	16.0
3.	November	20.15	18.5	85.0	85.0	13.0
4.	December	15.0	16.0	73.75	73.75	15.0
	1975					
5.	January	16.0	17.0	67.85	67.85	18.0
6.	February	16.5	17.5	67.85	67.75	33.0
7.	March	25.0	21.0	48.75	60.0	21.0
8.	April	33.0	26.0	68.9	68.9	14.0
9.	May	39.0	27.5	58.75	62.5	17.0
10.	June	36.0	29.5	43.75	62.5	58.0
11.	July	25.25	24.0	12.5	70.0	234.0
12.	August	29.0	23.5	40.0	48.75	160.0
13.	September	28.0	24.0	41.75	41.75	24.0
14.	October	32.6	24.4	37.5	37.5	25.0
15.	November	22.5	17.65	35.0	35.0	33.0
16.	December	23.35	18.5	25.0	25.0	30.0
	1976					
17.	January	16.7	19.5	25.0	25.0	25.0
18.	February	22.5	23.9	15.0	15.0	23.0
19.	March	23.25	24.2	15.0	15.0	20.0

Table XXVII. Mean values of temperature (air & water), transparency, depth and suspended matter at Station II in Gadigarh stream.

S.No. Period	Temperature (C°) Air	Temperature (C°) Water	Transparency (cm)	Depth (cm)	Suspended matter (mg / lit)
1974					
1. September	30.0	27.0	85.0	102.5	16.0
2. October	26.0	23.0	87.5	87.5	12.0
3. November	20.75	18.25	82.5	82.5	15.0
4. December	15.0	16.5	80.0	80.0	15.0
1975					
5. January	17.0	19.5	73.25	73.25	20.0
6. February	14.5	19.25	81.25	81.25	28.0
7. March	27.0	22.5	56.25	76.25	23.0
8. April	33.0	25.5	63.75	75.0	15.0
9. May	39.0	28.0	80.0	88.75	18.0
10. June	35.5	27.5	86.25	86.5	50.0
11. July	26.0	24.0	16.0	82.5	249.0
12. August	29.0	24.0	45.0	87.5	162.0
13. September	29.5	23.75	65.0	100.0	23.0
14. October	32.8	23.4	65.0	80.0	20.0
15. November	23.1	18.15	87.5	87.5	14.0
16. December	22.95	18.25	72.0	72.0	25.0
1976					
17. January	17.05	19.1	83.75	86.25	28.0
18. February	22.75	21.4	90.0	90.0	21.0
19. March	26.25	17.6	95.0	95.0	22.0

Table XXVIII. Mean values of temperature (air & water), transparency, depth and suspended matter at Station III in Gadigarh stream.

S.No. Period	Temperature (C°) Air	Temperature (C°) Water	Transparency (cm)	Depth (cm)	Suspended matter (mg/lit)
1974					
1. September	29.0	26.5	85.0	105.0	18.0
2. October	26.5	23.0	90.0	100.0	16.0
3. November	21.35	18.6	90.0	90.0	21.0
4. December	14.5	16.2	93.5	100.0	11.0
1975					
5. January	16.9	17.2	90.0	93.75	28.0
6. February	15.5	16.5	90.0	90.0	31.0
7. March	25.5	22.5	82.5	90.5	18.0
8. April	31.5	27.0	90.0	90.0	12.0
9. May	38.5	30.0	76.5	87.5	22.0
10. June	36.5	30.5	66.25	87.5	50.0
11. July	27.0	25.0	15.0	120.0	264.0
12. August	28.95	25.0	40.0	96.25	186.0
13. September	29.5	23.5	67.5	80.0	25.0
14. October	29.4	24.0	67.5	77.5	28.0
15. November	24.65	17.35	81.75	81.75	20.0
16. December	24.0	16.45	87.5	87.5	22.0
1976					
17. January	16.85	15.9	75.0	80.0	24.0
18. February	21.2	18.2	90.0	90.0	18.0
19. March	26.25	18.9	90.0	90.0	25.0

Table XXIX. Mean values of temperature (air & water), transparency, depth and suspended matter at Station IV in Gadigarh stream

S.No. Period	Temperature (C^{o}) Air	Water	Trans-parency (cm)	Depth (cm)	Suspended matter (mg / lit)
1974					
1. September	29.2	26.5	75.0	110.0	14.0
2. October	26.45	24.0	90.0	101.25	15.0
3. November	21.35	18.25	83.75	83.75	17.0
4. December	15.0	15.5	97.5	97.5	14.0
1975					
5. January	18.5	15.5	90.5	90.5	22.0
6. February	17.75	16.7	87.5	87.5	28.0
7. March	26.5	23.25	75.0	87.5	23.0
8. April	32.45	26.0	80.5	80.5	10.0
9. May	41.0	30.0	90.0	95.0	15.0
10. June	38.5	31.45	60.0	90.0	71.0
11. July	27.25	25.5	17.5	115.0	232.0
12. August	29.5	25.0	40.0	97.5	138.0
13. September	30.6	24.75	70.25	86.25	20.0
14. October	30.4	24.2	78.5	87.5	17.0
15. November	23.8	16.75	91.25	91.25	22.0
16. December	25.5	15.4	92.5	92.5	25.0
1976					
17. January	16.5	14.65	90.0	97.5	20.0
18. February	21.5	16.0	95.0	95.0	25.0
19. March	29.5	20.9	95.0	95.0	23.0

Table XXX. Mean values of temperature (air & water), transparency, depth and suspended matter at Station V in Gadigarh stream.

S.No.	Period	Temperature (C^o) Air	Temperature (C^o) Water	Transparency (cm)	Depth (cm)	Suspended matter (mg / lit)
	1974					
1.	September	31.0	28.0	75.0	95.0	160.0
2.	October	32.45	24.9	75.0	75.0	25.0
3.	November	24.8	20.5	78.75	78.75	22.0
4.	December	17.45	14.85	77.75	77.75	12.0
	1975					
5.	January	17.0	16.0	72.5	72.5	27.0
6.	February	18.55	16.95	72.5	72.5	35.0
7.	March	26.95	23.25	67.5	67.5	24.0
8.	April	30.6	24.45	71.25	71.25	12.0
9.	May	41.0	32.1	67.5	67.5	25.0
10.	June	37.95	32.35	58.75	70.0	70.0
11.	July	29.3	25.8	22.5	100.0	262.0
12.	August	30.5	26.45	40.0	86.25	199.0
13.	September	30.8	25.1	70.0	75.0	28.0
14.	October	30.4	22.4	57.5	70.0	35.0
15.	November	23.5	17.5	68.0	68.0	24.0
16.	December	22.0	15.3	72.5	72.5	30.0
	1976					
17.	January	16.3	15.2	68.75	72.5	32.0
18.	February	19.5	15.7	70.0	70.0	22.0
19.	March	30.9	17.5	74.0	74.0	29.0

Table XXXI. Mean values of temperature (air & water), transparency, depth and suspended matter at Station VI in Gadigarh stream.

S.No.	Period	Temperature (C°) Air	Temperature (C°) Water	Transparency (cm)	Depth (cm)	Suspended matter (mg / lit)
	1974					
1.	September	31.0	28.0	60.0	60.0	16.0
2.	October	34.1	24.45	60.0	60.0	26.0
3.	November	24.5	19.4	55.0	55.0	24.0
4.	December	17.05	15.25	50.0	50.0	14.0
	1975					
5.	January	16.6	16.15	52.0	52.0	27.0
6.	February	16.7	17.1	43.75	43.75	39.0
7.	March	24.45	20.95	52.5	52.5	36.0
8.	April	29.0	26.0	48.13	48.13	16.0
9.	May	37.9	31.65	48.75	48.75	30.0
10.	June	37.0	30.5	41.25	41.25	61.0
11.	July	26.55	25.45	18.75	76.25	232.0
12.	August	29.0	25.55	36.25	60.0	172.0
13.	September	29.0	23.5	55.0	55.0	30.0
14.	October	31.4	23.8	47.5	47.5	18.0
15.	November	26.2	17.7	50.0	50.0	26.0
16.	December	25.5	16.5	47.5	47.5	31.0
	1976					
17.	January	16.5	15.1	47.5	47.5	29.0
18.	February	22.6	17.85	45.0	45.0	25.0
19.	March	29.6	22.5	50.0	50.0	28.0

Table XXXII. Mean values of temperature (air & water), transparency, depth and suspended matter at Station VII in Gadigarh stream.

S.No.	Period	Temperature (C°) Air	Temperature (C°) Water	Transparency (cm)	Depth (cm)	Suspended matter (mg/lit)
	1974					
1.	September	32.0	28.5	55.0	55.0	17.0
2.	October	31.45	24.6	52.5	52.5	24.0
3.	November	25.5	19.0	46.25	46.25	25.0
4.	December	17.5	15.0	52.5	52.5	28.0
	1975					
5.	January	18.0	17.0	47.5	47.5	34.0
6.	February	19.0	18.0	43.75	43.75	37.0
7.	March	25.9	23.0	52.5	52.5	28.0
8.	April	33.45	24.95	43.75	43.75	13.0
9.	May	40.5	31.0	48.75	48.75	22.0
10.	June	39.25	29.0	48.75	48.75	47.0
11.	July	25.5	22.35	18.75	18.75	283.0
12.	August	30.3	25.75	40.0	40.0	178.0
13.	September	30.5	24.5	45.75	45.75	29.0
14.	October	29.0	24.2	42.5	42.5	19.0
15.	November	22.7	18.45	43.75	43.75	21.0
16.	December	25.0	16.75	40.0	40.0	27.0
	1976					
17.	January	17.5	15.65	40.0	40.0	33.0
18.	February	20.6	18.15	45.0	45.0	25.0
19.	March	30.4	22.4	42.5	42.5	27.0

Table XXXIII. Mean values of chemical parameters at Station I in Gadigarh stream.

S.No. Period	pH	Dissolved oxygen mg/lit	Carbon-dioxide mg/lit	Carbonates mg/lit	Bicarbonates mg/lit	Chlorides mg/lit	Water soluble phosphates µ mg/lit	Calcium mg/lit	Magnesium mg/lit
1974									
1. September	*	3.4	5.0	-	195.2	8.99	*	43.71	9.48
2. October	*	5.85	6.0	-	216.55	10.99	*	45.99	13.26
3. November	*	6.7	6.75	-	247.05	7.99	*	64.16	9.96
4. December	*	5.1	9.5	-	348.9	8.99	*	51.43	15.07
1975									
5. January	*	4.5	6.5	-	335.5	11.42	*	45.62	13.06
6. February	7.9	6.3	6.5	-	329.6	14.92	*	64.32	23.51
7. March	7.95	7.26	10.26	-	442.25	15.64	*	69.78	21.45
8. April	8.15	6.37	5.5	-	260.17	11.79	20.0	49.15	15.66
9. May	7.9	2.87	5.0	-	197.34	10.44	30.0	40.29	8.84
10. June	8.05	1.92	10.0	-	253.15	16.45	60.0	40.07	21.41
11. July	7.75	3.04	8.0	-	197.03	8.12	27.5	35.22	5.29
12. August	8.0	3.57	6.0	-	258.34	12.48	50.0	53.89	22.64
13. September	7.85	4.73	9.1	-	228.75	12.34	28.75	50.24	17.75
14. October	8.2	6.5	8.0	-	275.72	9.59	5.0	53.45	5.07
15. November	8.05	6.91	4.4	-	215.67	10.14	15.0	56.27	16.78
16. December	8.2	7.88	7.7	-	244.31	8.79	17.5	51.92	14.25
1976									
17. January	8.2	5.48	8.3	-	259.25	8.19	20.0	38.7	13.61
18. February	8.1	6.47	7.4	-	320.25	9.99	10.0	59.35	18.95
19. March	7.8	6.03	9.15	-	302.56	12.89	36.5	*	*

* Data not available.

Table XXXIV. Mean values of chemical parameters at Station II in Gadigarh stream.

S.No.	Period	pH	Dissolved oxygen mg/lit	Carbon dioxide mg/lit	Carbonates mg/lit	Bicarbonates mg/lit	Chlorides mg/lit	Water soluble phosphates µ mg/lit	Calcium mg/lit	Magnesium mg/lit
	1974									
1.	September	*	3.2	5.5	-	225.7	9.99	*	43.31	10.21
2.	October	*	5.75	6.0	-	240.95	10.99	*	51.68	11.03
3.	November	*	5.8	7.75	-	280.6	6.99	*	67.77	12.40
4.	December	*	5.1	8.0	-	311.1	8.99	*	57.14	14.42
	1975									
5.	January	*	5.0	6.5	-	338.55	15.99	*	45.12	14.28
6.	February	8.05	7.0	8.0	-	317.2	12.99	*	72.38	20.84
7.	March	8.15	7.65	7.75	-	381.25	18.48	*	74.29	25.22
8.	April	8.3	7.14	6.25	-	345.26	11.74	29.0	67.01	22.36
9.	May	8.0	5.9	6.0	-	316.29	15.63	7.5	63.46	12.33
10.	June	8.2	2.64	8.5	-	324.52	14.88	13.75	44.81	19.01
11.	July	8.05	4.13	10.0	-	185.44	16.14	11.25	42.01	10.15
12.	August	8.05	5.2	12.0	-	258.34	11.29	12.5	55.65	13.32
13.	September	8.0	4.71	11.5	-	251.32	12.34	12.5	59.24	16.46
14.	October	8.1	5.48	9.7	-	275.72	9.59	7.5	65.98	7.59
15.	November	8.05	6.23	8.25	-	248.27	9.44	16.25	52.78	17.69
16.	December	8.1	6.52	9.5	-	258.64	8.04	20.0	53.46	10.9
	1975									
17.	January	8.15	3.84	8.0	-	284.7	9.04	14.0	49.91	9.85
18.	February	8.15	5.97	8.7	-	325.74	9.99	13.25	43.71	18.5
19.	March	7.2	6.45	14.85	-	305.00	12.89	26.0	*	*

* Data not available.

Table XXXV. Mean values of chemical parameters at Station III in Gadigarh stream.

S.No.	Period	pH	Dissolved oxygen mg/lit	Carbon dioxide mg/lit	Carbonates mg/lit	Bicarbonates mg/lit	Chlorides mg/lit	Water soluble phosphates µ mg/lit	Calcium mg/lit	Magnesium mg/lit
	1974									
1.	September	*	3.6	6.0	-	231.8	9.99	*	52.13	9.72
2.	October	*	4.98	7.5	-	271.45	10.74	*	58.15	12.33
3.	November	*	6.4	6.5	-	289.75	6.99	*	73.18	11.24
4.	December	*	6.0	9.0	-	323.3	10.99	*	57.65	14.76
	1975									
5.	January	*	5.2	4.5	-	353.8	18.99	*	45.62	12.46
6.	February	8.0	8.6	7.0	-	317.2	12.99	*	71.78	23.02
7.	March	8.15	7.41	13.25	-	335.5	17.78	*	73.39	20.39
8.	April	8.35	9.03	5.0	-	342.52	13.29	21.0	72.69	15.13
9.	May	8.0	4.42	7.0	-	308.36	11.54	23.5	66.97	18.72
10.	June	8.35	2.93	7.3	-	274.5	14.59	10.0	39.22	12.94
11.	July	7.85	3.69	8.0	-	242.78	10.39	13.5	43.41	12.28
12.	August	7.95	5.64	6.0	-	267.49	12.04	47.5	59.61	12.45
13.	September	7.75	4.72	6.5	-	262.3	12.34	8.75	58.29	16.5
14.	October	8.0	6.56	7.3	-	298.9	9.59	6.5	63.48	9.11
15.	November	8.15	5.25	6.55	-	246.44	9.39	12.5	55.52	15.04
16.	December	8.1	7.44	6.2	-	268.4	8.09	15.0	57.05	14.91
	1976									
17.	January	8.05	5.44	6.2	-	298.9	9.49	16.5	44.54	14.05
18.	February	8.3	4.93	9.2	-	342.21	20.88	8.75	*	*
19.	March	7.7	5.61	11.75	-	295.85	15.88	19.0	*	*

* Data not available.

Table XXXVI. Mean values of chemical parameters at Station IV in Gadigarh stream.

S.No. Period	pH	Dissolved oxygen mg/lit	Carbon dioxide mg/lit	Carbonates mg/lit	Bicarbonates mg/lit	Chlorides mg/lit	Water soluble phosphates µ mg/lit	Calcium mg/lit	Magnesium mg/lit
1974									
1. September	*	3.6	6.0	-	231.8	8.99	*	53.13	10.81
2. October	*	6.0	4.5	-	274.5	10.49	*	56.14	16.53
3. November	*	6.6	5.75	-	292.9	6.99	*	72.68	11.73
4. December	*	5.1	9.0	-	317.2	10.99	*	55.74	14.18
1975									
5. January	*	4.6	4.0	-	341.6	17.48	*	47.12	10.94
6. February	7.9	8.88	9.5	-	344.65	12.97	*	61.66	17.62
7. March	8.0	8.14	11.25	-	381.25	18.48	*	73.14	14.61
8. April	8.3	8.01	4.5	-	350.14	14.99	27.75	68.37	22.18
9. May	8.06	3.55	6.0	-	298.6	9.99	4.0	60.89	19.82
10. June	8.25	5.1	6.5	-	286.7	12.09	20.0	42.31	12.33
11. July	7.9	3.16	6.45	-	230.89	9.89	4.75	58.90	7.08
12. August	7.95	5.65	10.35	-	277.55	12.04	57.5	56.5	14.57
13. September	7.85	5.91	7.0	-	271.45	11.84	7.5	56.2	15.19
14. October	7.8	6.04	6.5	-	298.9	11.79	7.5	58.47	12.66
15. November	8.15	6.75	4.05	-	271.15	9.04	11.25	53.27	14.39
16. December	8.05	9.05	6.45	-	276.03	9.39	8.75	57.91	15.03
1976									
17. January	7.95	6.0	6.2	-	240.95	8.94	10.0	40.45	11.57
18. February	8.1	7.96	5.4	-	315.68	12.49	10.0	51.13	19.01
19. March	7.7	7.91	10.1	-	251.02	12.89	21.5	*	*

* Data not available.

Table XXXVII. Mean values of chemical parameters at Station V in Gadigarh stream.

S.No.	Period	pH	Dissolved oxygen mg/lit	Carbon dioxide mg/lit	Carbonates mg/lit	Bicarbonates mg/lit	Chlorides mg/lit	Water soluble phosphates µ mg/lit	Calcium mg/lit	Magnesium mg/lit
	1974									
1.	September	*	3.6	4.0	-	256.2	11.99	*	52.13	6.56
2.	October	*	5.36	3.0	-	280.6	10.99	*	60.75	12.58
3.	November	*	6.7	5.3	-	280.6	6.99	*	69.98	13.43
4.	December	*	7.0	6.0	-	305.0	12.99	*	61.06	12.15
	1975									
5.	January	*	8.5	3.5	-	329.4	16.48	*	49.13	11.18
6.	February	7.85	8.9	7.0	-	329.4	12.49	*	63.46	15.49
7.	March	7.95	9.5	7.6	-	355.5	21.13	*	64.56	24.7
8.	April	8.35	9.05	3.75	-	350.14	13.29	17.5	65.0	21.21
9.	May	8.05	8.06	5.0	-	330.25	15.89	70.5	56.5	20.25
10.	June	8.3	7.88	6.0	-	275.72	10.94	25.0	36.33	10.47
11.	July	7.6	3.69	7.5	-	230.89	12.14	2.5	45.23	11.9
12.	August	7.9	4.65	7.25	-	280.6	13.24	47.5	58.45	14.18
13.	September	7.8	5.33	5.5	-	285.48	11.79	6.25	58.47	17.37
14.	October	8.3	6.02	6.5	-	329.4	9.99	2.5	60.97	23.8
15.	November	8.25	8.23	5.35	-	277.55	9.74	10.5	58.15	14.54
16.	December	8.05	9.2	6.8	-	283.35	9.74	59.0	58.13	17.51
	1976									
17.	January	7.95	9.45	5.2	-	245.83	8.49	8.0	39.16	13.53
18.	February	8.05	8.1	4.1	-	314.76	11.09	32.5	73.42	21.51
19.	March	7.85	8.03	10.63	-	240.95	10.69	35.5	*	*

* Data not available.

Table XXXVIII. Mean values of chemical parameters at Station VI in Gadigarh stream.

S.No. Period	pH	Dissolved oxygen mg/lit	Carbon dioxide mg/lit	Carbonates mg/lit	Bicarbonates mg/lit	Chlorides mg/lit	Water soluble phosphates µ mg/lit	Calcium mg/lit	Magnesium mg/lit
1974									
1. September	*	3.2	3.0	-	256.2	9.99	*	49.32	8.26
2. October	*	6.0	4.0	-	280.6	12.99	*	62.01	11.39
3. November	*	6.9	6.25	-	305.0	6.99	*	72.68	12.33
4. December	*	7.6	5.5	-	347.7	10.99	*	63.46	8.39
1975									
5. January	*	6.5	4.5	-	341.6	16.48	*	47.62	10.64
6. February	7.8	8.1	5.75	-	341.6	11.99	*	64.77	19.43
7. March	8.05	7.89	9.45	-	305.0	19.48	*	76.95	14.44
8. April	8.35	10.8	2.25	-	337.94	13.99	24.5	49.34	22.16
9. May	8.1	6.77	5.0	-	353.8	16.03	50.0	65.27	19.27
10. June	8.25	5.3	6.5	-	240.65	10.94	15.0	33.20	13.37
11. July	7.7	4.71	5.4	-	252.24	12.14	18.75	56.33	9.62
12. August	7.95	4.7	7.25	-	274.5	13.24	25.0	51.31	13.22
13. September	7.9	5.24	5.5	-	285.48	12.69	13.25	56.73	16.23
14. October	8.0	6.74	6.5	-	341.6	11.09	2.5	70.18	7.08
15. November	8.25	7.89	5.0	-	277.55	9.04	31.25	57.83	16.23
16. December	8.15	9.06	5.95	-	290.36	10.89	41.0	57.99	14.92
1976									
17. January	8.0	9.2	4.0	-	248.88	8.49	9.0	38.35	9.83
18. February	7.9	11.1	6.0	-	318.12	12.49	28.25	46.20	16.00
19. March	7.95	5.94	7.1	-	251.32	10.69	122.5	*	*

* Data not available.

Table XIL. Mean values of chemical parameters at Station VII in Gadigarh stream.

S.No. Period	pH	Dissolved oxygen mg/lit	Carbon dioxide mg/lit	Carbonates mg/lit	Bicarbonates mg/lit	Chlorides mg/lit	Water soluble phosphates µ mg/lit	Calcium mg/lit	Magnesium mg/lit
1974									
1. September	*	2.8	3.5	-	244.0	9.99	*	50.73	15.43
2. October	*	6.07	4.5	-	311.1	11.99	*	61.41	27.46
3. November	*	6.7	5.4	-	298.9	6.99	*	70.33	14.74
4. December	*	7.0	6.0	-	323.23	11.99	*	53.53	15.31
1975									
5. January	*	7.30	5.0	-	347.7	16.48	*	43.81	11.73
6. February	7.8	9.5	8.4	-	341.6	13.99	*	81.61	25.27
7. March	8.35	8.45	11.45	-	305.0	16.99	*	64.53	18.74
8. April	8.35	9.27	3.0	-	231.19	13.29	40.5	52.03	14.34
9. May	8.1	5.93	4.0	-	338.86	15.03	16.50	66.27	21.56
10. June	8.3	6.24	6.0	-	259.56	10.94	17.05	36.28	11.57
11. July	7.75	3.99	6.0	-	230.89	11.04	3.75	42.98	11.38
12. August	7.95	7.02	7.25	-	286.7	11.44	25.0	57.5	12.76
13. September	7.9	5.7	6.5	-	285.48	11.99	21.25	63.79	20.38
14. October	7.9	6.8	6.5	-	317.2	10.09	2.0	68.49	10.13
15. November	8.3	6.76	5.35	-	277.35	9.04	22.5	53.04	18.41
16. December	7.85	9.36	5.75	-	290.36	10.14	25.0	58.65	15.31
1976									
17. January	7.95	7.2	4.1	-	256.2	8.49	6.25	36.92	11.53
18. February	7.95	9.26	6.3	-	310.8	10.19	30.0	53.51	16.56
19. March	8.0	9.37	8.05	-	255.29	10.64	26.5	*	*

* Data not available.

Legend :

Air temperature ○——○

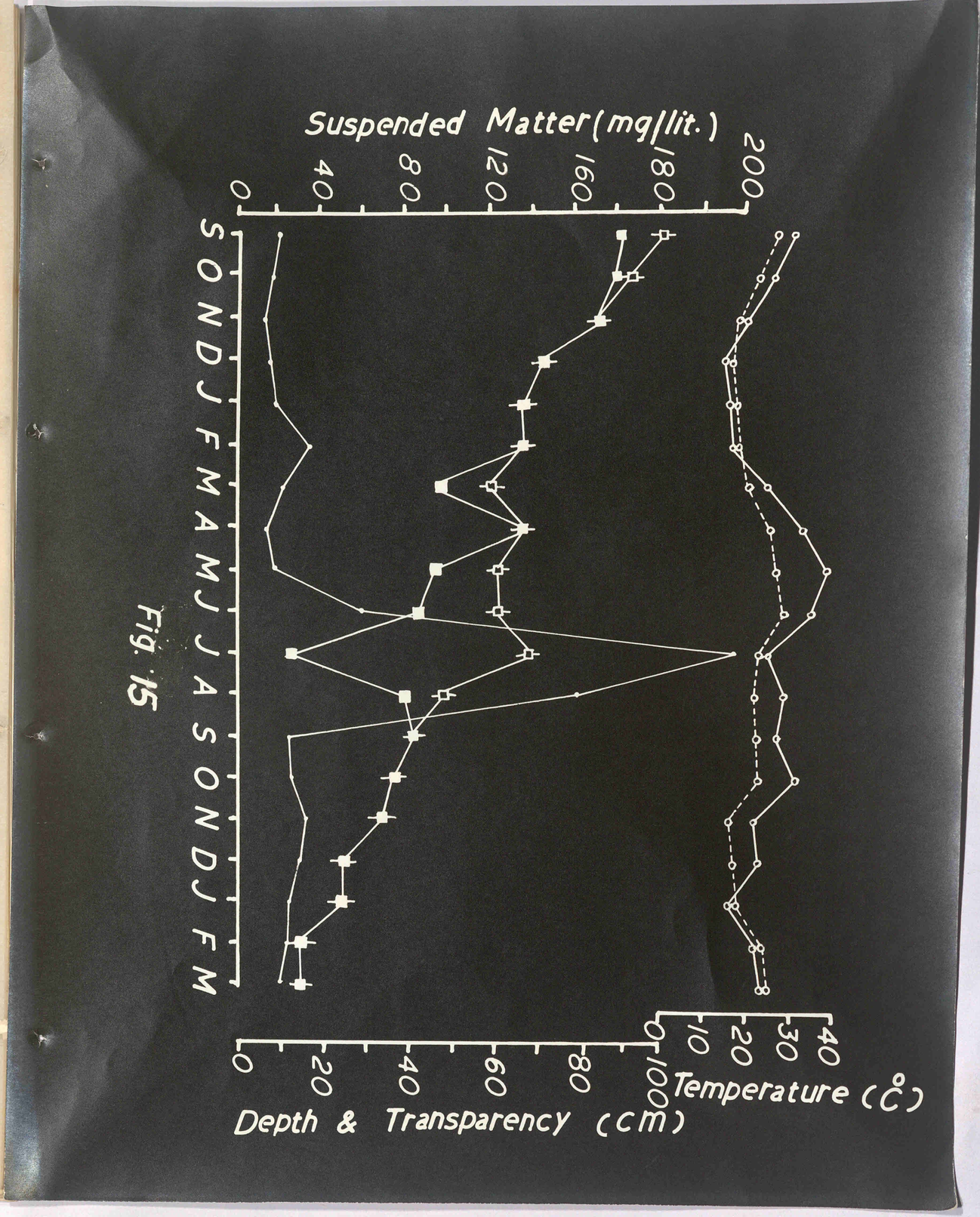
Water surface temperature ○- - - -○

Depth □——□

Transparency □——□

Suspended matter •——•

Fig. 15. Seasonal changes in physical parameters at Station No. I during September, 1974 to March, 1976.



Legend :

Air temperature ○——○

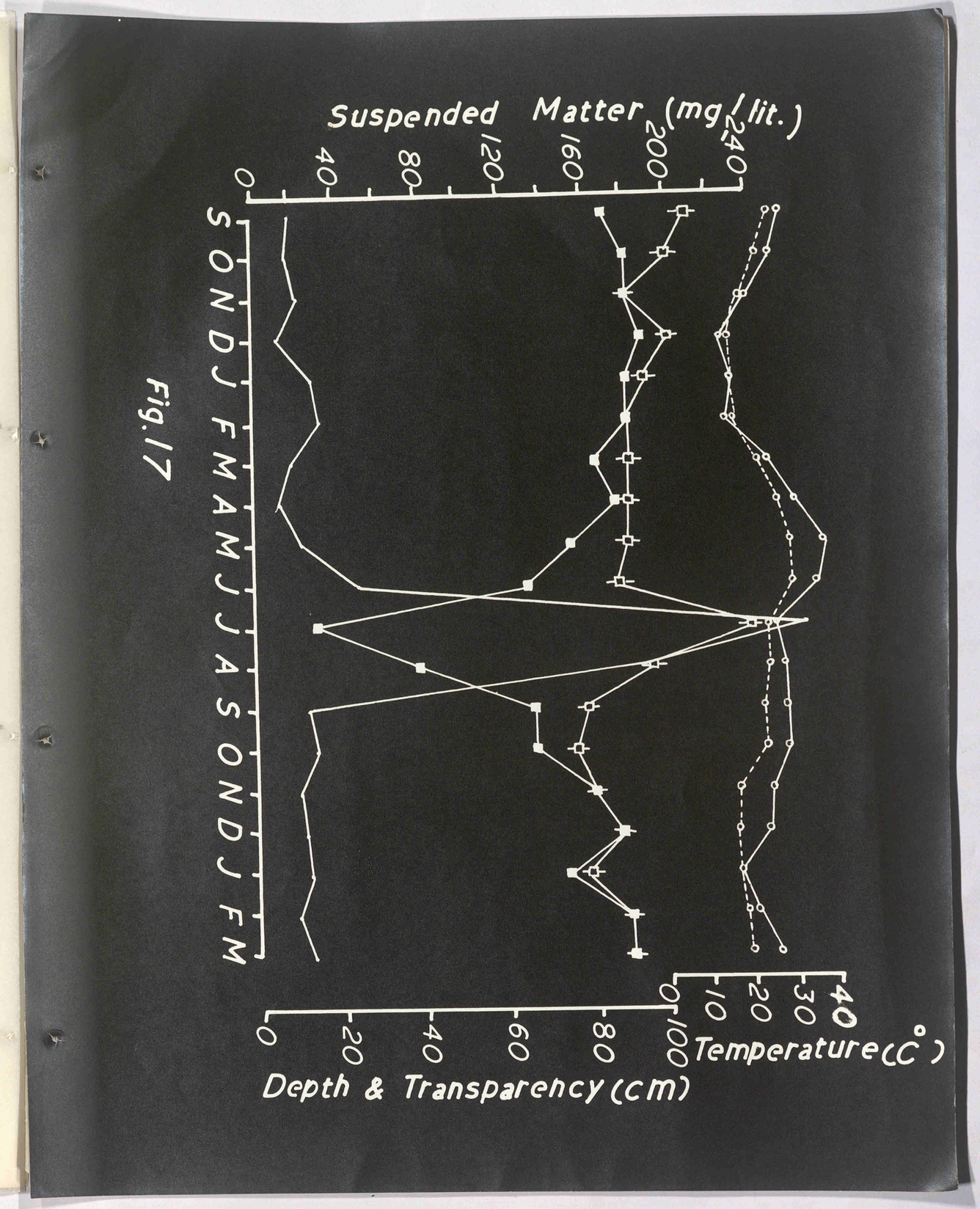
Water surface temperature ○- - - -○

Depth □——□

Transparency □——□

Suspended matter •——•

Fig. 17. Seasonal changes in physical parameters at Station No. III during September, 1974 to March, 1976.



Legend :

Air temperature ○——○

Water surface temperature ○- - - -○

Depth □——□

Transparency □——□

Suspended matter •——•

Fig. 16. Seasonal changes in physical parameters at Station No. II during September, 1974 to March, 1976.

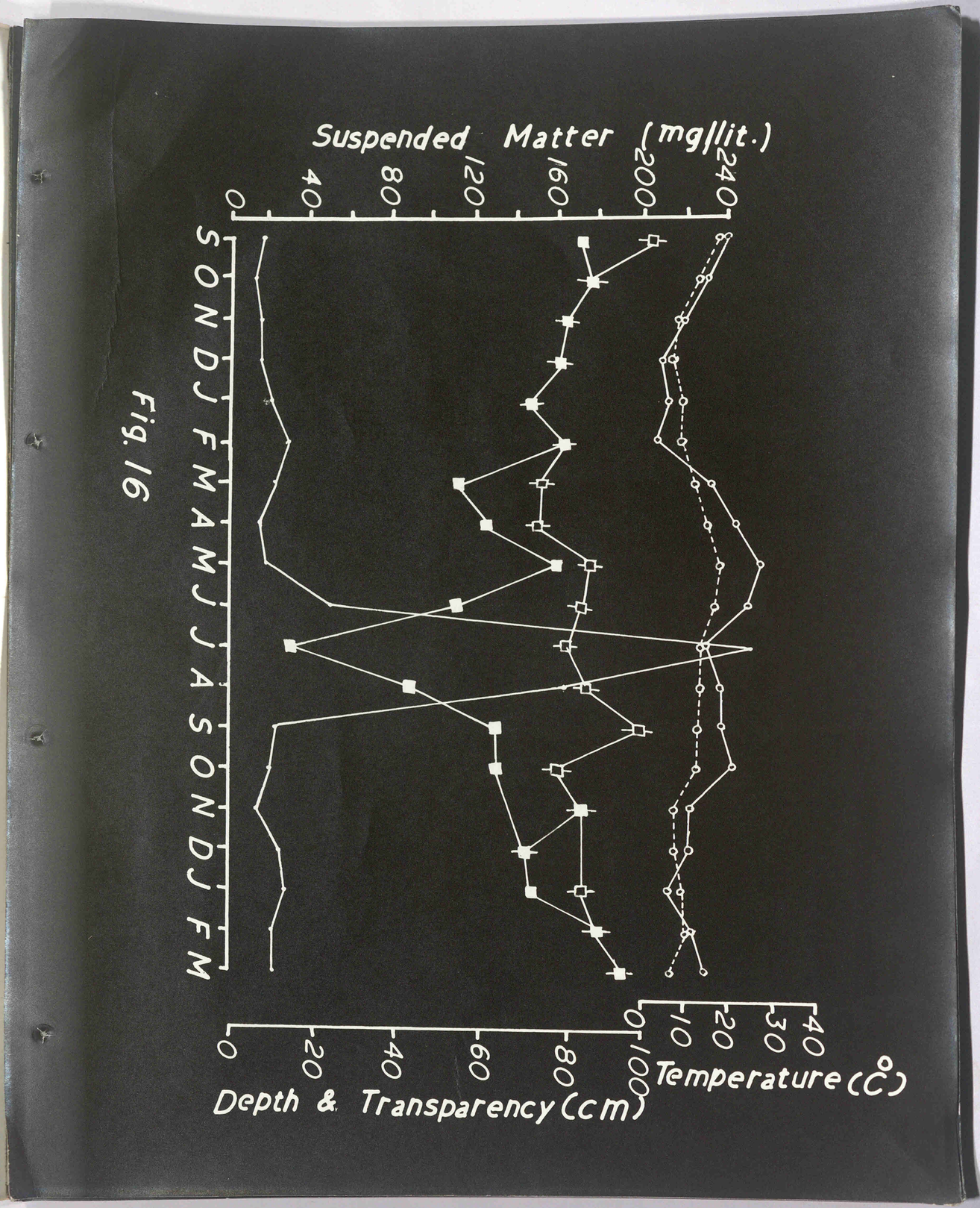


Fig. 16

Legend :

Air temperature ○——○

Water surface temperature ○- - - -○

Depth □——□

Transparency □——□

Suspended matter •——•

Fig. 18. Seasonal changes in physical parameters at Station No. IV during September, 1974 to March, 1976.

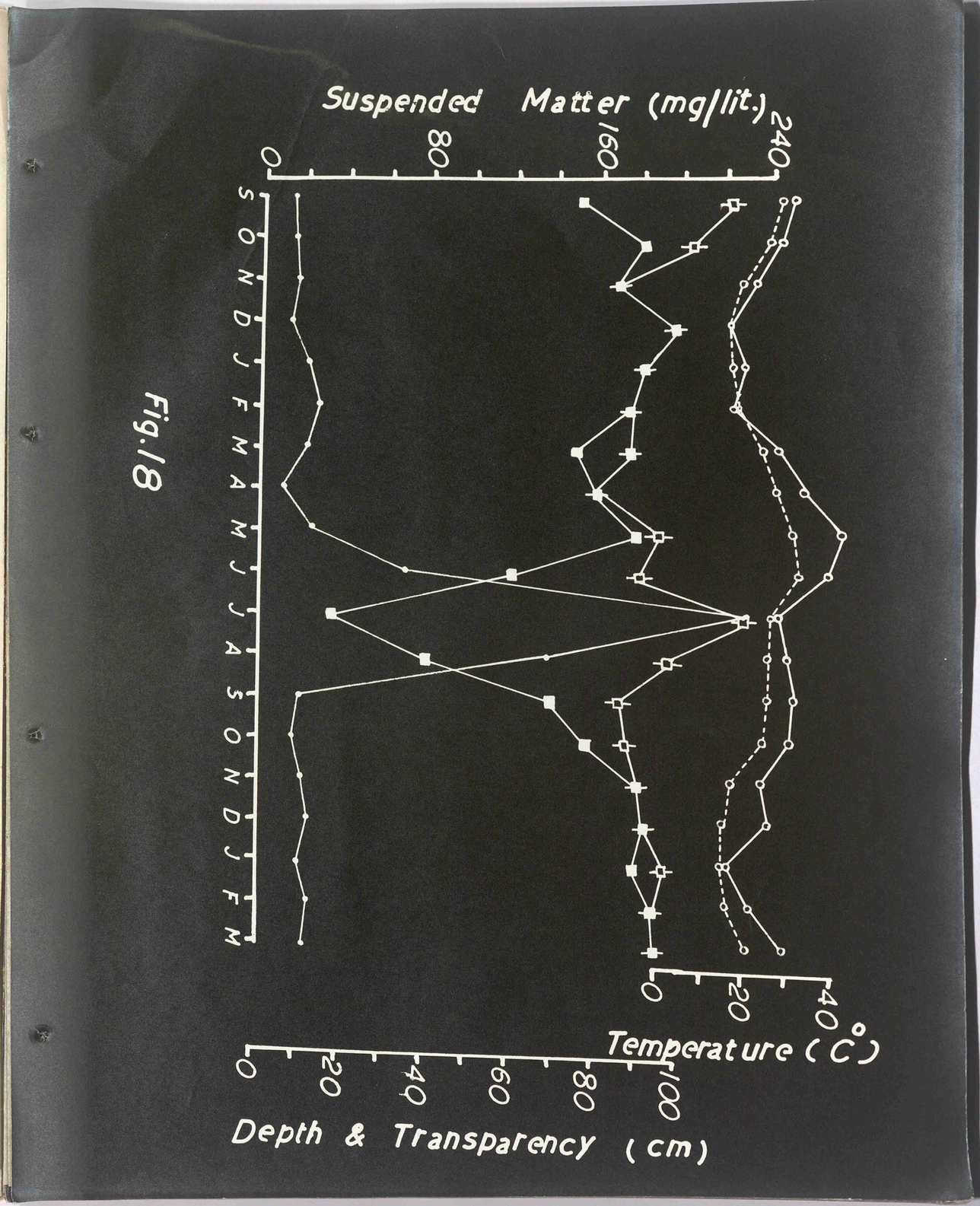


Fig. 18

Legend :

Air temperature ○——○

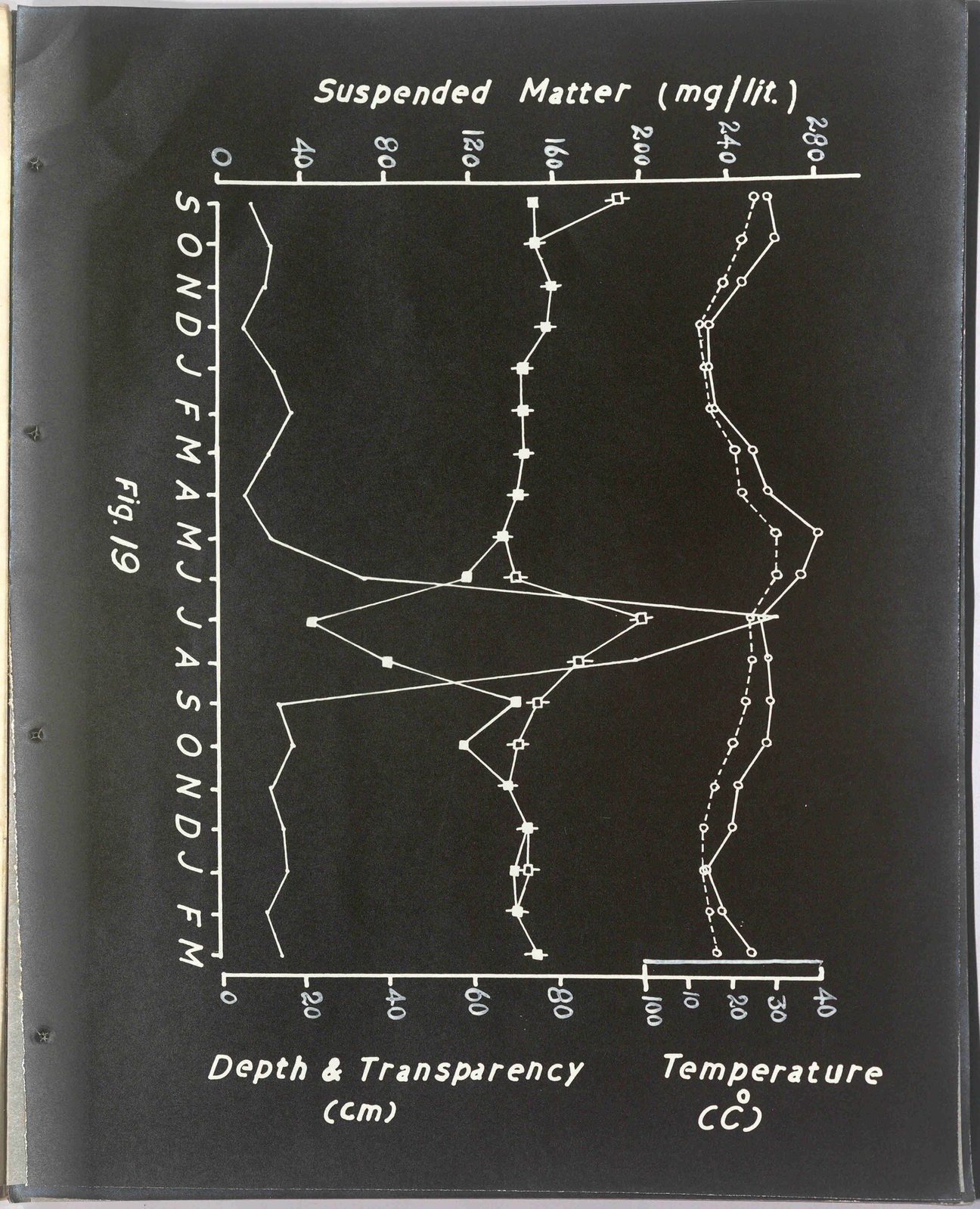
Water surface temperature ○- - - -○

Depth ⊓—⊓

Transparency □——□

Suspended matter •——•

Fig. 19. Seasonal changes in physical parameters at Station No. V during September, 1974 to March, 1976.



Legend :

Air temperature ○——○

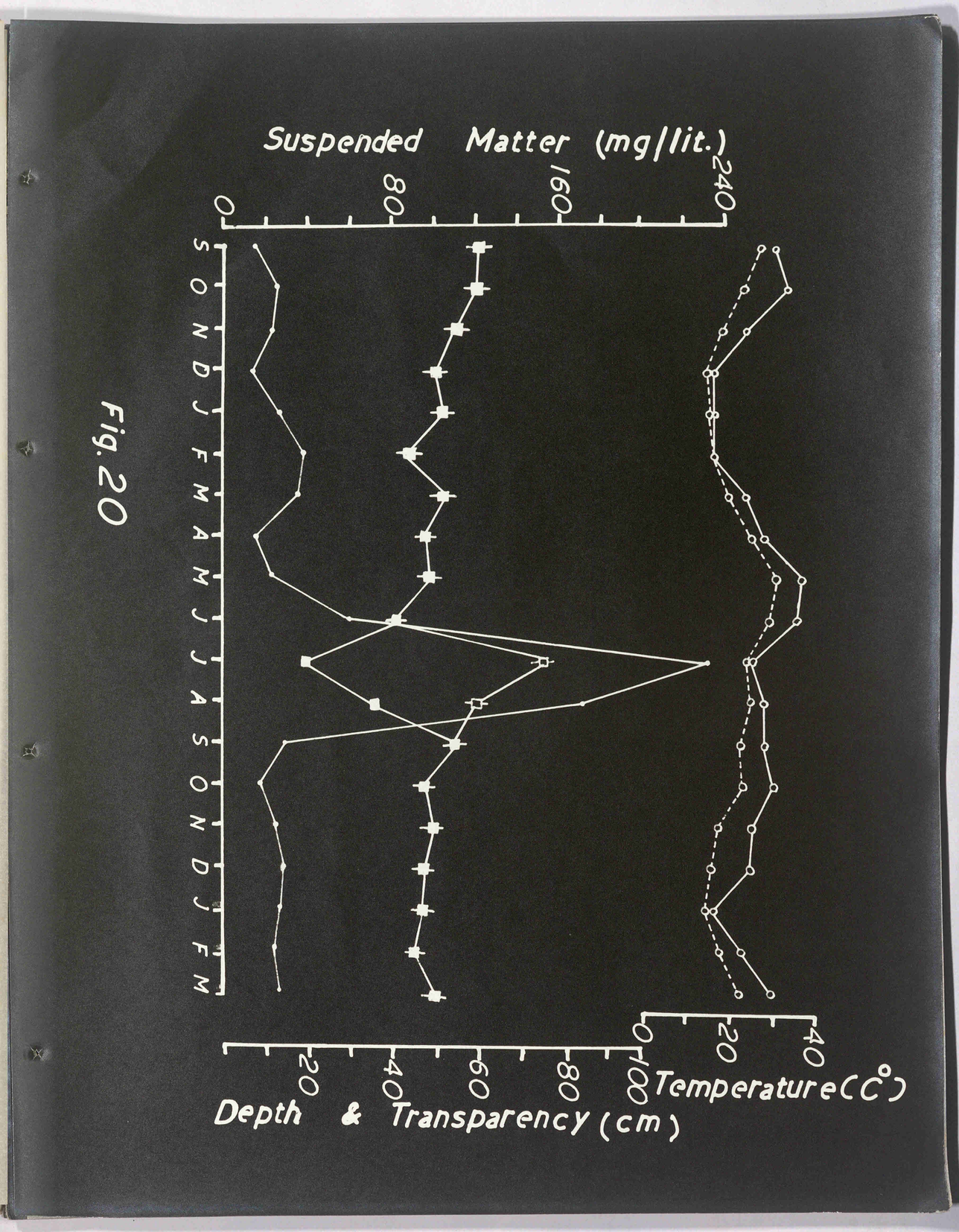
Water surface temperature ○- - - -○

Depth □——□

Transparency □——□

Suspended matter •——•

Fig. 20. Seasonal changes in physical parameters at Station No. VI during September, 1974 to March, 1976.



Legend :

Air temperature ○——○

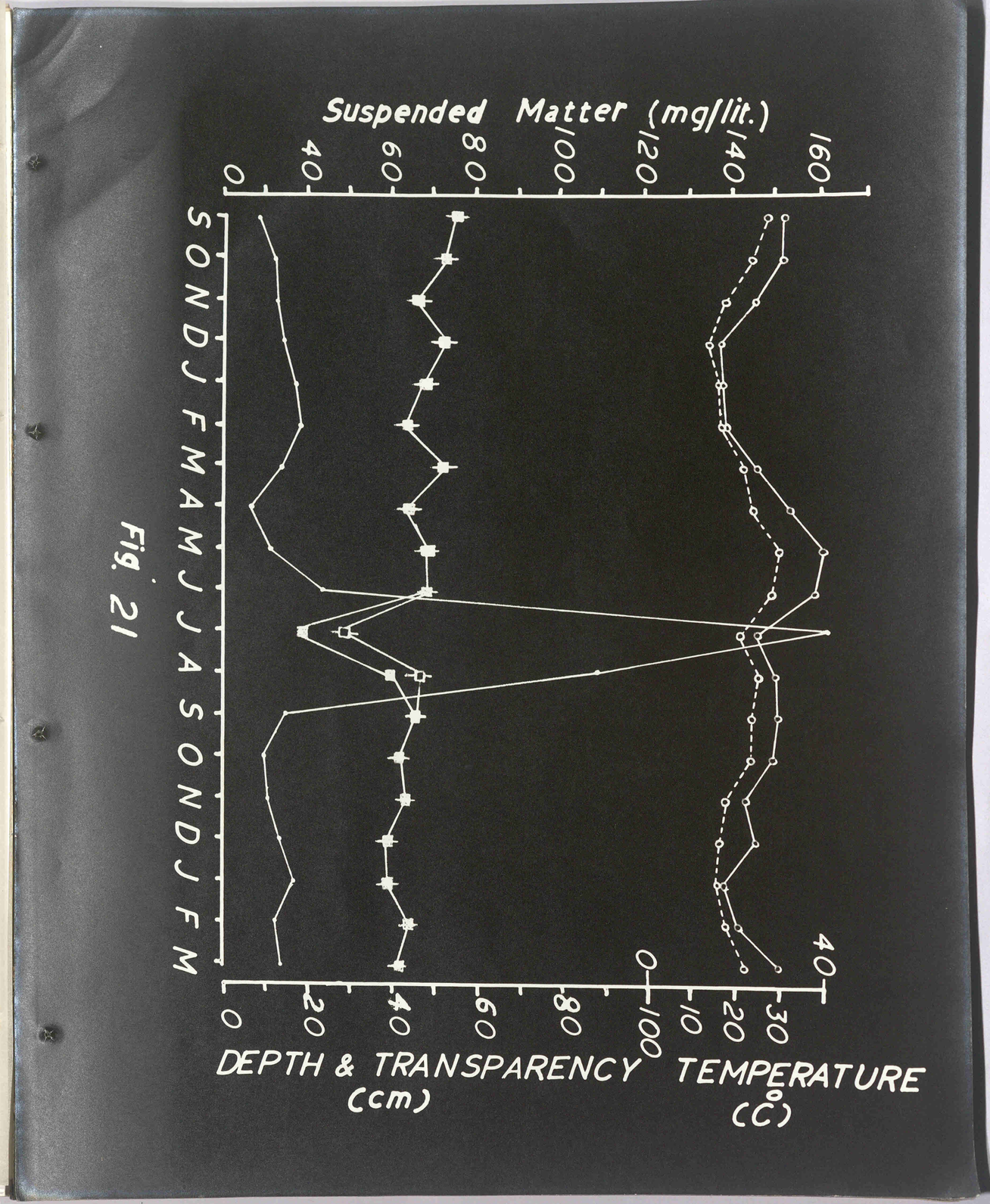
Water surface temperature ○- - - -○

Depth □——□

Transparency □——□

Suspended matter •——•

Fig. 21. Seasonal changes in physical parameters at Station No. VII during September, 1974 to March, 1976.



Legend :

Free carbon dioxide

Dissolved oxygen

Bicarbonates

Calcium

Magnesium

Chloride

Phosphate

pH

Fig. 22. Seasonal changes in chemical parameters of water at Station No. I. during September, 1974 to March, 1976.

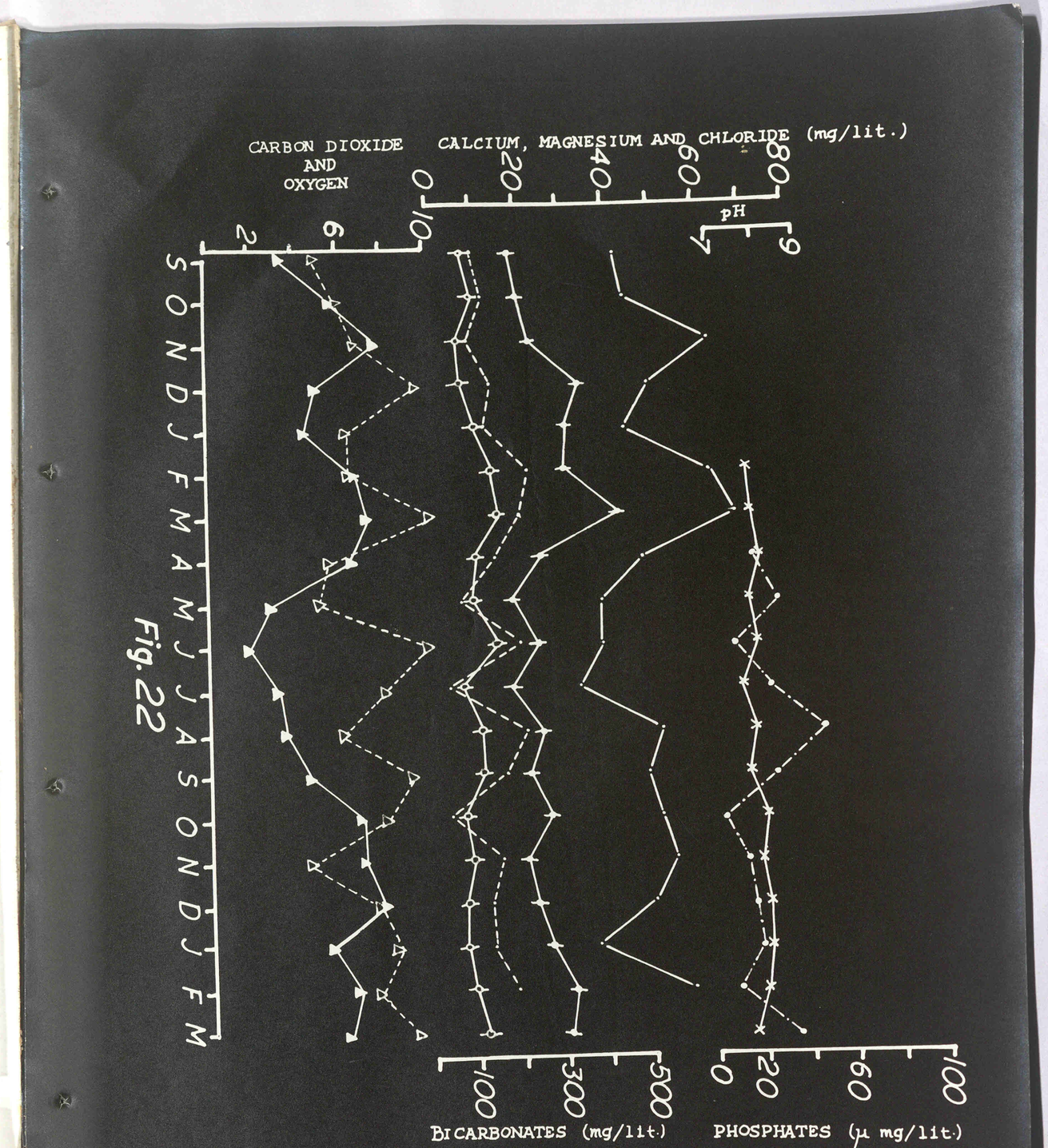


Fig. 22

Legend :

Free carbon dioxide

Dissolved oxygen

Bicarbonates

Calcium

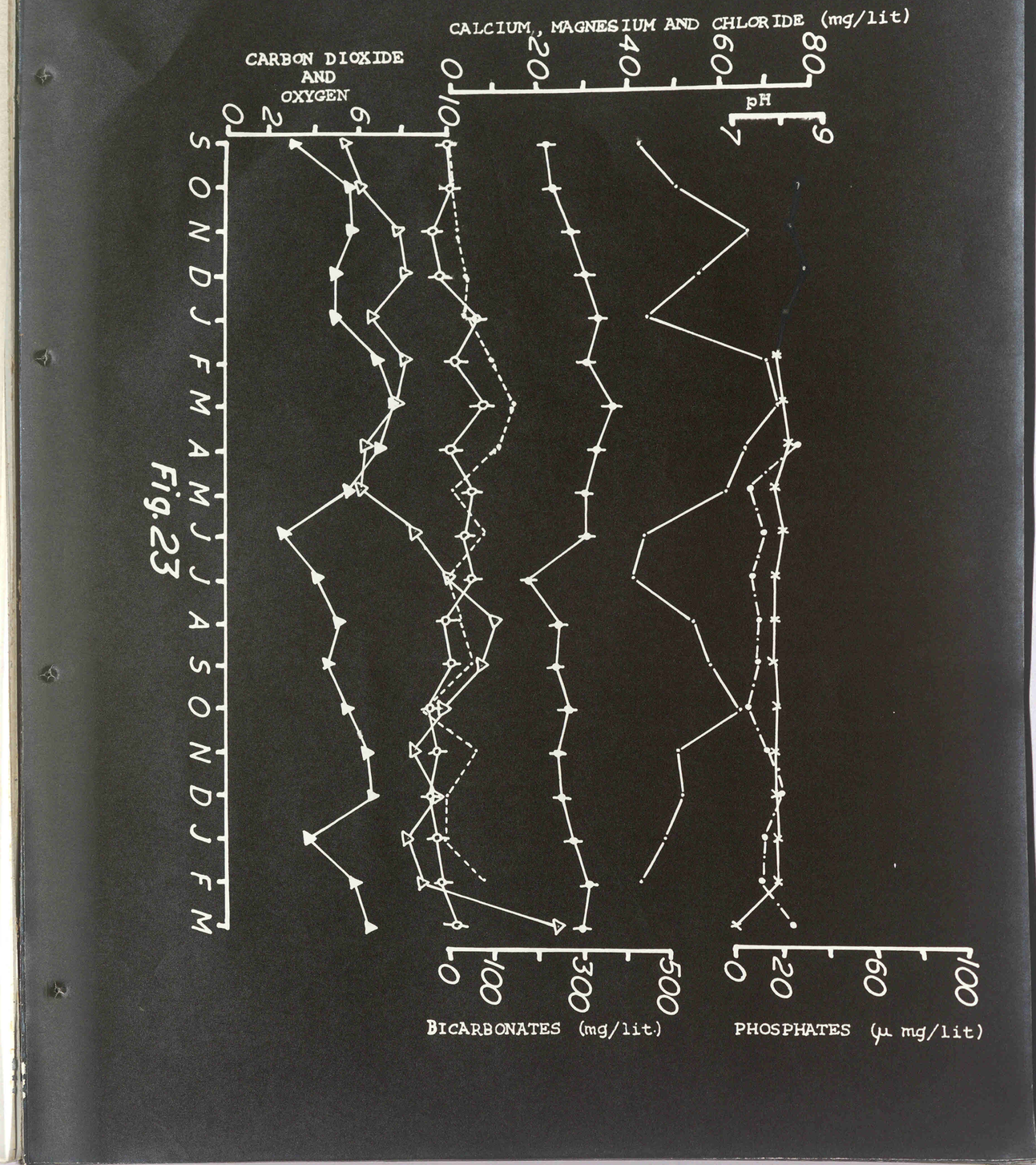
Magnesium

Chloride

Phosphate

pH

Fig. 23. Seasonal changes in chemical parameters of water at Station No. II during September, 1974 to March, 1976.



Legend :

Free carbon dioxide

Dissolved oxygen

Bicarbonates

Calcium

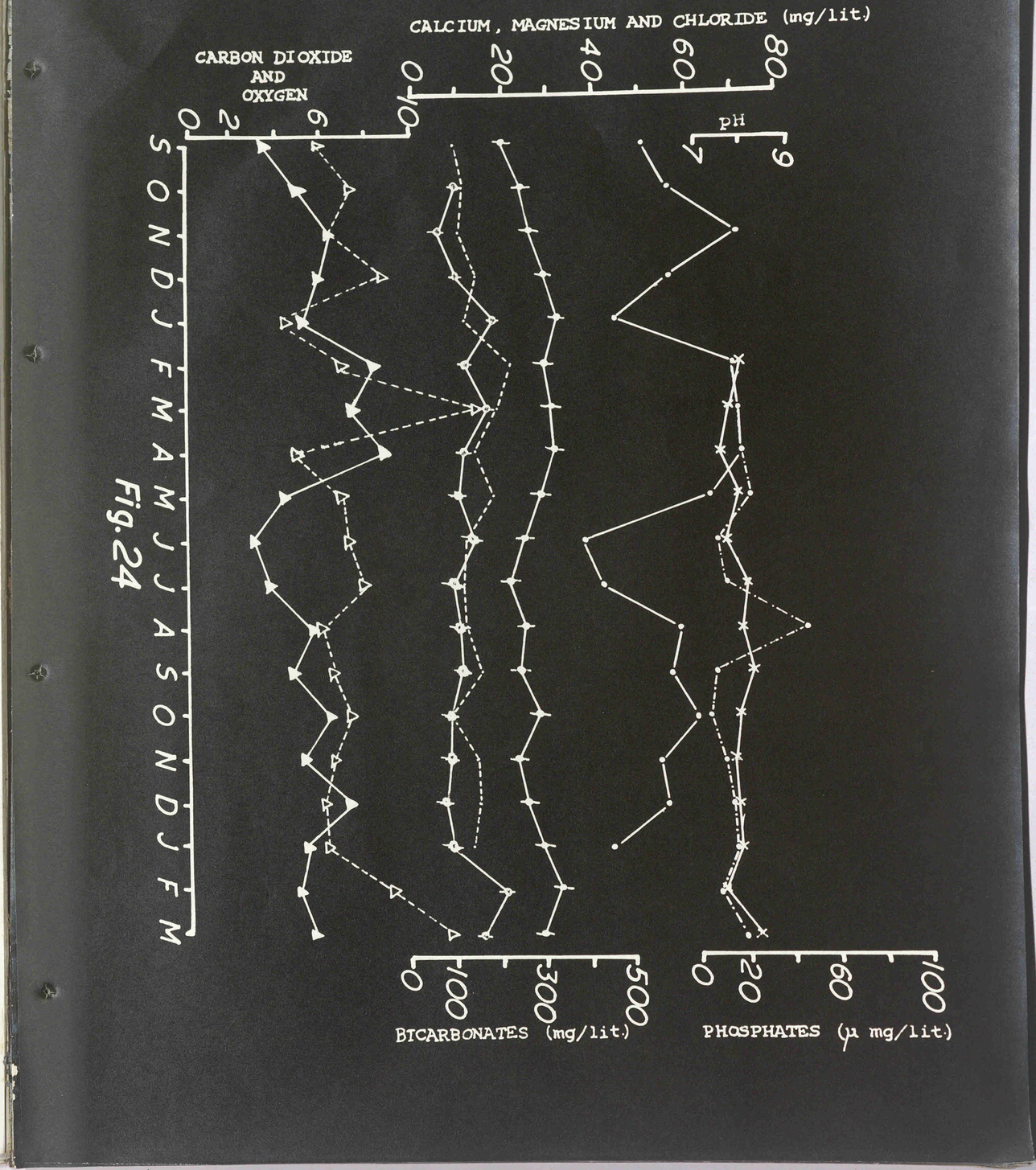
Magnesium

Chloride

Phosphate

pH

Fig. 24. Seasonal changes in chemical parameters of water at Station No. III during September, 1974 to March, 1976.



Legend :

Total sand
Silt
Clay
Loam
pH
Available Potassium
Total nitrogen
Organic matter
Organic carbon
Bicarbonate
Conductivity
Available phosphorus

Fig. 25. Seasonal changes in physico-chemical parameters of bottom soil at Station No. IV during October, 1974 to June, 1976.

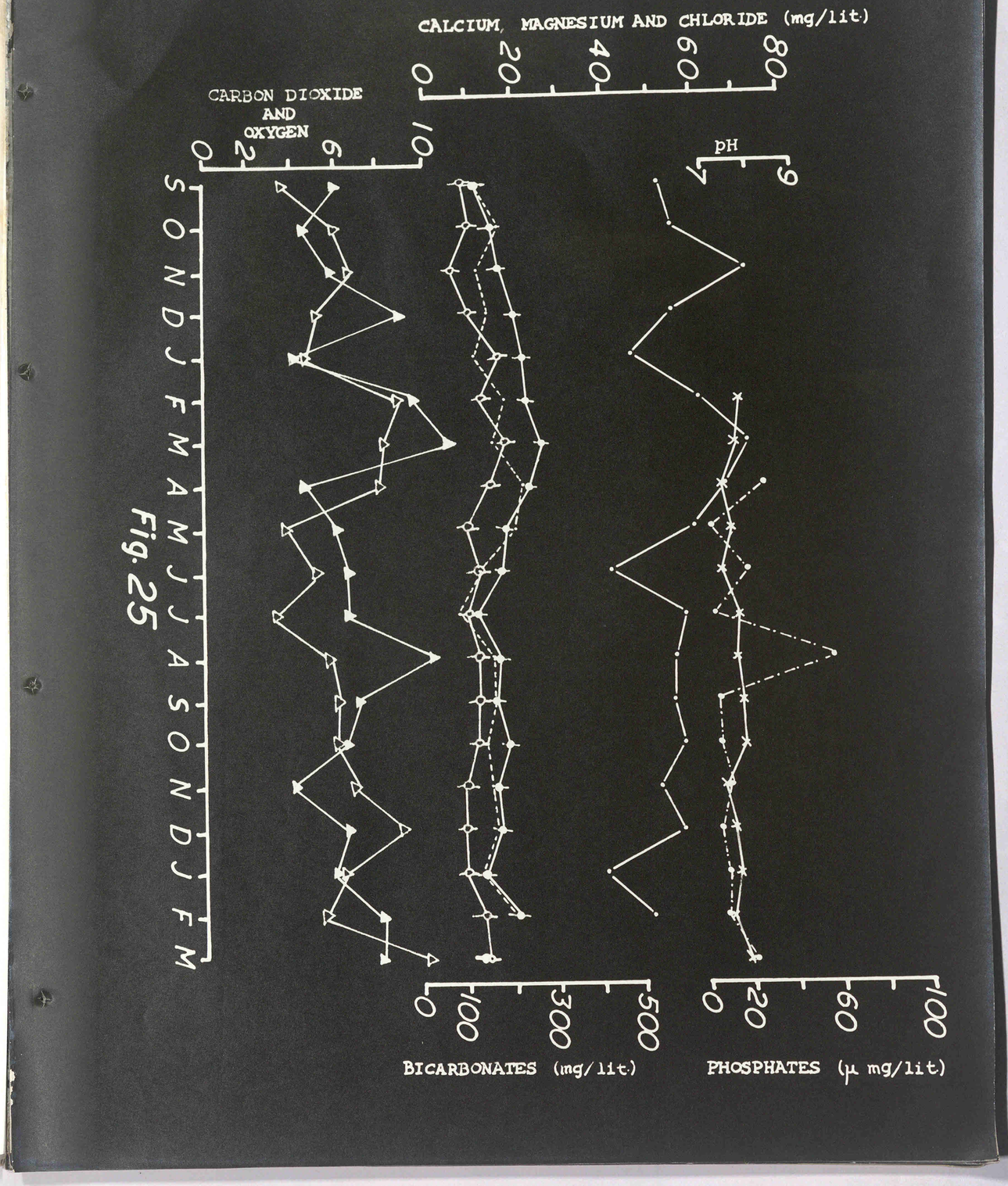


Fig. 25

Legend :

Free carbon dioxide

Dissolved oxygen

Bicarbonates

Calcium

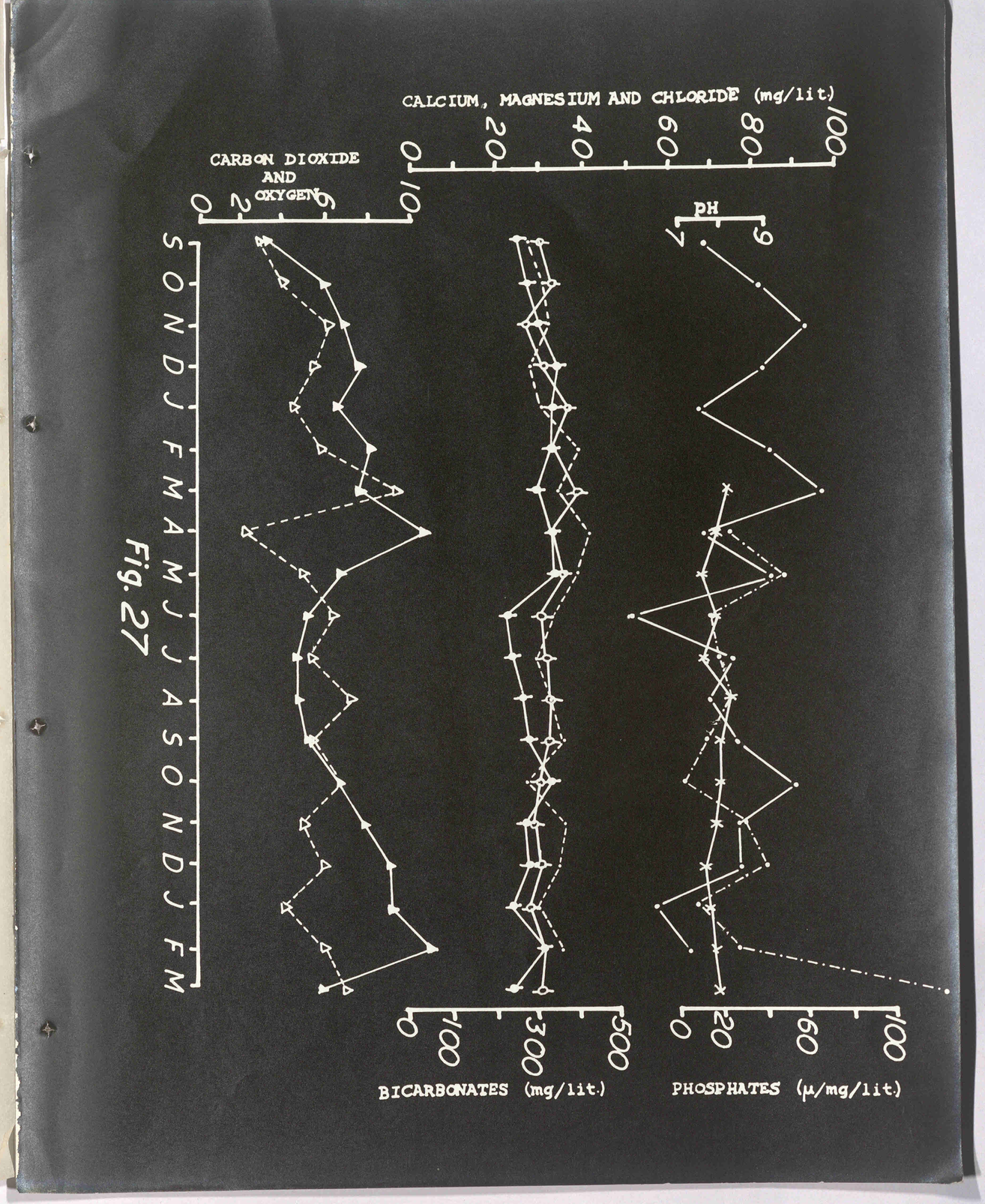
Magnesium

Chloride

Phosphate

pH

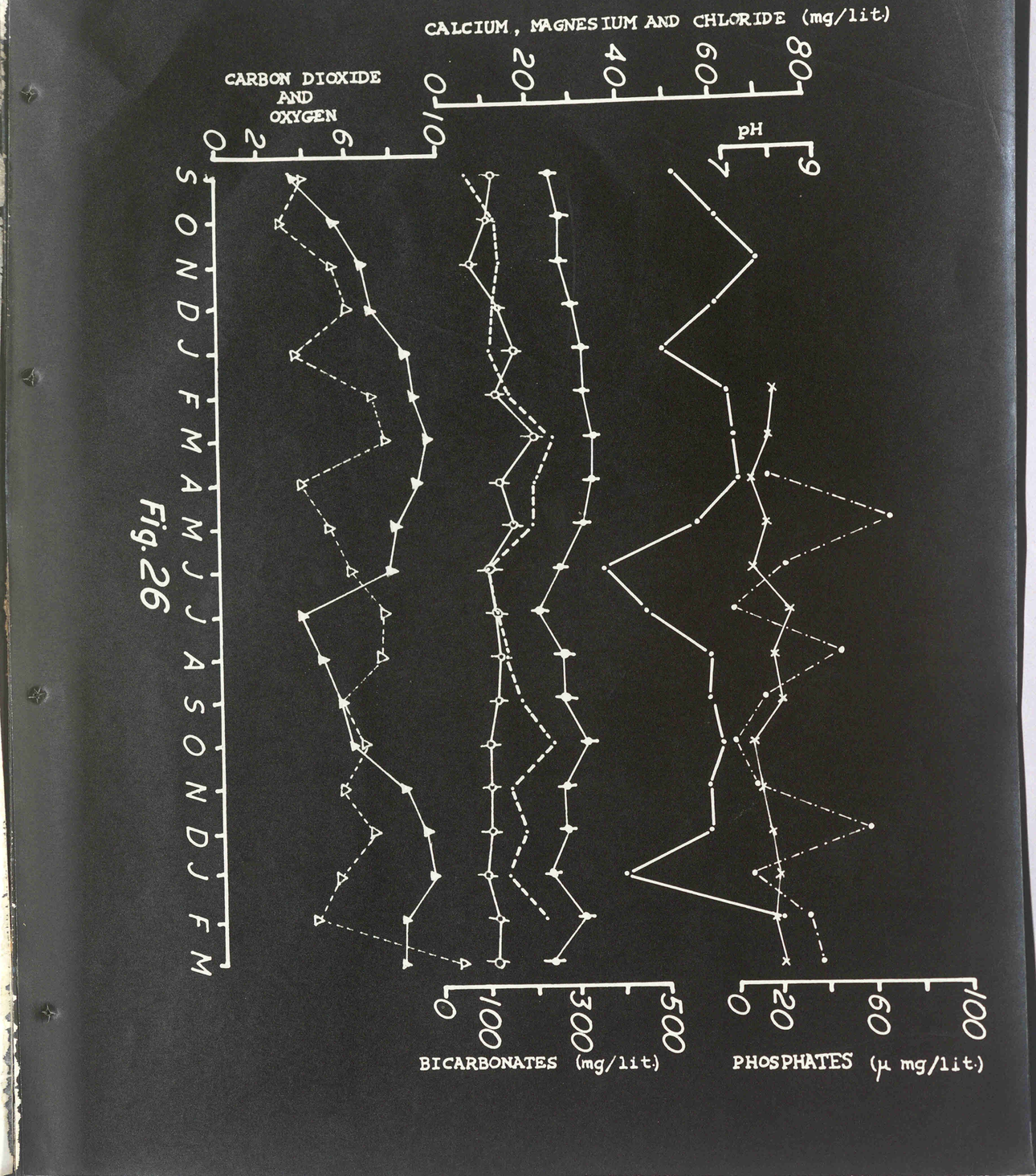
Fig. 27. Seasonal changes in chemical parameters of water at Station No. VII during September, 1974 to March, 1976.



Legend :

Total sand
Silt
Clay
Loam
pH
Available Potassium
Total nitrogen
Organic matter
Organic carbon
Bicarbonate
Conductivity
Available phosphorus

Fig. 26. Seasonal changes in physico-chemical parameters of bottom soil at Station No. V during October, 1974 to June, 1976.



Legend :

Free carbon dioxide

Dissolved oxygen

Bicarbonates

Calcium

Magnesium

Chloride

Phosphate

pH

Fig. 28. Seasonal changes in chemical parameters of water at Station No. VII during September, 1974 to March, 1976.

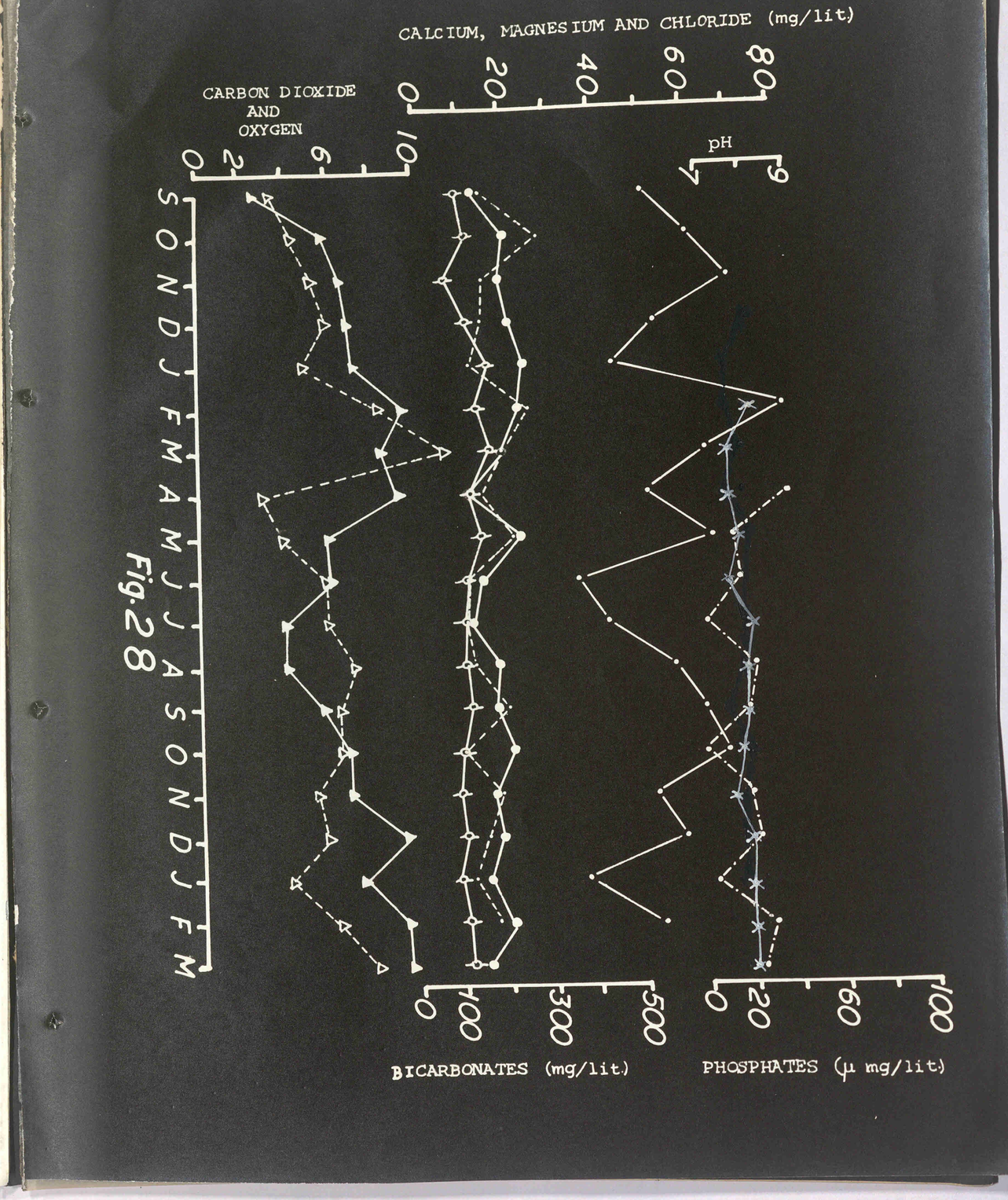


Fig. 29. - Herds of animals grazing on the sides of the stream.

Fig. 30. - Cattle drinking water

Fig. 31. - Mud embankments at Station II.

Fig. 32. - Soil erosion at Station II.



A. BOTTOM FAUNA

Soil micro-organisms viz. bacteria, fungi and protozoa remained outside the scope of present investigations. However, benthic macro-organisms have been studied in sufficient details.

Qualitative composition of benthos: Bottom macro-fauna of Gadigarh stream is diverse. The following macro-invertebrates have been found associated with the bottom.

Insecta

Chironomus sp.

Annelida

Oligochaeta

Mollusca

Viviparus bengalensis (Lamarck)
Melanoides (*Melanoides*) *tuberculatus* (Muller)
Lymnaea (*Pseudosuccinea*) *acuminata* f. *gracilior* Martens
Lymnaea (*Pseudosuccinea*) *acuminata* f. *rufescens* Gray
Lymnaea (*Pseudosuccinea*) *luteola* f. *australis* Annandale and Rao
Lymnaea (*Pseudosuccinea*) *acuminata* f. *typica* Lamarck
Indoplanorbis exustus Deshayes
Gyraulus convexiusculus (Hutton)
Lamellidens marginalis (Lamarck)
Lamellidens corrianus (Lea)
Indonia sp.

Chironomus larvae, which according to Valle (1930), Miyadi (1931), Miyadi and Hazema (1932), [redacted], Srivastava (1956), Baggae and Jumpanen (1968), Hynes *et al.* (1974), and Mandal and Moitra (1975) dominate rivers, ponds or lakes during one season or the other, never appear to dominate over the other benthos in Gadigarh stream, and may even be absent from some stations during greater part of the year. As concluded by Alm (1922), Valle (1930),

Jarnefelt (1940), Zelinka (1962), Bagge and Tukki (1967), Bagge and Jumpanen (1968) and Hynes et al. (1974) abundance of Chironomus larvae is related to the presence of rich nutrients coupled with deficient oxygeh. In Gadigarh stream which has rich nutrients, never showed poor oxygen conditions in seasonal and diurnal studies (Tables XXXIII - XXXIX and LIV - LVIII; Figs. 22 - 28 and 47 - 51) and thus does not support enough Chironomus larvae.

Oligochaetes in Gadigarh stream are present throughout the year, though decreasing almost to complete absence at some stations during monsoon months (Tables XL - IVL ; Figs. 33 - 39), An observation opposed to that of Ray et al. (1966) who conversely observed the presence of oligochaetes at Bhagalpur only during monsoons, which may be correlated with dilution of pollutants; the pollution of river Ganga upstream of Bhagalpur is on record (Thakur and Deshpande, 1976). However, Goodnight and Whitley (1961), Hynes (1960), and Howmiller and Beeton (1971) suggested the abundance of oligochaetes as an indication of pollution. Within Gadigarh stream which is free from pollution, oligochaetes abound at places where current is weak (pools) and bottom is soft, sandy and organically rich. Similar observations have been made by

Kownacka (1971), Kownacka and Kownacki (1965), and Drantal and Szczensy (1965).

It may thus be concluded that presence of oligochaetes at Gadigarh stream is indicative of organic enrichment of the stream bed, but not of organic pollution as mentioned by various investigators.

Molluscan predominance in the bottom of Gadigarh stream is similar to that recorded from some stations of the river Ganga (Ray et al.1966).

Relative abundance:

Oligochaetes: Seasonal studies reveal maximum abundance of oligochaetes during April and May at all stations, and declining to a minimum during July to September (Tables XL - IVL; Figs. 33 - 39). This may be due to organic richness of Gadigarh stream from February - June. Such a relationship of organic richness with abundance of benthos has been suggested by Kownacka and Kownacki (1965), and Egglishaw et al. (1967).

Since benthos is related to detritus and detritus to the standing plant production, it has been observed by contemporary worker (unpublished) that the peak production period of aquatic vegetation is

during February to April after which it decreases. The relationship is reflected in the increase of benthic animals. The role of higher temperature within the optimum range linked with greater production of benthic annelids during April to May come to surface during present observations, which supports the view of Kownacka et al. (1965).

Another important correlation of benthos has been suggested by Egglishaw et al. (1967), who proposed that bacterial decomposition is accelerated by high concentration of calcium in water and that the benthos consumes organic detritus, only when it has been sufficiently decomposed. The benthic abundance in Gadigarh stream is from April to May, while the higher calcium values in stream water are observed from February to April (Tables XXXIII - XXXIX) which observation thus supports the above view.

Maximum benthic population of oligochaetes has been observed at Station V which may be attributed to bathing of cattle (including addition of cattle excreta) and immersion of ashes from nearby cremation grounds situated close to the Station. These major factors along with subsidiary influences of clothes washing contribute to oligochaete abundance at Station V

in comparison with other stations. A similar conclusion of oligochaete abundance in isolated spots of river Dunajec attributed to domestic sewage influence was recorded by Drantal et al. (1965).

As discussed above Station V supports maximum oligochaetes and in normal sequence it would be expected that the stations that follow should support equal if not more oligochaetes. But the present investigations suggest a decline in oligochaete population in Station VII which may be due to scarcity of detritus (caused by greater run down from entry point of water in Station VII) and gravely bottom (confluence with Ballol further augmenting the sand content by deposition).

Molluscs: Present observations do not leads us to any conclusion in which the seasonal abundance of Lamellidens sp., Indoplanorbis sp., Gyrulus sp., Melanoides sp., and Lymnaea sp., could be explained. But some reasons causing fluctuations of Viviparous sp., and Indonia sps., are being discussed.

Viviparous bengalensis attains its peak during May and June which could be due to higher

organic matter in the stream serving as food of viviparus.

Maximum production of Indonaia spp., has been observed in the month of May and June, which may be due to sufficient detritus and other factors as already discussed for Viviparus.

Table XL. Seasonal variations in abundance of benthic components at Station I in Gadigarh stream.

Year	1975												1976		
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Organism															
Insecta															
Chironomus sp.	3	5	8	10	25	8	-	-	-	3	5	5	-	-	-
Annelida															
Oligochaeta	10	55	110	240	240	63	18	8	-	-	13	10	18	8	38
Mollusca															
Viviparus bengalensis (Lamarck)	5	3	1	4	8	14	5	4	2	3	2	-	1	3	5
Melanoides (*Melanoides*) *tuberculatus* (Muller)	2	1	2	2	2	1	-	-	-	-	-	-	-	-	-
Lymnaea sp.	1	5	3	2	6	1	1	3	-	-	-	-	-	-	-
Gyraulus convexiusculus (Hutton)	2	6	2	3	3	1	2	3	-	-	-	-	-	-	-
Indoplanorbis exustus (Deshayes)	-	2	3	1	3	5	-	-	-	-	-	-	-	-	-
Lamellidens sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indonaia sp.	3	2	2	1	6	8	3	2	-	-	-	-	-	-	-

Table IXL. Seasonal variations in abundance of benthic components at Station II in Gadigarh stream.

Year	1975												1976			
Month / Organism	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	
Insecta																
Chironomus sp.	3	15	5	8	3	3	15	-	-	-	-	3	3	8	5	
Annelida																
Oligochaeta	15	38	40	90	160	67	8	-	-	13	25	10	45	15	60	
Mollusca																
Viviparus bengalensis (Lamarck)	4	3	5	8	13	18	4	2	3	5	2	2	6	3	8	
Melanoides (Melanoides) tuberculatus (Muller)	-	-	1	3	-	-	-	2	-	-	-	-	-	-	-	
Lymnaea sp.	4	3	-	-	2	1	-	2	-	-	-	2	1	3	1	
Gyraulus convexiusculus (Hutton)	3	2	2	1	1	-	-	-	-	-	-	2	1	-	-	
Indoplanorbis exustus (Deshayes)	2	1	-	3	1	-	-	-	-	-	2	3	1	-	-	
Lamellidens sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Indonaia sp.	5	2	6	5	11	8	2	-	-	1	4	3	2	3	5	

Table VIIIL. Seasonal variations in abundance of benthic components at Station III in Gadigarh stream.

Year	1975												1976		
Month / Organism	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Insecta															
Chironomus spp.	3	10	10	5	5	3	-	-	-	-	-	5	3	5	18
Annelida															
Oligochaeta	18	33	55	110	200	25	13	-	-	5	40	25	8	10	25
Mollusca															
Viviparus bengalensis (Lamarck)	6	3	2	5	14	19	3	-	-	-	3	4	5	1	6
Melanoides (Melanoides) tubdrculatus (Muller)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaea spp.	-	-	-	1	3	-	5	-	-	-	4	-	-	2	-
Gyraulus convexiusculus (Hutton)	-	-	-	-	4	3	2	-	-	-	-	3	-	-	1
Indoplanorbis exustus (Deshayes)	2	5	3	-	-	-	2	2	1	-	-	-	-	-	-
Lamellidens spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indonaia spp.	2	4	3	4	8	10	5	-	-	2	4	5	5	3	4

Table VIIL. Seasonal variations in abundance of benthic components at Station IV in Gadigarh stream.

Year	1975												1976		
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Organism															
Insecta															
Chironomus sp.	3	3	5	10	10	5	-	-	-	-	-	-	-	-	-
Annelida															
Oligochaeta	13	43	63	150	78	63	40	-	-	15	33	20	15	20	53
Mollusca															
Viviparus bengalensis (Lamarck)	3	5	3	4	8	10	3	1	-	2	1	4	1	3	4
Melanoides (Melanoides) tuberculatus (Muller)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaea sp.	-	-	-	2	2	4	-	3	5	1	-	-	-	-	-
Gyraulus convexiusculus (Hutton)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indoplanorbis exustus (Deshayes)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lamellidens sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indonaia sp.	2	1	1	3	7	6	1	-	-	-	-	2	3	1	3

Table VII. Seasonal variations in abundance of benthic components at Station V in Gadigarh stream.

Year	1975												1976		
Month / Organism	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Insecta															
Chironomus spp.	3	18	10	-	-	8	-	-	-	3	5	5	8	3	7
Annelida															
Oligochaeta	85	105	153	300	360	105	28	40	18	35	44	48	30	33	7
Mollusca															
Viviparus bengalensis (Lamarck)	3	5	6	10	9	5	1	6	4	3	2	4	4	5	3
Melanoides (Melanoides) tuberculatus (Muller)	1	1	5	2	1	3	-	-	-	-	3	1	2	3	4
Lymnaea spp.	2	5	3	3	2	4	1	-	-	-	-	1	5	3	6
Gyraulus convexiusculus (Hutton)	-	-	2	5	1	2	3	-	-	1	-	3	1	4	2
Indoplanorbis exustus (Deshayes)	2	5	3	1	2	1	-	-	5	-	-	-	3	-	4
Lamellidens spp.	1	1	2	3	-	2	3	3	4	1	-	1	5	1	4
Indonaia spp.	4	3	4	5	10	9	3	1	2	5	3	4	4	2	4

Table VL. Seasonal variations in abundance of benthic components at Station VI in Gadigarh stream.

Year	1975												1976		
Month / Organism	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Insecta															
Chironomus sp.	10	5	5	8	3	3	18	-	-	-	-	-	-	-	-
Annelida															
Oligochaeta	23	53	100	320	203	105	50	40	18	35	44	48	18	25	33
Mollusca															
Viviparus bengalensis (Lamarck)	5	3	2	5	9	15	5	1	1	4	2	2	6	3	5
Melanoides (Melanoides) tuberculatus (Muller)	1	1	3	1	3	5	-	-	-	-	1	1	5	2	3
Lymnaea sp.	-	-	-	-	-	3	5	3	1	-	2	-	-	-	-
Gyraulus convexiusculus (Hutton)	-	-	2	3	5	-	-	2	6	1	-	-	3	1	2
Indoplanorbis exustus (Deshayes)	2	2	3	2	5	1	1	3	-	-	-	2	-	-	3
Lamellidens sp.	-	2	1	1	3	5	-	-	-	1	-	2	3	-	1
Indonaia sp.	3	5	3	6	8	10	3	2	1	1	4	2	5	3	4

Table IVL. Seasonal variations in abundance of benthic components at Station VII in Gadigarh stream.

Year	1975												1976		
Month / Organisms	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Insecta															
Chironomus spp.	8	4	-	-	-	-	-	-	-	5	2	3	-	-	-
Annelida															
Oligochaeta	5	48	10	113	63	10	-	-	-	10	18	15	10	15	8
Mollusca															
Viviparus bengalensis (Lamarck)	2	4	3	1	6	8	-	-	-	-	-	2	3	1	5
Melanoides (*Melanoides*) (Muller) *tuberculatus* (Muller)	-	-	3	1	2	-	1	-	-	5	-	-	1	-	-
Lymnaea spp.	-	-	-	-	-	5	-	3	-	-	-	1	1	-	-
Gyraulus convexiusculus (Hutton)	1	-	-	5	3	-	2	-	1	1	-	-	-	1	-
Indoplanorbis exustus (Deshayes)	-	2	1	-	-	-	2	-	6	-	-	1	-	3	2
Lamellidens spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indonaia spp.	-	1	3	2	4	5	3	-	-	-	2	2	1	3	4

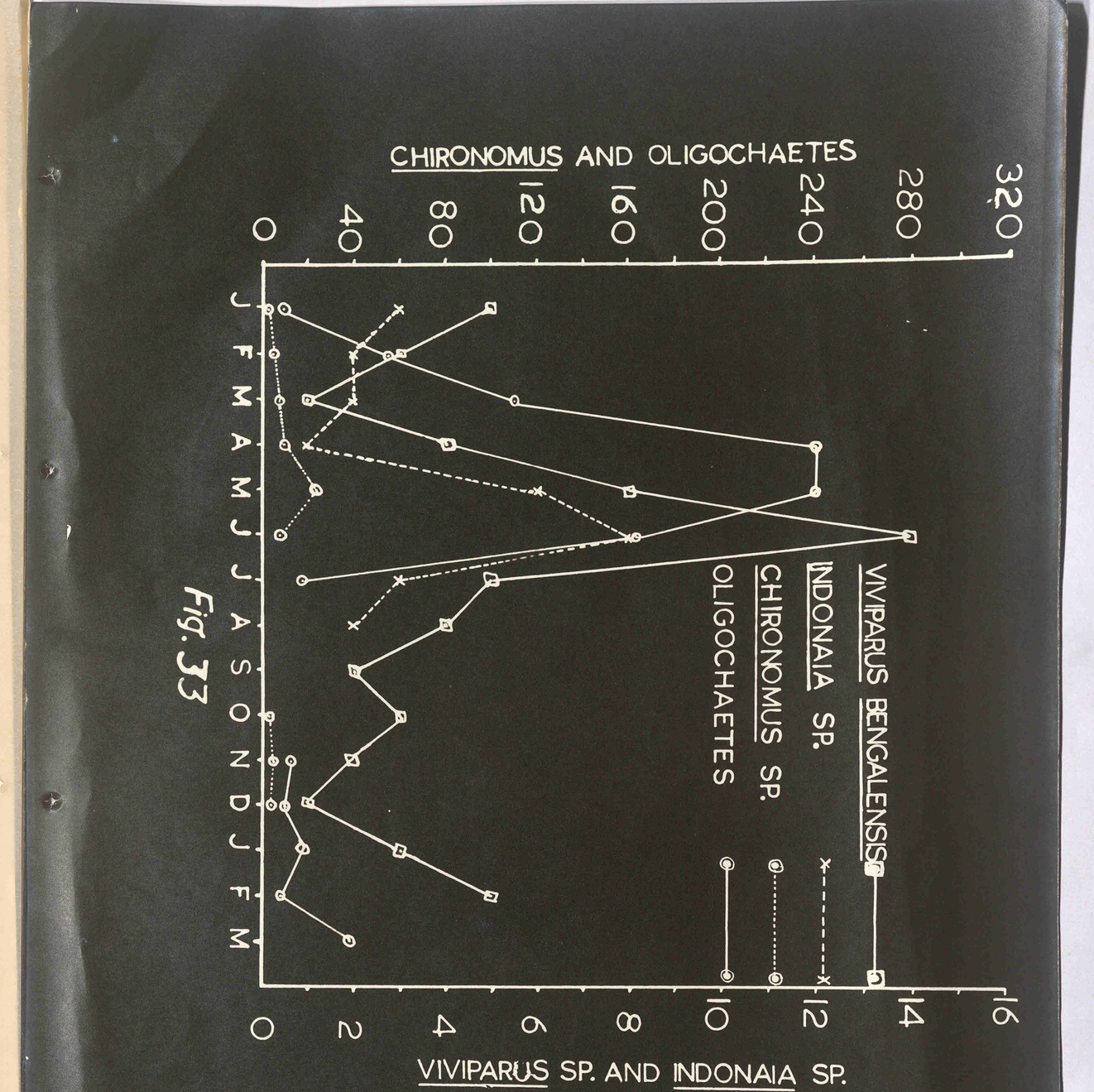


Fig. 33

Figs. 33. – Seasonal variations in abundance of benthic components at Station I, Gadigarh stream Viviparus bengalensis (Lamarck), Indonaia sps., Chironomus sps., and Oligochaetes.

Fig. 34. - Seasonal variations in abundance of benthic components at Station II in Gadigarh stream.

Viviparus bengalensis (Lamarck),
Indonaia sp.,
Chironomus sp., and
Oligochaetes.

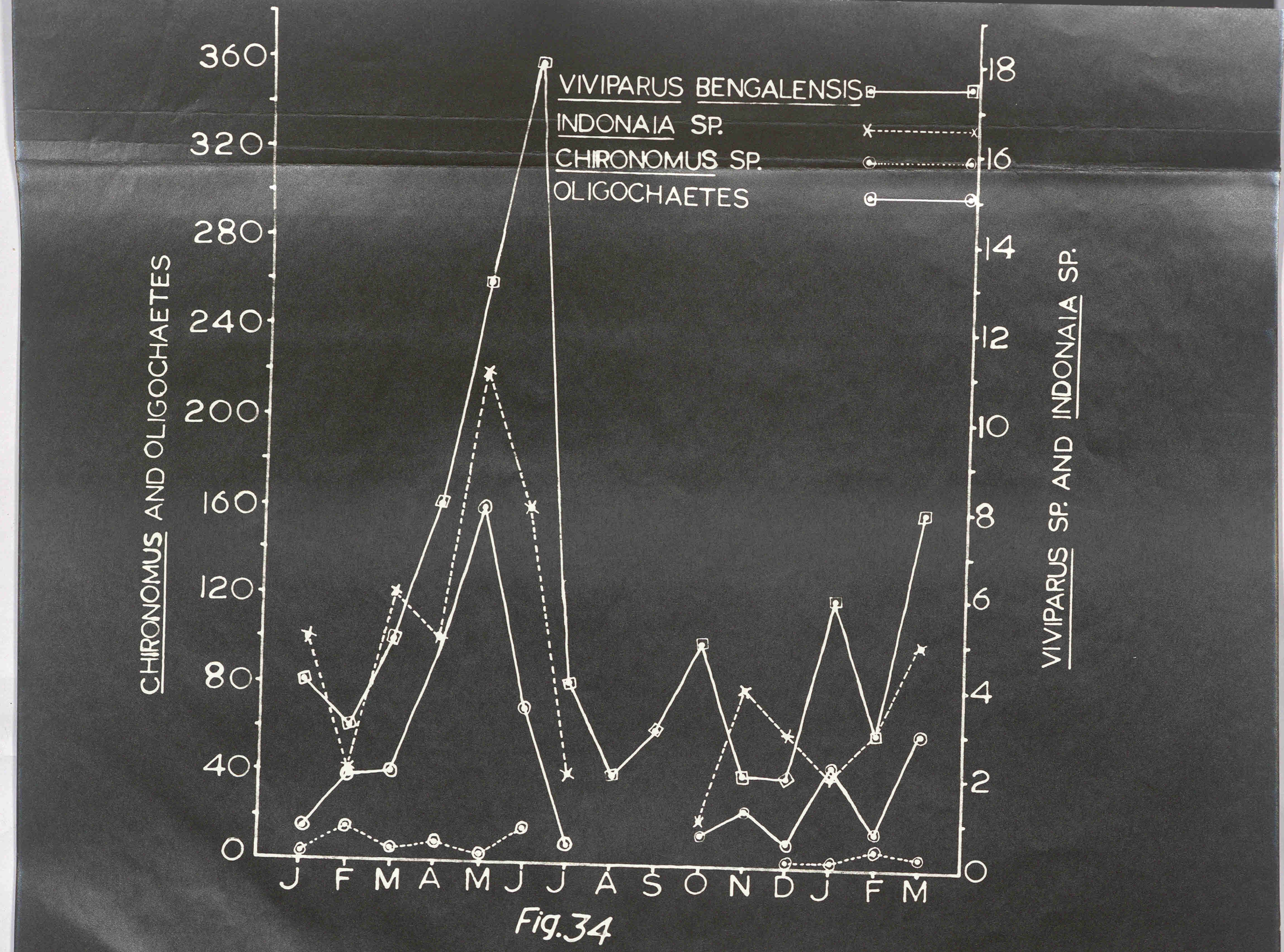

VIVIPARUS BENGALENSIS
INDONAIA SP.
CHIRONOMUS SP.
OLIGOCHAETES
CHIRONOMUS SP. AND OLIGOCHAETES
VIVIPARUS SP. AND INDONAIA SP.
360
320
280
240
200
160
120
80
40
0
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D J F M

Fig.34

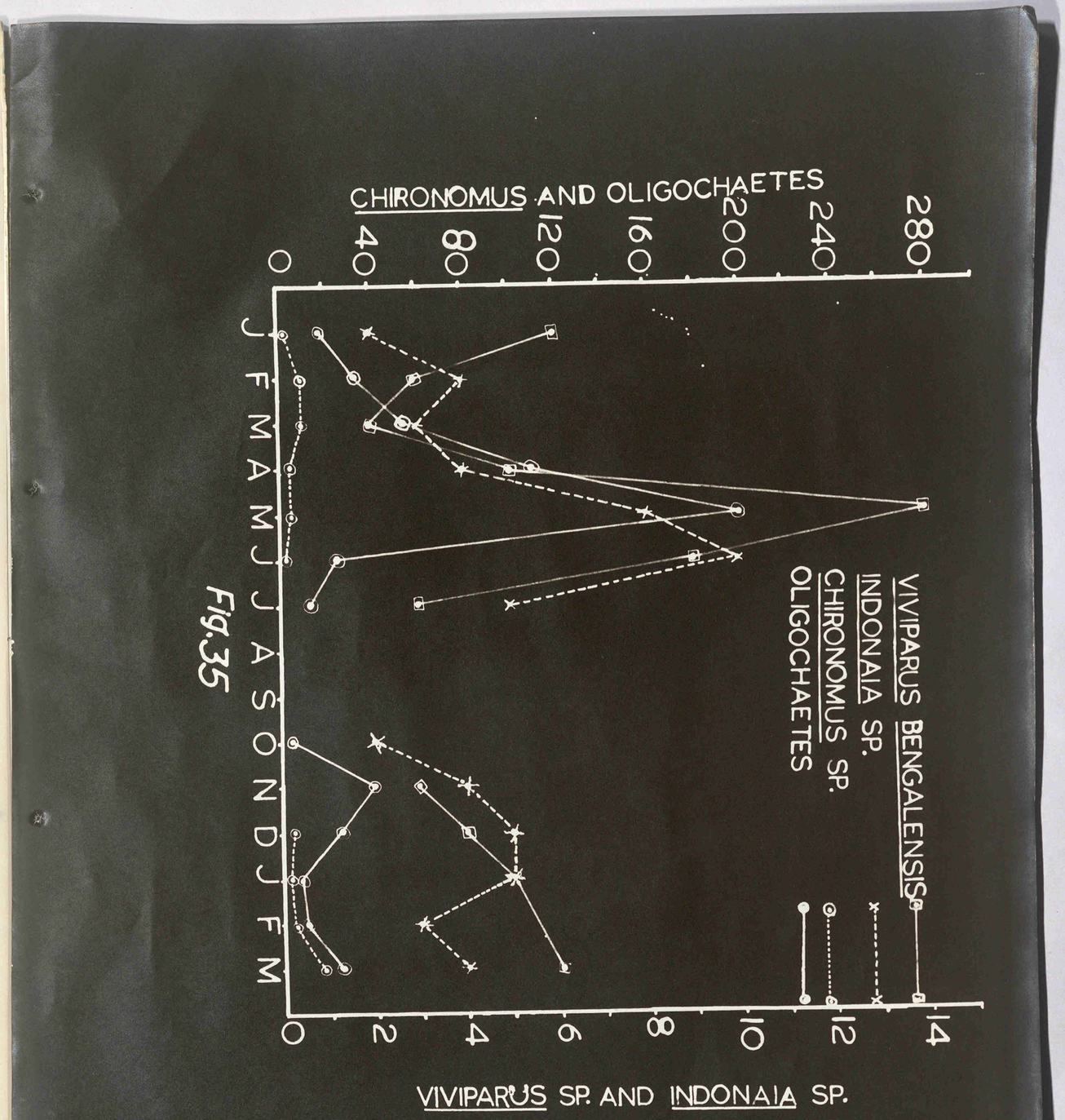


Fig.35

Fig. 35. - Seasonal variations in abundance of benthic components at Station II in Gadigarh stream.

Viviparus bengalensis (Lamarck)
Indonaia sp.,
Chironomus sp., and
Oligochaetes.

Fig. 36. - Seasonal variation in abundance of benthic components at Station IV in Gadigarh stream.

Viviparus bengalensis (Lamarck),
Indonaia spp.,
Chironomus spp., and
Oligochaetes.

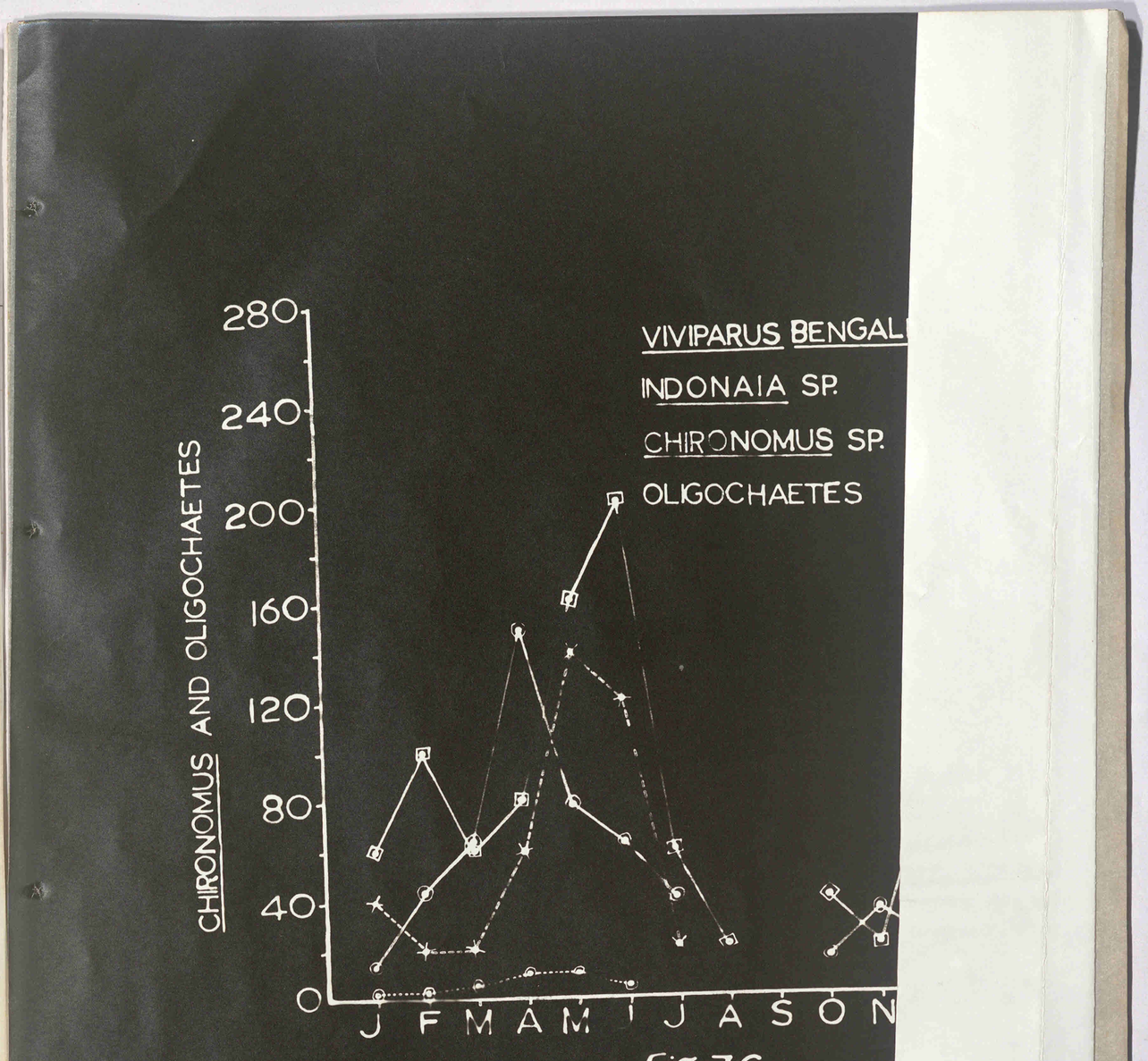


Fig.36

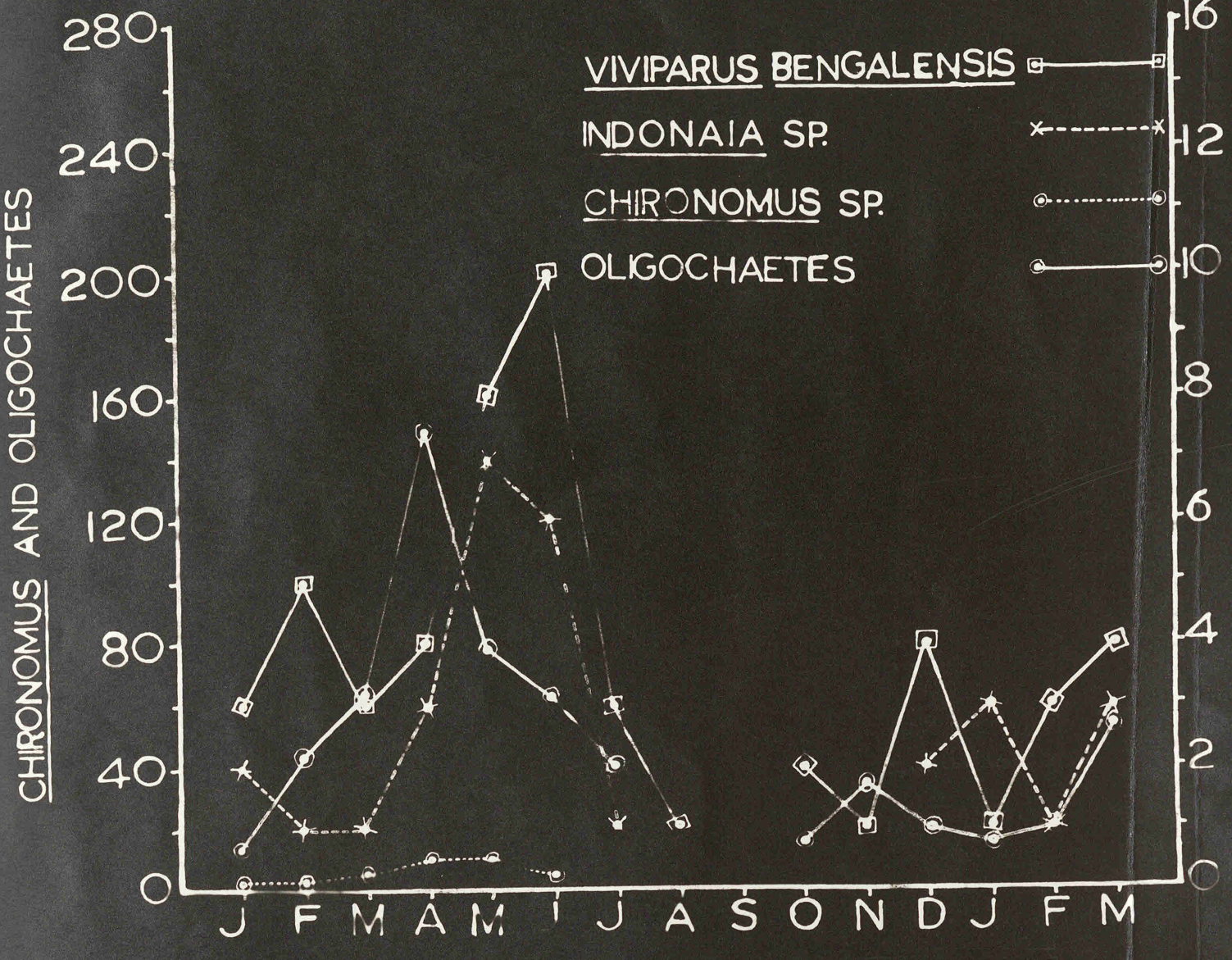

VIVIPARUS BENGALENSIS
INDONAIA SP.
CHIRONOMUS SP.
OLIGOCHAETES
CHIRONOMUS AND OLIGOCHAETES
VIVIPARUS SP. AND INDONAIA SP.
0
40
80
120
160
200
240
280
0
2
4
6
8
10
12
16
J F M A M J J A S O N D J F M

Fig.36

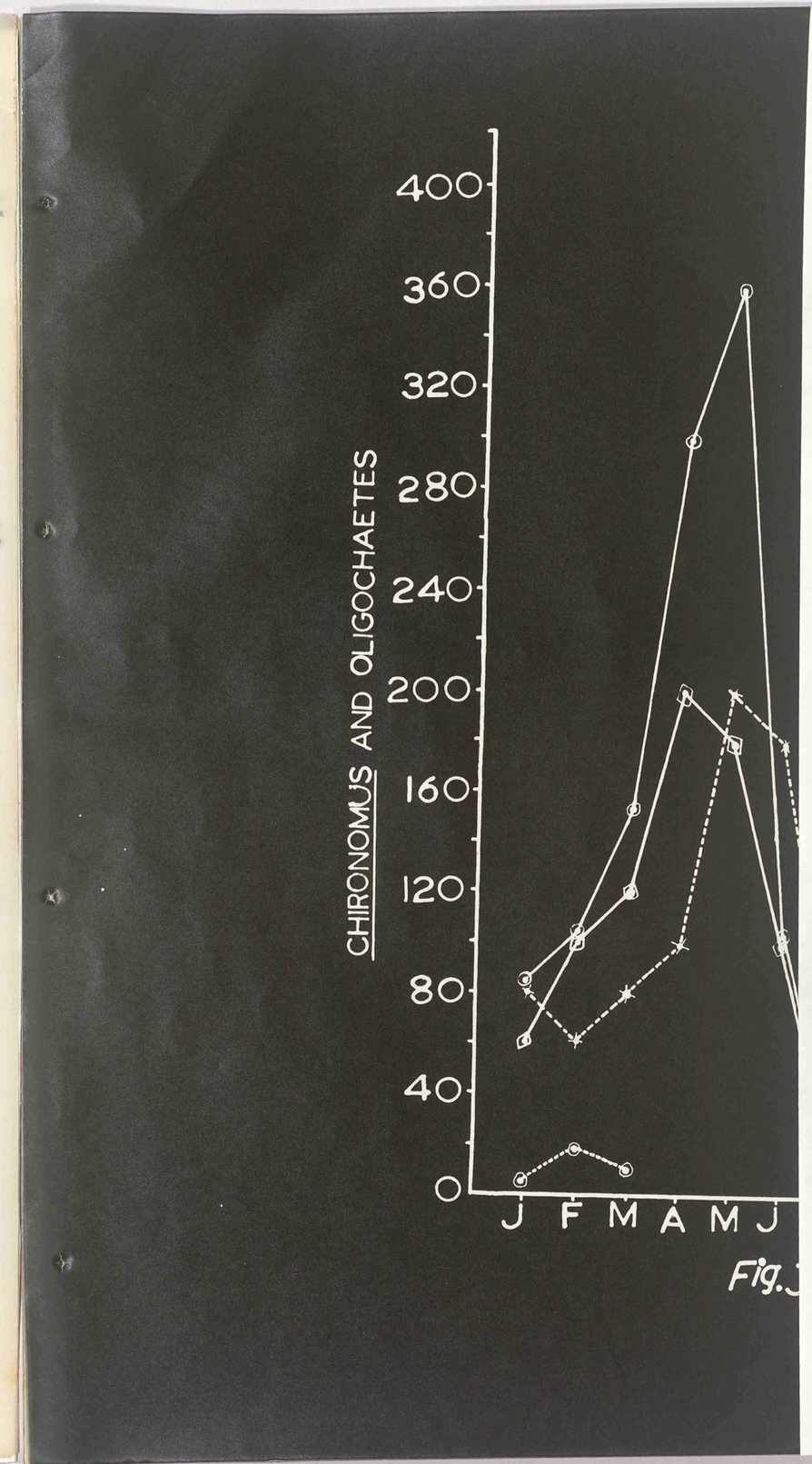


Fig. 37. - Seasonal variations in abundance of benthic components at Station V in Gadigarh stream.

Viviparus bengalensis (Lamarck),
Indonaia sp.,
Chironomus sp., and
Oligochaetes.

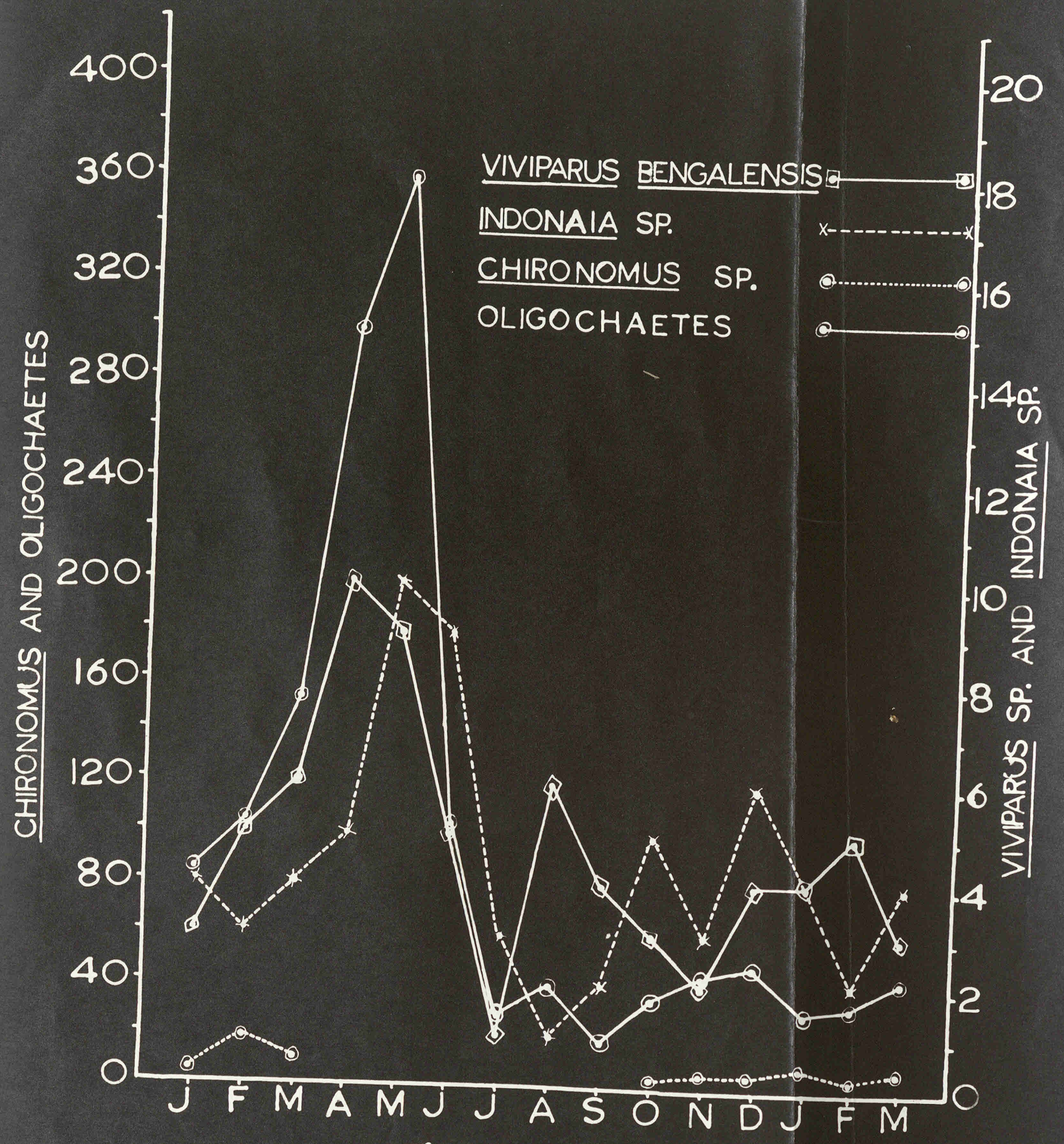

VIVIPARUS BENGALENSIS
INDONAIA SP.
CHIRONOMUS SP.
OLIGOCHAETES
CHIRONOMUS AND OLIGOCHAETES
VIVIPARUS SP. AND INDONAIA SP.
0
40
80
120
160
200
240
280
320
360
400
0
2
4
6
8
10
12
14
16
18
20
J F M A M J J A S O N D J F M

Fig.37

Fig. 38. - Seasonal variations in abundance of benthic components at Station VI in Gadigarh stream.

Viviparus bengalensis (Lamarck),
Indonaia sp.,
Chironomus sp., and
Oligochaetes.

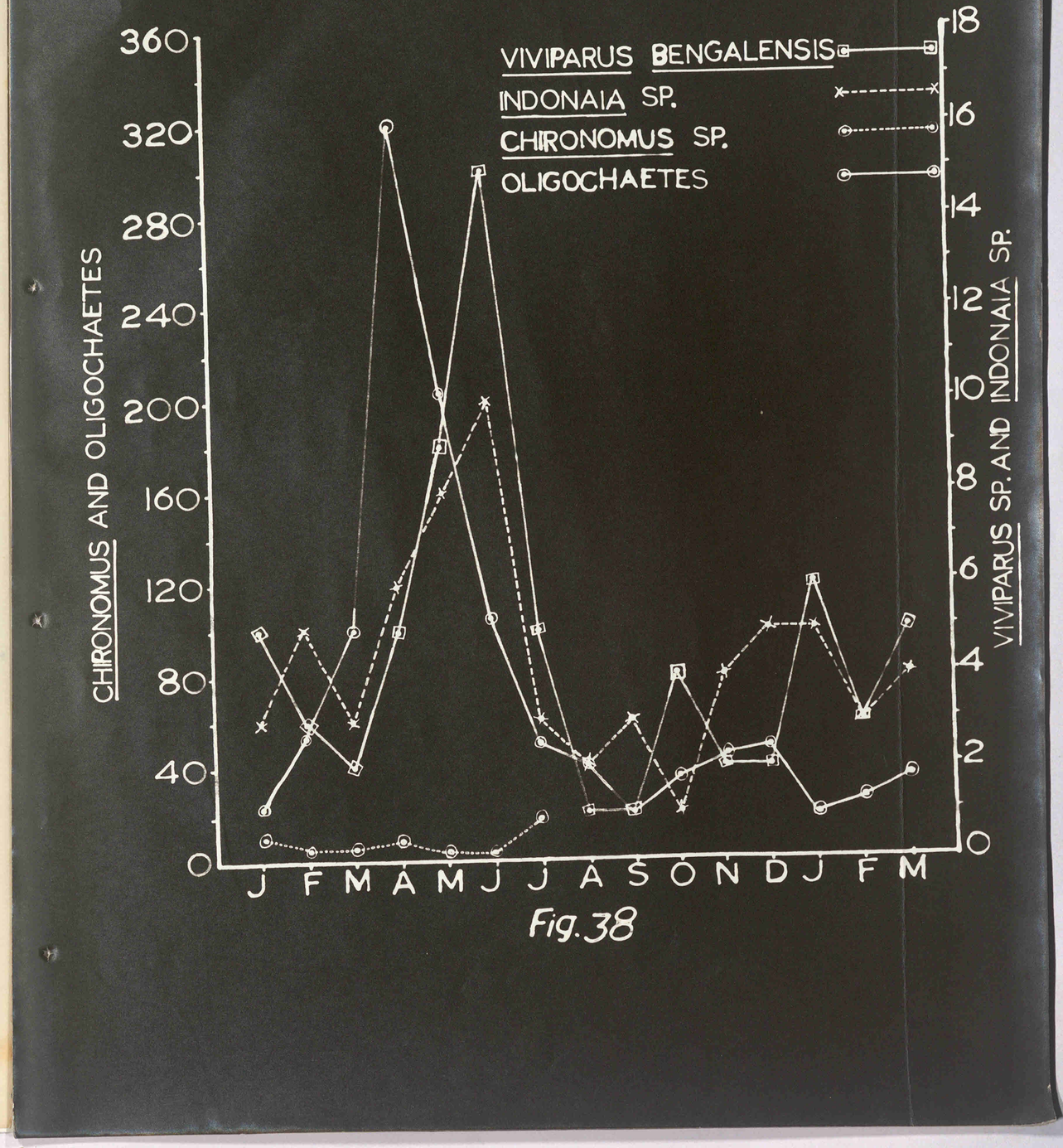
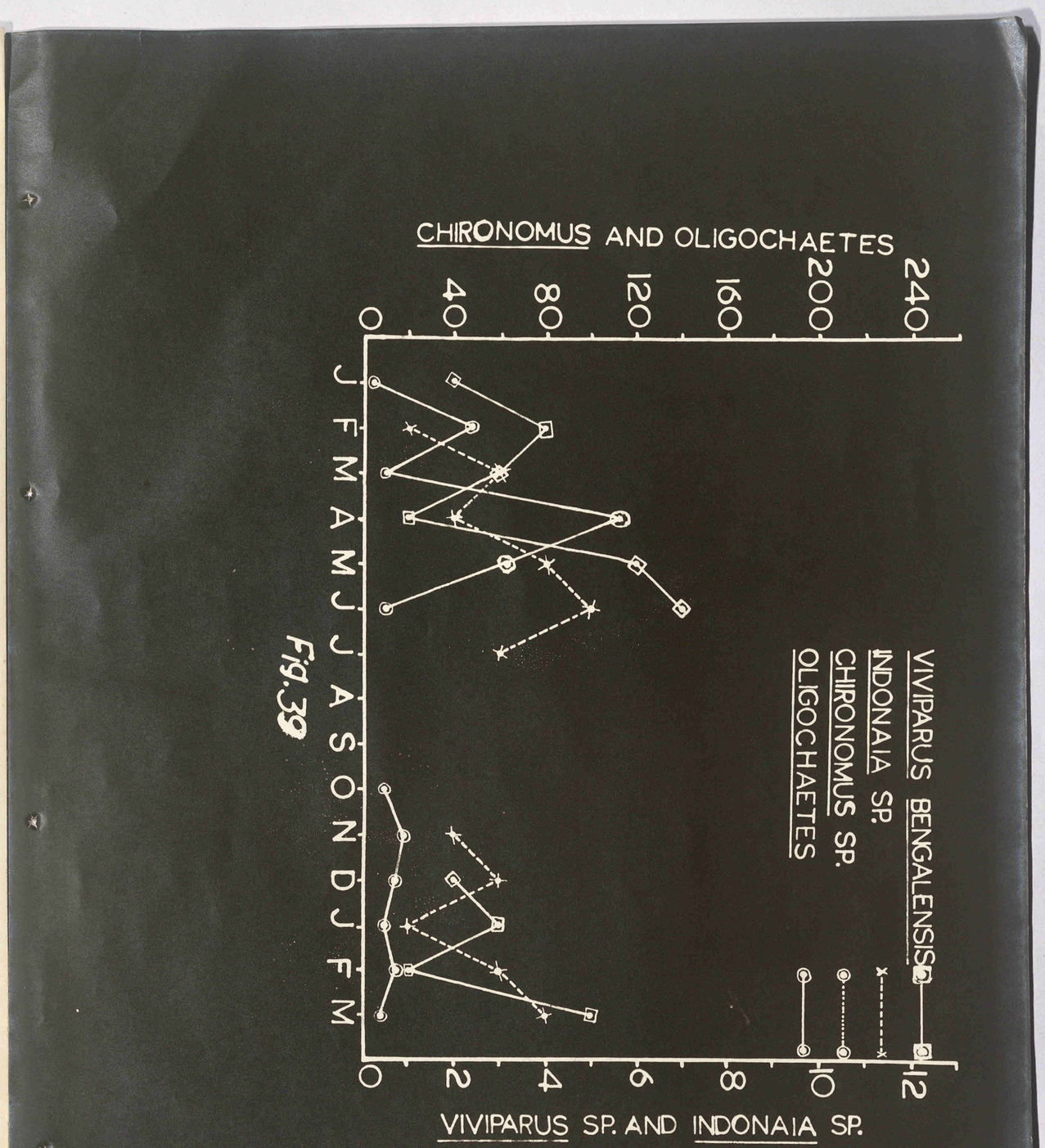


Fig. 38

Fig. 39. - Seasonal variations in abundance of benthic components at Station VII in Gadigarh stream.

Viviparus bengalensis (Lamarck),
Indonaia spp.,
Chironomus spp., and
Oligochaetes.



B. ZOOPLANKTON

1. Origin of zooplankton of Gadigarh stream:

Zooplankton of Gadigarh stream is generally of autogenetic origin, though some of it is allogenetic. In determining the autogenetic nature of zooplankton, we may have to examine the plankton producing capacity of different sources feeding the stream; as also concluded by Kofoid (1908), Krieger (1927), and Galtsoff (1929).

According to these investigators river plankton originates generally in areas around headwaters of rivers, their slow tributaries, pools formed along their course (heleoplankton) or finally in the connected lakes (limnoplankton).

Since Gadigarh is mostly a spring fed slow running pool, its plankton may be of autogenetic origin. The other minor sources of its water viz. Ranbir canal distributaries and the adjoining fields do not appear to contribute much to its plankton population and thereby eliminate the chances of much of its plankton being of allogenetic origin. Even rare components of plankton observed on

one or few occasions are autogenetic, being produced within the stream, but outside the limits of designated stations (from where they have been picked up); their production is, however, restricted in time and their life cycles are too short to be observed over an extended period.

Qualitative composition of zooplankton:

The plankton of the stream is composed of the following organisms.

Protozoa (11 species of 4 genera)	Arcella vulgaris Ehrenberg, A. discoides Ehrenberg, A. dentata Ehrenberg, Centropyxis ecornis Ehrenberg, C. aculeata, Ehrenberg, C. spinosa (Cash & Hopkinson), Difflugia corona, Wallich, D. tuberculata (Wallich), D. pyriformis Perty, D. acuminata Ehrenberg, Lesquersia spiralis (Ehrenberg).
Rotifera (5 genera)	Brachionus sp., Keratella sp., Lepadella sp., Monostyla sp., Lecane sps.
Copepoda (4 genera)	Cyclops sp., Mesocyclops sp., Macrocyclops sp., Eucyclops sp.

Cladocera (9 genera)	Simocephalus sps.,
	Scapholeberis sps.,
	Moina sps.,
	Ceriodaphnia sps.,
	Diaphanosoma sps.,
	Macrothrix sps.,
	Pleuroxus sps.,
	Leydigia sps.,
	Camptocerus sps.

Running waters of India have been analysed for planktonic composition by Chacko and Sreenivasan (1955), (Rivers Godavari and Krishna), Chakrabarty et al. (1959) (Jumna), and Rajan (1963) (Pykara and Moyar Nilgiris). The maximum number of species reported from these water bodies are 6 protozoa, 19 rotifera, 6 Cladocera (River Jumna); 3 Copepoda (Rivers Krishna and Jumna).

This richer variety of plankton in Gadigarh (when compared with other Indian lotic waters), is thus due to comparative abundance of nutrients producing greater phytoplankton which in turn supports this diversity of zooplankton. The various components of zooplankton indicating its richness may not occur concurrently but a succession in time appears to be prevalent in their ecological niches. Such a staggered occurrence helps to avoid competition and maintains a healthier population. May be for this reason all the

reported species are not observed at the same time, and to an observer the zooplanktonic composition of this stream reflects an impoverished picture.

Qualitative seasonal variations:

Crustacean components of zooplankton occur seasonally (Tables IIIL - LIII ; Figs. 40 - 46) which, as pointed out by Welch (1952), may be due to fewer active individuals of more quiescent forms, and extended intervals between successive generations. While Cladocera are unrepresented from August through November (Tables IIIL - LIII ; Figs. 40 - 46), Copepoda as a taxonomic group is present throughout the year (except during heavy rains); Copepod genera Macrocyclops, and Eucyclops, however, occur seasonally.

Suitable temperature and greater availability of nutrients from February - April appear to be responsible for phytoplankton variety which in turn supports a rich zooplanktonic composition.

Appearance of Diaphanosoma sp. in the stream from May - July may be due to their positive response to warmer waters in these months, as has been reported by Apstein (1896), Birge (1898), and Vasisht and Dhir (1970).

Relative abundance:

Zooplankton in Gadigarh occurs throughout the year except in August and September (Tables IIIL - LIII ; Figs. 40 - 46) exhibiting great fluctuations in their relative abundance.

Rebruary - April is the period of zooplankton abundance; because this is also the reproductive period of composing species. The fecundity of these organisms is also under the influence of exteroceptive factors like food and temperature. Winberg (1971) stated that the size of egg producing individual appears to influence fecundity as also pointed out earlier by Marshall (1949) for marine Copepods; Ravera and Tonolli (1949) for fresh water diaptomids; Green (1954), Dunke (1960) and Margalef (1955) for Cladocera. Allen (1920), Raj and Hussain (1956), Prasad (1956) and Byars (1960) concluded that temperature determines zooplankton production. Burns (1968), and Schindler (1968) supported this through their observations that processes like food consumption and digestion are temperature dependent. Temperature may also influence zooplankton growth indirectly, through its effect on

primary production, which is related to the optimum temperature (16.0° - 23.0°C) prevailing in Gadigarh stream in February - April. Heisig (1977) also indicated the importance of food supply in egg building and zooplankton growth and attributed abundance of Daphnia pulex in a German pond to this factor.

Additionally zooplankton abundance during the months under discussion could also be favoured by higher oxygen tension, and increased calcium contents in the stream. Such abiotic factors have been considered to be responsible for augmentation of zooplankton in other global water bodies also(Obreshakove, 1930; Terrao, 1937; Harris, 1957; Rigler, 1961; Cushing, 1964; Parker and Olson, 1966; Porcella et al. 1969, and Hazelwood, et al. 1973)

Decrease of absence of zooplankton recorded from July - October at most of the stations is the effect of monsoon. The increased flow of water results in greater speed of currents which sweep and disorganize planktonic population and aquatic vegetation. Such an explanation is in line with that held earlier by Kofoid (1908), Chandler et al. (1945) Berner (1951), Chakrabarty et al. (1959) all of whom

have observed a decrease of zooplankton due to increase in current velocity, and turbidity in a water body. This is also supported by the decline observed in May due to dilution caused by inflow of water from canal, which sheds its water load into Gadigarh stream during this month.

Table IIIL. Seasonal variations in abundance of zooplanktonic components at Station I in Gadigarh stream.

Year	1974												1975										1976		
Month	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Organism																								
Protozoa																								
Arcella spp.	-	1	-	-	5	-	3	-	9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Centropyxis spp.	-	1	-	-	-	-	-	3	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Difflugia spp.	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lesquereusis spp.	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rotifera																								
Brachionus spp.	-	-	-	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Keratella spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepadella spp.	-	1	-	-	-	-	-	5	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Monostyla spp.	-	5	-	-	-	-	-	8	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Lecane spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified	-	5	-	-	-	-	-	5	-	-	-	-	-	8	-	3	-	-	-	-	-	-	-	-
Copepoda																								
Cyclops spp.	60	33	13	33	10	8	10	38	120	108	98	158	68	45	98	68	-	-	-	-	-	-	-	-
Mesocyclops spp.	5	9	3	9	-	-	5	13	33	13	38	33	15	1	13	10	-	-	-	-	-	-	-	-
Macrocyclops spp.	1	1	-	3	-	-	-	-	-	8	5	15	5	-	1	-	-	-	-	-	-	-	-	-
Eucyclops spp.	3	3	3	1	-	-	-	3	28	10	5	28	10	1	5	-	-	-	-	-	-	-	-	-
Nauplius	-	5	-	5	1	-	10	5	-	5	18	23	3	3	-	15	-	-	-	-	-	-	-	-
Unidentified	-	1	-	-	10	-	10	13	18	10	70	30	5	3	18	13	-	-	-	-	-	-	-	-
Cladocera																								
Simocephalus spp.	38	5	10	7	8	-	-	-	-	1	20	18	103	53	40	13	-	-	-	-	-	-	-	-
Scapholeberis spp.	10	-	-	-	-	-	-	-	-	-	-	15	13	-	-	-	-	-	-	-	-	-	-	-
Moina spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Ceriodaphnia spp.	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
Diaphanosoma spp.	-	8	15	5	15	-	-	-	-	-	-	-	-	5	35	13	-	-	-	-	-	-	-	-
Macrothrix spp.	-	-	-	-	5	-	-	-	-	-	-	-	10	3	38	10	-	-	-	-	-	-	-	-
Leydigia spp.	-	-	-	-	1	-	-	-	-	-	-	-	1	63	-	-	-	-	-	-	-	-	-	-
Pleuroxus spp.	-	-	-	-	1	-	-	-	-	-	-	-	5	8	-	-	-	-	-	-	-	-	-	-
Camptocercus spp.	5	-	-	-	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
Unidentified	20	3	1	-	1	-	-	-	-	3	30	5	3	-	1	10	-	-	-	-	-	-	-	-

Table IIL. Seasonal variation in abundance of zooplanktonic components at Station II in Gadigarh stream.

Year	1974													1975									1976	
Month	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Organism																								
Protozoa																								
Arcella sp.	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	8	3
Centropyxis sp.	3	3	-	-	5	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	6	-
Difflugia sp.	3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Lesquereusis sp.	-	3	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1
Rotifera																								
Brachionus sp.	-	1	-	-	3	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-
Keratella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-
Lepadella sp.	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monostyla sp.	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lecane sp.	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified	20	-	-	-	-	-	-	-	-	-	5	-	-	25	-	-	-	-	-	-	-	-	5	3
Copepoda																								
Cyclops sp.	75	15	25	13	10	-	-	20	18	18	90	70	98	30	33	100	-	-	-	25	33	25	28	45
Mesocyclops sp.	-	10	13	9	5	-	5	28	8	10	63	13	35	8	13	15	-	-	-	30	20	10	25	38
Macrocyclops sp.	-	23	3	-	-	-	-	-	-	-	-	3	9	-	15	5	-	-	-	-	-	-	5	15
Eucyclops sp.	3	3	1	-	-	-	-	-	3	5	3	10	35	13	8	3	-	-	-	-	-	-	-	-
Nauplius	8	10	5	-	-	-	5	5	15	-	13	20	25	-	10	-	-	-	-	5	10	8	18	20
Unidentfied	13	-	1	100	15	30	130	25	38	35	100	33	15	18	33	45	-	-	25	70	13	35	153	120
Cladocera																								
Simocephalus sp.	88	13	-	-	-	-	-	-	-	-	90	10	40	60	10	8	-	-	-	-	-	-	50	108
Scapholeberis sp.	-	-	-	-	-	-	-	-	-	-	-	5	-	3	-	-	-	-	-	-	-	-	-	-
Moina sp.	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	5
Ceriodaphnia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Diaphanosoma sp.	-	5	10	18	8	-	-	-	-	-	38	-	-	3	30	15	-	-	-	-	-	-	-	-
Macrothrix sp.	3	-	-	-	-	-	-	-	-	-	28	-	3	33	-	23	-	-	-	-	-	-	15	18
Pleuroxus sp.	10	-	-	-	-	-	-	-	-	-	5	8	-	3	1	-	-	-	-	-	-	-	8	10
Leydigia sp.	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Camptocercus sp.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified	8	5	5	-	-	-	-	-	-	-	18	-	68	1	8	-	-	-	-	-	-	30	3	3

Table IL. Seasonal variations in abundance of zooplanktonic components at Station III in Gadigarh stream.

Year	1974										1975												1976		
Month	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Organism																								
Proto zoa																								
Arcella sps.	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	1	-	-	-	-	-	-	-	5
Centropyxis sps.	-	-	-	-	-	-	-	-	-	5	-	-	1	-	-	-	-	-	-	-	-	1	1	3
Difflugia sps.	-	3	-	-	-	-	5	-	-	-	5	1	-	-	3	-	-	-	-	-	-	-	3	-
Lesquereusia sps.	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rotifera																								
Brachionus sps.	-	1	-	-	-	-	-	-	-	-	-	-	-	9	10	-	-	-	-	-	-	-	-	-
Keratella sps.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepadella sps.	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1	-	-	-	-	-	-	-	-	-
Monostyla sps.	-	-	-	-	-	-	-	-	5	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
Lecane sps.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Unidentified	-	3	-	18	10	-	3	-	-	-	-	5	8	-	-	-	-	-	-	-	-	3	-	-
Copepoda																								
Cyclops sps.	38	8	15	55	15	-	60	40	153	80	25	90	35	50	65	-	13	-	-	5	250	8	45	30
Mesocyclops sps.	15	20	3	10	1	5	5	-	30	28	90	23	20	10	15	5	-	3	-	5	10	8	20	15
Macrocyclops sps.	-	-	1	3	-	-	3	-	-	10	15	13	-	-	-	-	-	1	-	-	3	-	5	3
Eucyclops sps.	-	-	-	-	-	-	-	-	25	-	33	-	15	-	-	-	-	1	1	-	-	-	50	10
Nauplius	35	10	-	13	-	-	13	5	28	13	45	15	30	28	20	5	-	-	-	-	28	18	50	65
Unidentified	13	38	10	18	13	15	13	5	-	5	135	110	100	30	28	50	-	-	21	35	300	120	200	105
Cladocera																								
Simocephalus sps.	50	10	14	10	-	-	-	1	-	25	108	150	138	70	18	20	-	-	-	-	-	20	78	90
Scapholeberis sps.	-	-	-	-	-	-	-	-	-	-	10	10	15	-	15	-	-	-	-	-	-	-	-	20
Moina sps.	-	-	-	-	-	-	-	-	-	-	-	-	1	5	5	-	-	-	-	-	-	-	-	-
Ceriodaphnia sps.	-	-	-	10-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	---	-	-	-
Diaphanosoma sps.	-	-	13	20	1	-	-	-	-	-	-	-	25	10	40	10	-	-	-	-	-	-	-	-
Macrothrix sps.	35	1	-	-	-	-	-	-	-	-	-	-	10	13	40	-	-	-	-	-	-	-	-	-
Pleuroxus sps.	-	-	-	-	-	-	-	-	-	1	-	-	5	3	5	-	-	-	-	-	-	40	-	10
Leydigia sps.	-	-	-	-	--	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	8	-
Camptocercus sps.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Unidentified	10	1	5	3	3	8	-	-	20	15	5	5	10	5	100	30	-	-	-	-	5	45	60	43

Table L. Seasonal variation in abundance of zooplanktonic components at Station IV in Gadigarh stream.

Year	1974										1975												1976		
Month	APRM	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Organisms																								
Protozoa																								
Arcella spp.	-	-	-	-	-	3	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Centropyxis spp.	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Difflugia spp.	-	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Lesquereusia spp.	-	1	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Rotifera																								
Brachionus spp.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Keratella spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepadella spp.	-	-	-	-	11	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
Monostyla spp.	1	1	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-
Lecane spp.	-	1	-	1	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-
Copepoda																								
Cyclops spp.	10	30	20	13	5	-	8	-	35	25	50	10	28	20	20	28	-	-	-	5	10	18	15	20
Mesocyclops spp.	3	18	35	15	10	-	5	3	33	10	48	25	30	50	15	30	-	-	-	8	23	20	63	15
Macrocydops spp.	5	8	5	3	-	-	-	-	-	3	15	10	10	-	-	-	-	-	-	-	-	-	-	30
Eucyclops spp.	3	-	-	-	-	-	-	-	5	-	33	-	5	3	5	-	-	-	-	-	-	-	-	-
Nauplius	10	15	10	3	-	-	5	5	23	10	35	8	18	20	13	13	-	-	-	15	8	5	15	15
Unidentified	33	20	25	10	13	13	30	40	80	20	100	30	5	20	35	33	-	-	33	78	68	10	20	25
Cladocera																								
Simocephalus spp.	10	10	5	-	-	-	-	-	5	35	48	28	30	10	20	15	-	-	-	-	-	-	10	25
Scapholeberis spp.	-	-	-	-	-	-	-	-	3	13	10	10	-	-	-	-	-	-	-	-	-	-	-	5
Moina spp.	-	-	-	-	-	-	-	-	-	-	-	3	3	5	-	-	-	-	-	-	-	-	-	-
Ceriodaphnia spp.	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Diaphanosoma spp.	-	-	-	5	5	-	-	-	-	-	-	-	28	5	10	-	-	-	-	-	-	-	-	-
Macrothrix spp.	3	5	-	5	1	-	-	-	-	-	-	5	15	10	5	-	-	-	-	-	-	-	18	-
Pleuroxus spp.	-	-	-	-	-	-	-	-	10	20	3	5	13	1	-	-	-	-	-	-	-	-	9	-
Leydigia spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Camptocercus spp.	-	-	-	-	-	-	-	-	-	10	3	-	3	-	-	-	-	-	-	-	-	-	3	1
Unidentified	3	-	3	5	-	-	-	3	-	8	8	30	-	10	-	18	-	-	-	-	-	-	38	15

Table LI. Seasonal variations in abundance of zooplanktonic components at Station V in Gadigarh stream.

Year	1974									1975												1976		
Month	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Organism																								
Protozoa																								
Arcella spp.	3	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Centropyxis spp.	1	3	-	-	-	-	-	-	1	-	-	-	-	3	-	-	-	-	-	-	-	-	1	1
Difflugia sps.	3	1	-	1	-	-	1	11	-	-	1	1	5	-	-	-	-	-	-	-	-	-	3	-
Lesquereusia spp.	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rotifera																								
Brachionus spp.	-	5	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Keratella spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepadella spp.	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monostyla spp.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
Lecane spp.	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified	5	10	-	-	-	-	5	1	-	-	-	-	-	3	5	-	-	-	-	-	-	-	-	-
Copepoda																								
Cyclops spp.	10	20	20	10	-	-	3	21	115	79	110	18	10	30	15	10	-	-	-	-	10	3	28	15
Mesocyclops spp.	38	13	23	3	-	-	3	3	28	25	23	35	20	13	80	5	-	-	-	3	15	1	85	5
Macrocyclops spp.	3	-	-	-	-	-	-	-	5	1	5	-	-	-	-	3	-	-	-	-	-	-	5	23
Eucyclops spp.	-	-	-	-	-	-	-	3	13	-	3	23	5	1	3	-	-	-	-	-	5	-	10	-
Nauplius spp.	10	5	1	-	-	-	-	1	10	5	5	10	13	20	5	-	-	-	-	5	10	-	40	18
Unidentified	3	25	5	10	13	10	23	1	5	13	20	108	105	33	8	31	28	-	25	25	48	10	90	93
Cladocera																								
Simocephalus spp.	58	10	30	5	-	-	-	-	-	23	45	90	50	20	58	-	-	-	-	-	-	5	110	70
Scapholeberis spp.	5	-	-	-	-	-	-	-	-	-	3	5	5	-	-	-	-	-	-	-	-	-	3	5
Moina spp.	3	5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	1	-
Ceriodaphnia spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
Diaphanosoma spp.	-	5	8	10	-	-	-	-	-	-	-	3	-	1	8	18	-	-	-	-	-	-	-	-
Macrothrix spp.	10	15	5	15	-	-	-	-	-	-	-	8	18	5	10	-	-	-	-	-	-	-	3	5
Pleuroxus spp.	-	5	-	-	-	-	-	-	5	3	5	-	20	5	5	-	-	-	-	-	-	5	-	3
Leydigia spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Camptocerucus spp.	5	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	3	5
Unidentified	-	1	5	15	-	-	-	-	5	10	20	50	45	15	-	-	-	-	-	-	10	5	18	23

Table LII. Seasonal variations in abundance of zooplanktonic components at Station VI in Gadigarh stream.

Year	1974											1975												1976		
Month	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Organism																								
Protozoa																								
Arcella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Centropyxis sp.	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-
Difflugia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lesquereusia sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Rotifer																								
Brachionus sp.	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Keratella sp.	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepadella sp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monostyla sp.	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lecane sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copepoda																								
Cyclops sp.	138	48	15	28	-	-	-	10	15	5	3	100	80	33	13	5	-	-	-	-	-	-	-	-
Mesocyclops sp.	85	20	75	30	-	-	-	18	10	8	28	78	100	18	50	-	-	-	-	-	-	-	-	-
Macrocyclops sp.	25	18	28	-	-	-	-	-	-	-	10	33	8	-	-	-	-	-	-	-	-	-	-	-
Eucyclops sp.	18	5	-	-	-	-	-	-	-	-	3	-	13	-	-	-	-	-	-	-	-	-	-	-
Nauplius	23	5	10	-	-	-	-	5	-	3	15	50	18	9	-	-	-	-	-	-	-	-	-	-
Unidentified	18	1	3	3	-	-	8	25	40	-	30	50	50	-	-	-	-	-	-	-	-	-	-	-
Cladocera																								
Simocephalus sp.	150	75	50	-	-	-	-	-	-	-	13	105	100	105	-	-	-	-	-	-	-	-	-	-
Scapholeberis sp.	-	3	5	-	-	-	-	-	8	-	2	10	8	-	-	-	-	-	-	-	-	-	-	-
Moina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceriodaphnia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphanosoma sp.	-	-	20	25	-	-	-	-	-	-	-	-	-	8	13	10	-	-	-	-	-	-	-	-
Macrothrix sp.	-	-	15	10	-	-	-	-	-	3	-	-	-	-	15	8	-	-	-	-	-	-	-	-
Pleuroxus sp.	-	-	-	-	-	-	-	-	-	-	-	-	5	3	-	-	-	-	-	-	-	-	-	-
Leydigia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Camptocercus sp.	-	-	10	-	-	-	-	-	-	-	5	15	-	3	-	-	-	-	-	-	-	-	-	-
Unidentified	-	-	5	-	-	-	-	-	-	5	-	-	50	-	-	-	-	-	-	-	-	-	-	-

Table LIII. Seasonal variation in abundance of zooplanktonic components at Station VII in Gadigarh stream.

Year	1974											1975												1976		
Month	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Organism																								
Protozoa																								
Arcella sp.	3	-	-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	1
Centropyxis sp.	3	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-
Difflugia sp.	-	5	-	-	-	-	-	-	-	-	3	-	-	-	3	-	-	-	-	-	-	-	1	3
Lesquereusia sp.	1	-	-	-	-	-	-	-	-	-	-	3	-	-	1	-	-	-	-	-	-	-	-	-
Rotifera																								
Brachionus sp.	-	-	-	3	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1	-
Keratella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Lepadella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
Monostyla sp.	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Lecane sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	1	-	-	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-
Copepoda																								
Cyclops sp.	20	28	18	5	-	-	-	-	8	10	18	48	20	18	10	15	-	-	-	-	-	-	25	18
Mesocyclops sp.	20	15	8	15	-	-	-	-	33	20	10	25	10	3	8	80	-	-	-	-	-	3	25	15
Macrocyclops sp.	5	1	-	5	-	-	-	-	-	3	5	10	3	-	-	-	-	-	-	-	-	-	5	-
Eucyclops sp.	5	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nauplius	3	5	18	10	-	-	-	-	3	5	10	3	3	9	5	10	-	-	-	-	-	5	13	10
Unidentified	35	10	13	3	-	-	13	13	25	30	40	38	35	13	5	18	-	-	-	30	18	10	18	8
C																								
Cladocera																								
Simocephalus sp.	18	5	10	-	-	-	-	-	5	-	-	65	10	15	5	15	-	-	-	-	-	3	50	15
Scapholeberis sp.	3	-	-	-	-	-	-	-	-	-	-	5	5	-	-	-	-	-	-	-	-	1	1	3
Moina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Ceriodaphnia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diaphanosoma sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	18	-	-	-	-	-	-	-	-
Macrothrix sp.	-	-	-	3	-	-	-	-	-	-	-	10	-	5	5	20	-	-	-	-	-	-	-	-
Pleuroxus sp.	5	-	-	-	-	-	-	-	-	-	-	5	5	10	1	-	-	-	-	-	-	-	-	-
Leydigia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	1	-	-	-	-	-	-	-	-
Camptocercus sp.	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified	-	-	-	10	-	-	-	-	8	5	-	-	5	38	5	23	-	-	-	-	-	-	5	-

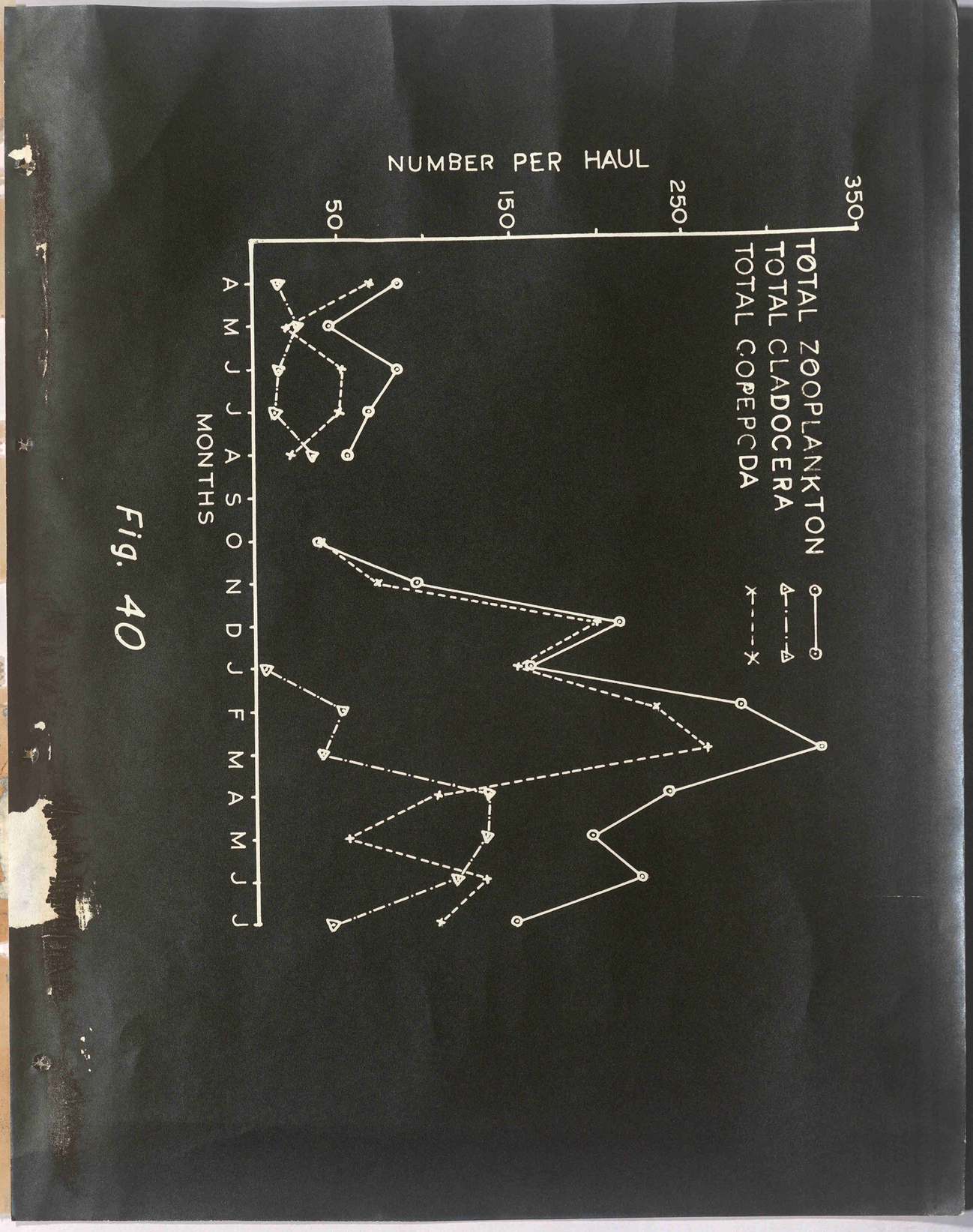


Fig. 40

Fig. 40. - Seasonal variations in abundance of zooplanktonic components at Station I in Gadigarh stream.

Fig. 41. - Seasonal variations in abundance of zooplanktonic components at Station II in Gadigarh stream.

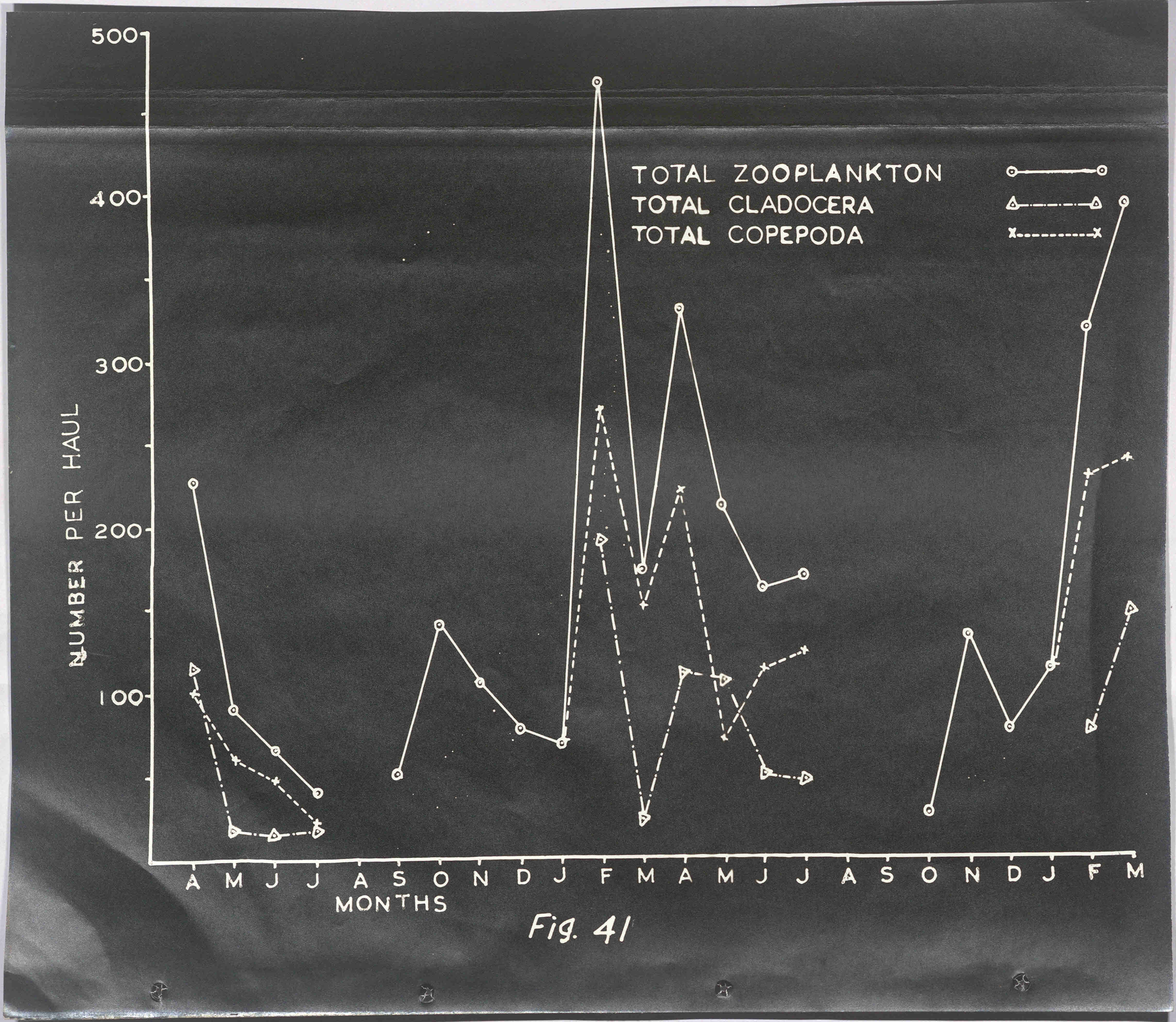

500
400
300
200
100
NUMBER PER HAUL
TOTAL ZOOPLANKTON
TOTAL CLADOCERA
TOTAL COPEPODA
A M J J A S O N D J F M A M J J A S O N D J F M
MONTHS

Fig. 41

Fig. 42. Seasonal variations in abundance of zooplanktonic components at Station III in Gadigarh stream.

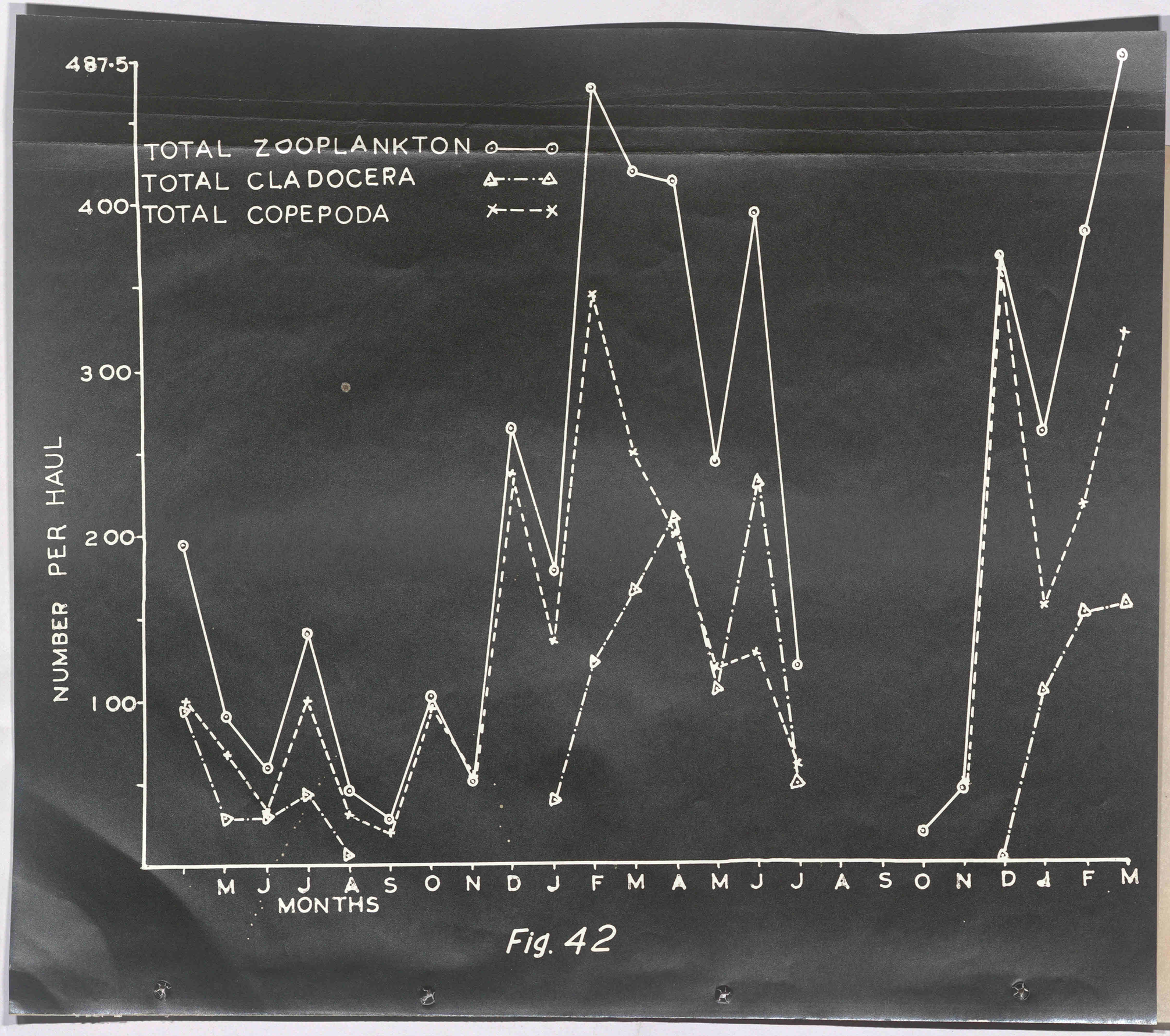

487·5
400
300
200
100
TOTAL ZOOPLANKTON
TOTAL CLADOCERA
TOTAL COPEPODA
NUMBER PER HAUL
M J J A S O N D J F M A M J J A S O N D J F M
MONTHS

Fig. 42

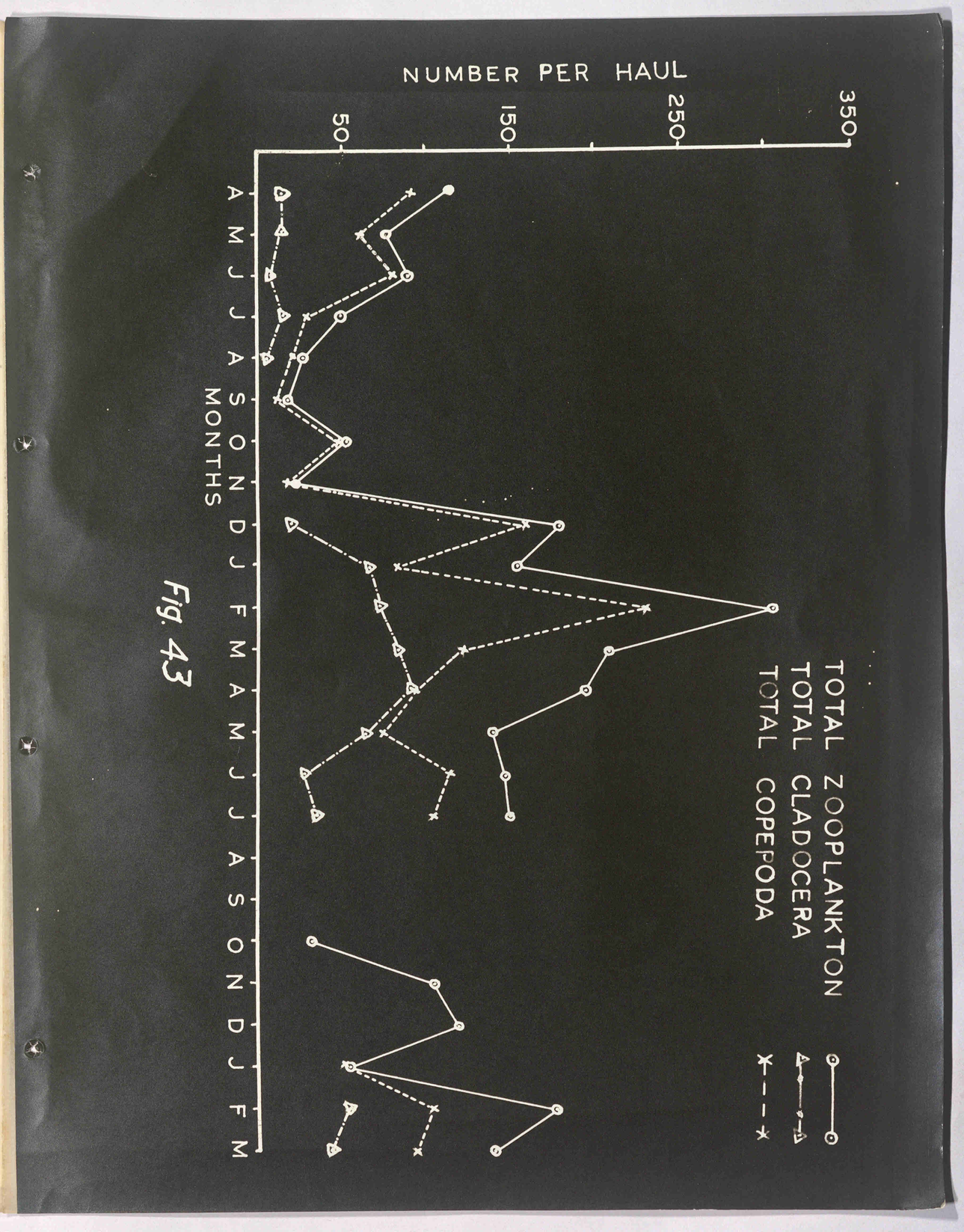


Fig. 43

Fig. 43. Seasonal variations in abundance of zooplanktonic components at Station IV in Gadigarh stream.

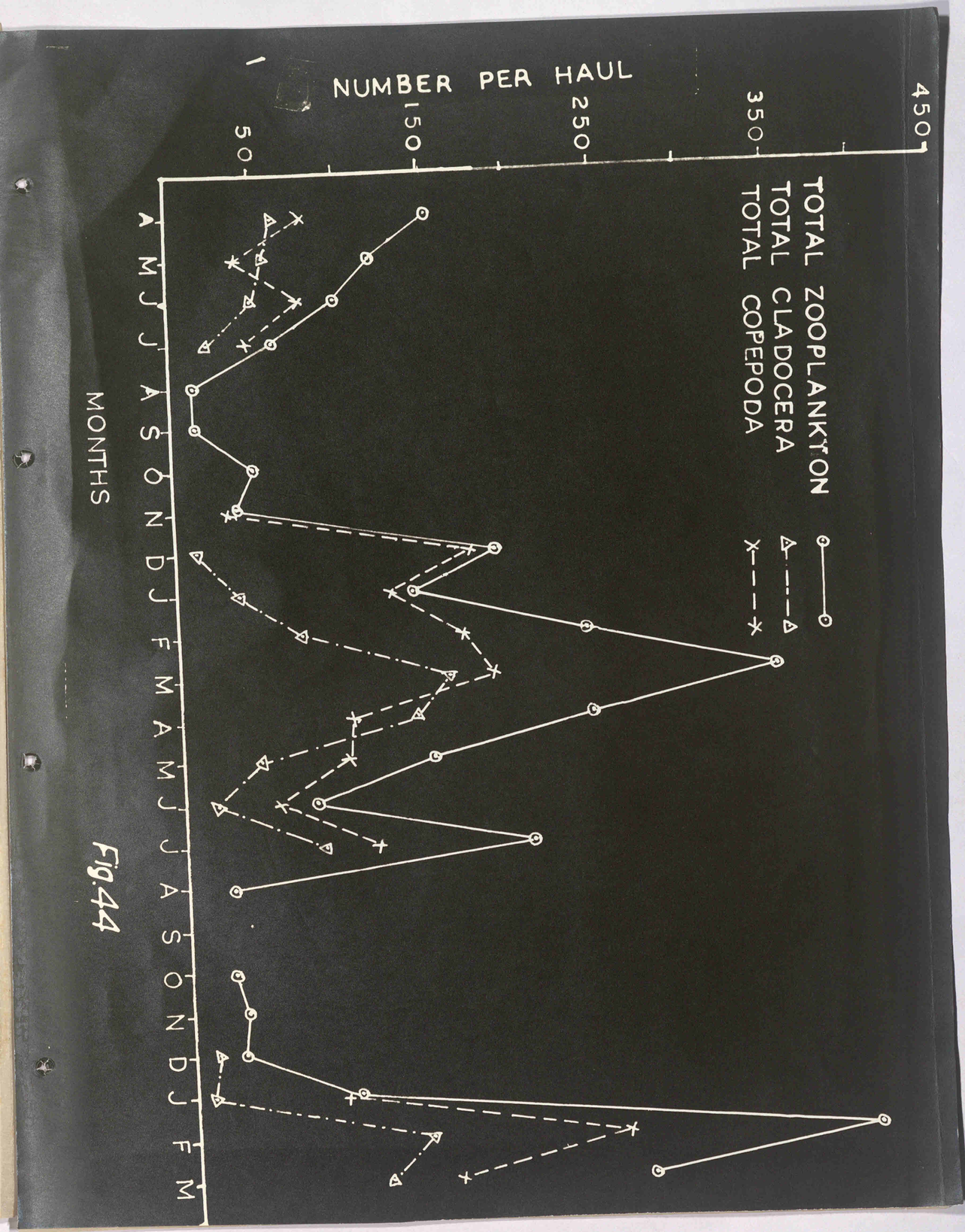


Fig. 44. - Seasonal variations in abundance of zooplanktonic components at Station V in Gadigarh stream.

Fig. 45. - Seasonal variations in abundance of zooplanktonic components at Station VI in Gadigarh stream.

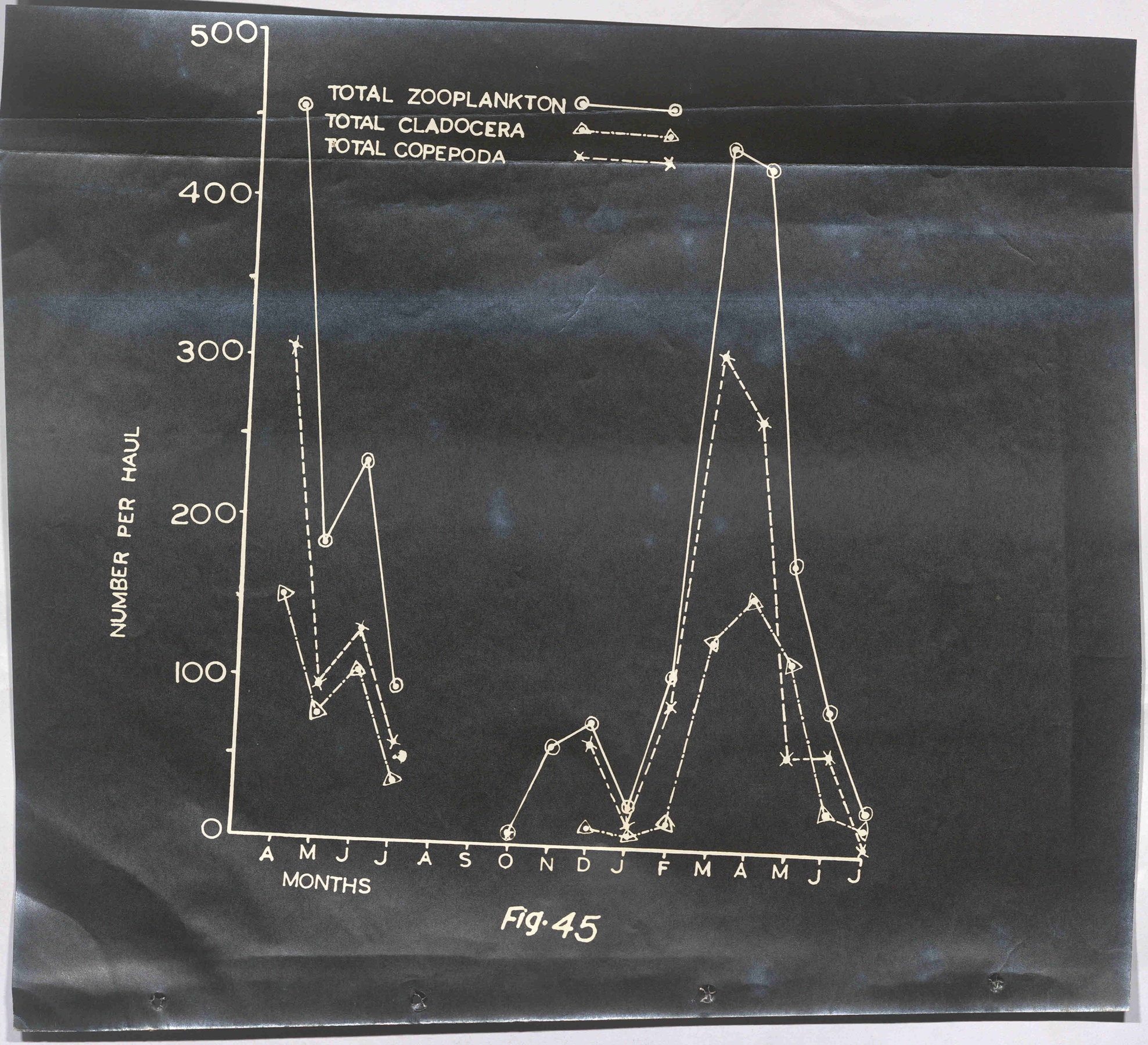

500
400
300
200
100
0
TOTAL ZOOPLANKTON
TOTAL CLADOCERA
TOTAL COPEPODA
NUMBER PER HAUL
A M J J A S O N D J F M A M J J
MONTHS

Fig. 45

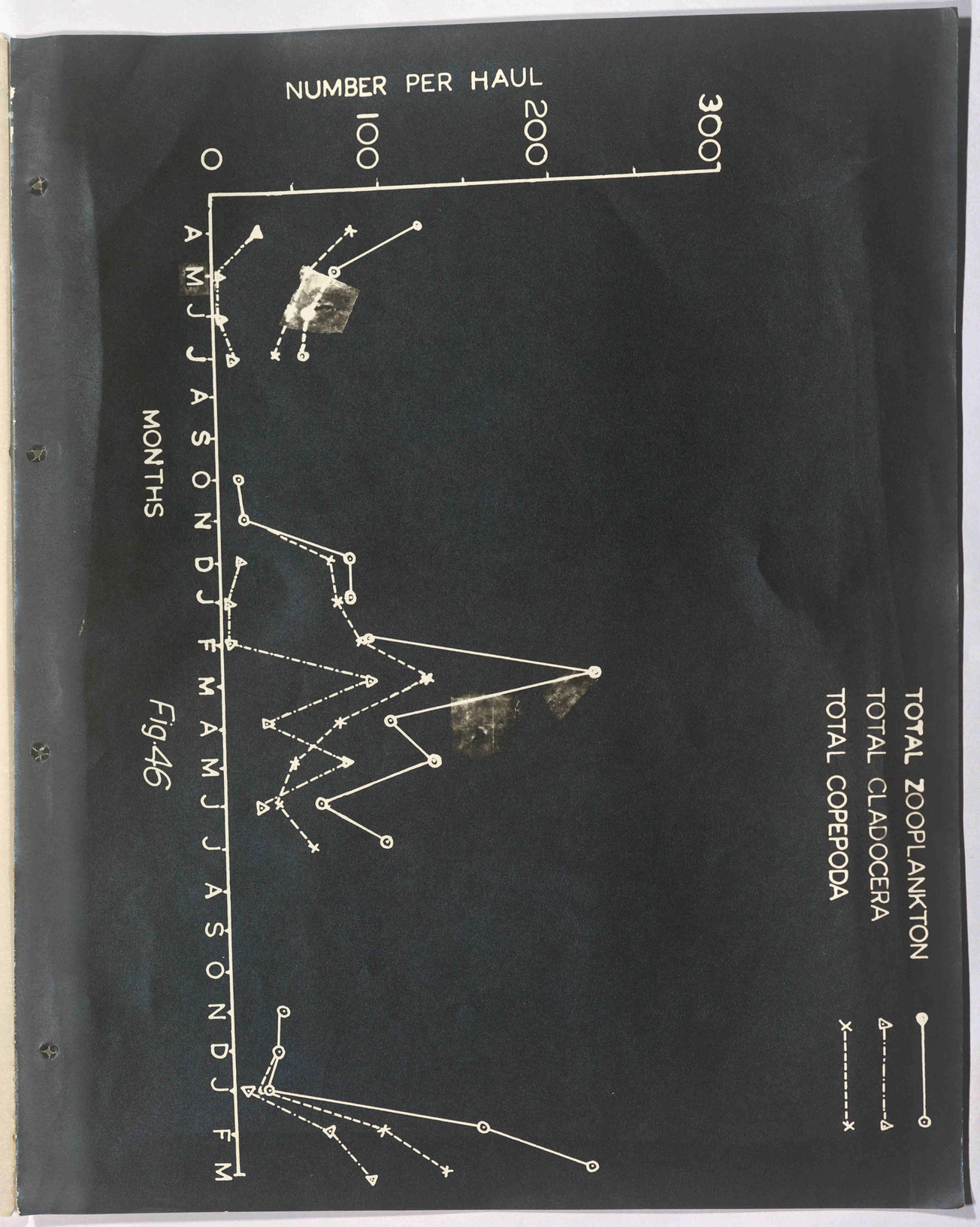


Fig. 46. - Seasonal variations in abundance of zooplanktonic components at Station VII in Gadigarh stream.

QUALITATIVE COMPOSITION OF NEKTON:

The following nektonic components inhabiting Gadigarh stream have been recognized. They occupy all the consumer levels in the operative food chain.

Coleoptera:

Canthydrus laetabilis Walker,
Laccophilus rufulus Regimbart,
L. sharpi Regimbart,
L. parvulus Aube,
Guignotus flammulatus Sharp,
G. inconstans (Reg.),
G. pendjabensis Guignot,
Uvarus genitilis (Sharp),
Sandracattus dejeani Aube,
Cybister tripunctatus asiaticus Sharp,
Cybister sugillatus Erichson,
Cybister sp.
Hydrovatus ferrugatus Regimbart,
Dineutus indicus Aube,
Berosus indicus Mots.,
B. pulchellus MacLeay,
Helochares pallens Mots.,
Hydrophilus bilineatus cashmirensis Red.
H. indicus Bedel,
Sternolophus rufipes Fabr.,
Regimbartia attenuata Fabr.

Hemiptera:

Lethocercus indicus (Lep.& Serv.),
Laccotrephes ruber Linn.,
L. griseus Guer.,
Cercometus pilipes (Dall),
Ranatra elongata Fabr.
R. filiformis Fabr.
Plea sp.,
Sphaerodema sp.

Crustacea:

Macrobrachium dayamum (Henderson),
M. lamarrei (H. Milne Edward),
Caridina sp.,
Paratelphusa (Barytelphusa)masonina (Henderson).

Fishes:

Garra gotyla gotyla (Gray),
Barilius vagra (Ham. Buch),
B. bendelisis (Ham. Buch),
Chela (Chela) cachius (Ham. Buch),
Oxygaster bacaila (Ham. Buch),
Amblypharyngodon gadigarhi,
Malhotra and Dutta.
Puntius sophore (Ham. Buch),
P. sarana (Russel),
P. ticto (Ham. Buch),
P. conchonius (Ham. Buch),
Tor sp.,
Labeo bata (Ham. Buch),
L. dero (Ham. Buch),
Danio devario (Ham. Buch),
D. rerio (Ham. Buch),
Cirrhinus reba (Ham. Buch),
Crossocheilus latius latius (Ham.),
Aspidoparia morar (Ham. Buch),
Esomus demrica (Ham. Buch),
Rasbora rasbora (Ham. Buch),
Osteobrama cotio (Heckel),
Lepidocephalichthys guntea (Ham.Buch),
Noemacheilus botia (Ham.Buch),
Mystus bleekeri (Day),
M. seenghala (Sykes),
M. vittatus (Bloch),
Wallago attu (Bloch, Schn.),
Ompok bimaculatus (Bloch),
Amblyceps mangois (Ham.Buch),
Glyptothorax pectinopterum (McCll.),
Heteropneustes fossilis (Bloch),
Xenentodon cancila (Ham.),
Channa punctatus (Bloch),
C. marulius (Ham.),
Badis badis (Ham.Buch),
Nandus nandus (Ham. Buch),
Ambassis nama (Ham. Buch),
Glossogobius giuris (Ham.),
Trichogaster fasiatus (Bloch, Schn.),
Mastocembelus armatus (Lacepede),
M. pancalus (Ham.)

Amphibians:

Rana tigrina Daud

Rana sp.

Reptiles: Kachuga tectum tectum (Gray),
K. smithi (Gray),
Lissemys punctata punctata (Bonn.),
Trionyx gangeticus (Cuvier),
Natrix piscator (Schneider).

QUALITATIVE COMPOSITION OF NEUSTON:

This ecological group is comprised of only Hemiptera namely, Hydrometra greeni Kirk. Metacoris communis (Distant), and Gerres sp. .

QUALITATIVE COMPOSITION OF PERIPHYTON:

Hydra in the stream was observed in a periphytonic relationship with submerged vegetation from December to April. Lymnaea sp., Viviparus sp., Gyraulus sp., and Indoplanorbis sp., among molluscs besides comprising the reverted to benthic situations as well.

DIURNAL STUDIES

WATER

1. Physical

1.1. Transparency: George (1966) reported mid-day reduction in transparency in some lentic waters due to planktonic migration, but during the course of present investigations it has been observed that transparency remained constant from sunrise to sunset.

This difference could be due to the different nature of the two water bodies.

1.2. Temperature: Water temperature closely follows atmospheric temperature and is higher during day than at night. The difference in the day and night temperature is attributed to insolation during the day. Maximum diel fluctuation of 8.5°C in water temperature has been recorded in July, 1975 and minimum of 1.1°C in December, 1975. It is a common knowledge that these fluctuations in summer and winter temperatures are controlled by geographic factors such as sun-earth distance and day light hours. Sudden fluctuations in atmospheric temperature were recorded in evenings. Similar fluctuations have been recorded earlier by Reed (1962) for river Saskatchewan (Canada) and attributed to evening breeze. Diurnal fluctuation of 8.5°C in water temperature (as recorded presently) is higher than previous records of 5.4°C and 2.8°C (Sreenivasan 1964a,b) and 6.5°C (George 1966). Anthankrishnan et al. (1976) reported that a very wide range of fluctuation in water temperature does not exist in lotic waters. In Gadigarh this wide range of temperature variation is due to slow and shallow pool that it is.

2. Chemical

2.1. Dissolved oxygen: It is maximum during the day and minimum during night; as also reported by Welch (1952), Reed (1962), George (1966), Saha et al. (1971), Ganning (1971), Sumitra-Vijayaraghavan (1971b), and Dimitrov et al. (1977). Higher dissolved oxygen druing day may be due to its greater production (through photosynthesis) than consumption by organismal respiration and decomposition. Nocturnal reduction in oxygen is attributed to deceleration of photosynthesis, and continued demand for organismal respiration (Newwell 1957).

Maximum diel variation in oxygen (4.90 - 10.88 mg per liter) has been observed during May, 1975, which may be consequence of combined effect of higher water temperature, increased organic decomposition (resulting in increased biological oxygen demand), and longer days. Nicol (1967) states that oxygen consumption increases with a rise in the temperature of poikilotherms; which conclusion is equally applicable to present data.

In July, the sunshine hours are more or less similar to those prevailing in May. Paradoxically

the oxygen concentration during the period is far lower. This difference can reasonably be attributed to increased turbidity caused by the monsoon rains and to scanty vegetation during this period (both these factors obliterating photosynthesis).

Minimum diel fluctuation (1.08 mg per liter) during 24 hours period was observed in October, 1975 which may be due to reduced biological activities (both productive and consumptive) within the stream.

Maximum dissolved oxygen content in Gadigarh stream has been recorded in February, 1976. The most important factor contributing to this appears to be increased photosynthesis by algae and other aquatic plants.

Although the maximum concentration of dissolved oxygen has been recorded at 1200 hours (in December 1975), the concentration was highest at 1600 hours during all other months. A more or less similar observation has earlier been made by Goldman (1968), Sumitra - Vijayaraghavan (1971b) who suggest that higher concentration during these hours is because of the cumulative effect of photosynthesis

with passage of time; another important attribute is that oxygen produced by aquatic plants is not released immediately, and time lag thus helps accumulate evolution of locked oxygen on release.

2.2. Free carbon dioxide: During the course of present study maximum CO_2 concentration is observed at night and minimum during the day. A similar observation has been made by Verma (1964) on ponds of Madhya Pradesh, Slack (1967) on Birch creek and George (1966) on ponds of Calcutta. Decrease in the daytime value of CO_2 is evident due to its uptake by aquatic organisms in photosynthesis.

Apart from greater carbon dioxide production by both plants and animals during night (through respiratory process of plants and animals) another factor contributing to its greater build up in solution at night is lowered temperature at which carbon dioxide solubility gets increased (Woff and Quinby 1969). Tables LIV - LVII ; Figs. 47 - 50 indicate that free carbon dioxide in Gadigarh stream was maximum at 400 hours in May, July and October; and at 2000 hours in the month of December, 1975. This increase in carbon dioxide in morning hours, apart from

low temperature is due to upward migration of zooplankton and feeding activity of fishes and other animals. All these activities of the animals collectively result in the release of greater quantities of carbon dioxide during respiration.

From the figures available it is evident that while carbon dioxide concentration is maximum in the early morning hours the oxygen concentration at these hours is minimum. This accounts for the maximum organismal kill during the early hours of summer days (Personal observation on a fresh water pond of Jammu).

From the diurnal studies conducted on Gadigarh stream it has emerged that CO_2 and oxygen concentration bear an inverse relationship to each other i.e. carbon dioxide increasing during the night and decreasing during the day and a reversed trend is observed for oxygen (Tables LIV - LVII ; Figs.52-55) such an observation is in consonance with that of Odum (1956) who has regarded carbon dioxide content as mirror image of oxygen and vice versa.

2.3. Carbonate: Carbonates were recorded only during the month of May (1975) and that too during the day, throughout the course of present investigations.

2.4. Bicarbonate : Increase of bicarbonates at night and their fall during the day (Tables LIV, LV, and LVIII ; Figs. 47, 48, and 51) was recorded almost in all months except October, 1975 (Table LVI ; Fig. 49). In December, 1975 no diel variation occurred in bicarbonate content except at about 400 hours (Table LVII ; Fig. 50). Earlier studies by Verma (1964), George (1966), Slack (1967) and Khan et al. (1970) have indicated nocturnal rise in the bicarbonate and its reduction during the day. During the day half bound carbon dioxide is removed from bicarbonates for use in photosynthesis which leads to a decline in bicarbonate content. During night, the respiratory activity of phyto- and zooplankton along with that of other macrophytes causes accumulation of carbon dioxide and leads to increase in bicarbonate level in the ecosystem.

George (1966), records that greater biological activity of organisms at higher temperatures results in wider diel variations in bicarbonate content; which thus explains maximum diel variations as observed

in May for Gadigarh waters. This also explains that organic poverty (scanty phytoplankton, zooplankton and hydrophytes) is responsible for minimum bicarbonate diel variations observed in December, 1975 in Gadigarh stream.

A direct correlation has been observed between carbon dioxide and bicarbonate as pointed out by their decline during the day and increase at night.

2.5. Chloride : Chloride concentration has shown a varied pattern. An increase in chloride concentration during the day has been observed in the months of October and December, 1975 and February, 1976. During May, 1975 a gradual decrease in chloride occurred from 800 hours to 2030 hours, thereafter, the chloride increased. In July, 1975 chloride quantity remained uniform both during the day and night (Tables LV ;Fig. 48). Hussainy (1965) has suggested that in a water body chloride enters either through the soil deposits or excreta of stray cattle, that use the water body for purposes of bathing or drinking water.

The diel variation in chloride content which gets reflected in increased quantities of

chloride during the day bears a direct correlation with the grazing of stray cattle along the banks of the stream (Figs. 29 and 30). In the afternoon and morning hours cattle graze in large numbers along the banks of the stream which they enrich with excreta.

2.6. Water soluble phosphate: Irregular fluctuations in phosphate concentration have been recorded during diurnal studies. In the months of May and July, (1975), maximum phosphate concentration has been observed around 1200 hours. On the other hand in the months of December, 1975 and February, 1976 the phosphate peak was recorded around 2000 hours. In October, 1975 higher phosphate concentration has been recorded around 2400 and 400 hours.

Noon peaks of May and July, (1975) are correlated with high temperature, which accelerates the activity of bacteria to release phosphate from dead organic matter. Phosphates so released get mixed up immediately in the entire water column partly because of shallowness and partly because of the continuous flow of the stream. Moreover, the consumption of phosphate is not proportional with its production. Zicker et al.(1957) observed that agitation of water results in the release of phosphate in water. Accordingly the mid-day higher

values of phosphate could therefore, be due to the agitation of water by animals wading through the stream.

Hussainy (1965) in his work on the limnology of a pond at Annamalainagar and Verma et al. (1970) while describing the physico-chemical conditions of Kamla Nehru tank, Muzaffarnagar (U.P) have mentioned that phosphate content declines with the increase in concentration of oxygen and vice versa. During the current studies and those of Misra et al. (1975), O_2 and phosphate do not show any relationship.

2.7. pH: In the course of diurnal studies it has been observed that pH registered a rise (towards the alkalinity) during the day in the months of May, July, October, 1975 and February, 1976. Tables LIV - LVI and LVIII ; Figs. 47 - 49 and 51) A similar observation has earlier been made by Verma (1964), George (1966), Khan et al. (1970), Ganning (1971), Saha et al. (1971) , and Kant and Kachroo (1975). This diurnal variation is mainly due to the decrease in carbon dioxide content during the day and its increase during the night. In this way carbon dioxide and pH have shown a direct correlation. In the month of December, 1975, pH values have shown a

gradual rise from 800 - 2000 hours and a mild decrease thereafter, but the values recorded during 2400 and 400 hours remained higher than the values recorded at 800 , 1200 , and 1600 hours.

Table LIV. Diurnal variations in physico-chemical parameters at Station V in Gadigarh stream during May 7th - 8th, 1975.

S.No.	Parameters	Time (hrs) 8.00	12.00	16.00	20.30	24.00	4.00
1.	pH	8.3	8.5	8.5	8.2	8.3	8.2
2.	Carbon dioxide (mg/lit.)	4.6	-	-	6.0	5.0	8.0
3.	Dissolved oxygen (mg/lit.)	4.9	9.6	10.88	7.2	5.8	5.22
4.	Carbonates (mg/lit.)	-	30.0	30.0	-	-	-
5.	Bicarbonates (mg/lit.)	305.0	274.5	289.5	402.5	440.42	335.5
6.	Chlorides (mg/lit.)	14.58	13.29	13.29	11.69	13.29	15.6
7.	Water soluble phosphates (u mg/lit.)	8.0	75.0	10.0	20.0	10.0	17.0
8.	Atmospheric temperature (C^o)	24.8	37.2	33.8	21.3	20.2	19.1
9.	Water temperature (C^o)	25.7	27.4	30.0	28.2	27.1	25.3
10.	Transparency (cm)	62.5	62.5	62.5	25.0	23.0	38.0
11.	Air	Calm	Wind	Wind	Calm	Calm	Calm
12.	Day/night	S U N N Y			D A R K		M O O N

Table LV. Diurnal variations in physico-chemical parameters at Station V in Gadigarh stream during July 3rd - 4th, 1975.

S.No.	Parameters	Time (hrs) 8.00	12.00	16.00	20.30	24.00	4.00
1.	pH	7.6	8.0	8.2	8.27	8.1	7.5
2.	Carbon dioxide (mg/lit.)	7.0	4.0	4.8	7.2	6.4	8.0
3.	Dissolved oxygen (mg/lit.)	2.8	3.66	4.4	2.24	2.46	2.2
4.	Carbonates (mg/lit.)	-	-	-	-	-	-
5.	Bicarbonates (mg/lit.)	237.9	237.9	274.5	274.5	274.5	237.9
6.	Chlorides (mg/lit.)	10.99	10.99	10.99	10.99	10.99	10.99
7.	Water soluble phosphates (u mg/lit.)	10.0	42.5	30.0	22.5	12.0	-
8.	Atmospheric temperature (C^{o})	29.2	36.8	34.8	24.9	22.1	23.5
9.	Water temperature (C^{o})	24.9	30.5	32.0	28.8	27.0	23.5
10.	Transparency (cm)	27.5	27.5	27.5	-	-	-
11.	Air	Calm	Calm	Calm	Calm	Calm	Cool breeze
12.	Day/night	SUNNY	C L O U D Y		D A	R	K

Table LVI. Diurnal variations in physico-chemical parameters at Station V during October 26th - 27th, 1975 in Gadigarh stream.

S.No.	Parameters	Time (hrs) 8.00	12.00	16.00	20.00	24.00	4.00
1.	pH	8.1	8.3	8.25	8.1	8.2	8.1
2.	Carbon dioxide (mg/lit.)	7.8	5.5	6.5	7.8	7.7	8.0
3.	Dissolved oxygen (mg/lit.)	5.4	6.02	6.48	6.2	6.2	5.94
4.	Carbonates (mg/lit.)	-	-	-	-	-	-
5.	Bicarbonates (mg/lit.)	317.5	329.4	329.4	310.49	310.49	287.31
6.	Chlorides (mg/lit.)	10.99	9.93	13.12	12.06	12.06	9.93
7.	Water soluble phosphates (u mg/lit.)	5.0	8.0	2.0	2.0	10.0	10.0
8.	Atmospheric temperature (C°)	19.4	30.4	29.0	16.6	14.8	11.0
9.	Water temperature (C°)	20.6	22.4	24.0	22.0	21.2	20.0
10.	Transparency (cm)	57.5	57.5	57.5	16.25	15.5	25.5
11.	Air	Calm	Calm	Wind	Calm	Slight wind	
12.	Day/night	SUN	NN	YD	AR	K MOON	

Table LVII. Diurnal variations in physico-chemical parameters at Station V in Gadigarh stream during December 3rd - 4th, 1975.

S.No.	Parameters	Time (hrs) 8.00	12.00	16.00	20.00	24.00	4.00
1.	pH	7.8	7.85	7.9	8.2	8.1	8.0
2.	Carbon dioxide (mg/lit.)	6.1	4.7	4.7	8.3	7.9	6.3
3.	Dissolved oxygen (mg/lit.)	8.2	9.26	8.6	8.7	7.72	7.72
4.	Carbonates (mg/lit.)	-	-	-	-	-	-
5.	Bicarbonates (mg/lit.)	243.39	243.39	243.39	243.39	243.39	281.40
6.	Chlorides (mg/lit.)	9.49	11.99	10.99	9.49	9.49	9.09
7.	Water soluble phosphates (u mg/lit.)	40.0	50.0	30.0	60.0	22.5	32.5
8.	Atmospheric temperature (C^{o})	18.0	21.4	14.8	11.2	10.0	10.0
9.	Water temperature (C^{o})	13.5	14.1	14.0	13.8	13.5	13.0
10.	Transparency (cm)	65.0	65.0	65.0	25.0	25.0	27.5
11.	Air	C		a		l	m
12.	Day/night	S U		N	N Y	D A	R K

Table LVIII. Diurnal variations in physico-chemical parameters at Station V in Gadigarh stream during February 23rd - 24th, 1976.

S.No.	Parameters	Time (hrs) 8.00	12.00	16.00	20.00	24.00	4.00
1.	pH	8.1	8.3	8.2	8.1	8.0	7.9
2.	Carbon dioxide (mg/lit.)	Data not available					
3.	Dissolved oxygen (mg/lit.)	7.2	11.8	12.6	10.26	9.08	8.8
4.	Carbonates (mg/lit.)	-	-	-	-	-	-
5.	Bicarbonates (mg/lit.)	320.25	310.8	309.27	309.27	314.76	320.25
6.	Chlorides (mg/lit.)	11.09	11.09	11.09	9.69	9.69	9.69
7.	Water soluble phosphates (u mg/lit.)	35.0	15.0	10.0	60.0	12.5	50.0
8.	Atmospheric temperature (C°)	15.5	23.3	20.1	13.2	10.0	9.0
9.	Water temperature (C°)	14.2	17.1	17.9	17.0	15.1	15.0
10.	Transparency (cm)	70.0	70.0	70.0	20.0	25.0	25.0
11.	Air	Clear			Dark		
12.	Day/night	SUNNY			DARK		

Legend :

Free carbon dioxide △- - - - -△

Dissolved oxygen △——△

Bicarbonates ○——○

Chloride ○——○

Phosphate •—•—•—•

pH ×——×

Transparency □——□

Air temperature ○——○

Water surface temperature ○- - - -○

Fig. 47. Diurnal changes in physico-chemical parameters at Station No. V in Gadigarh stream on 7th–8th May, 1975.

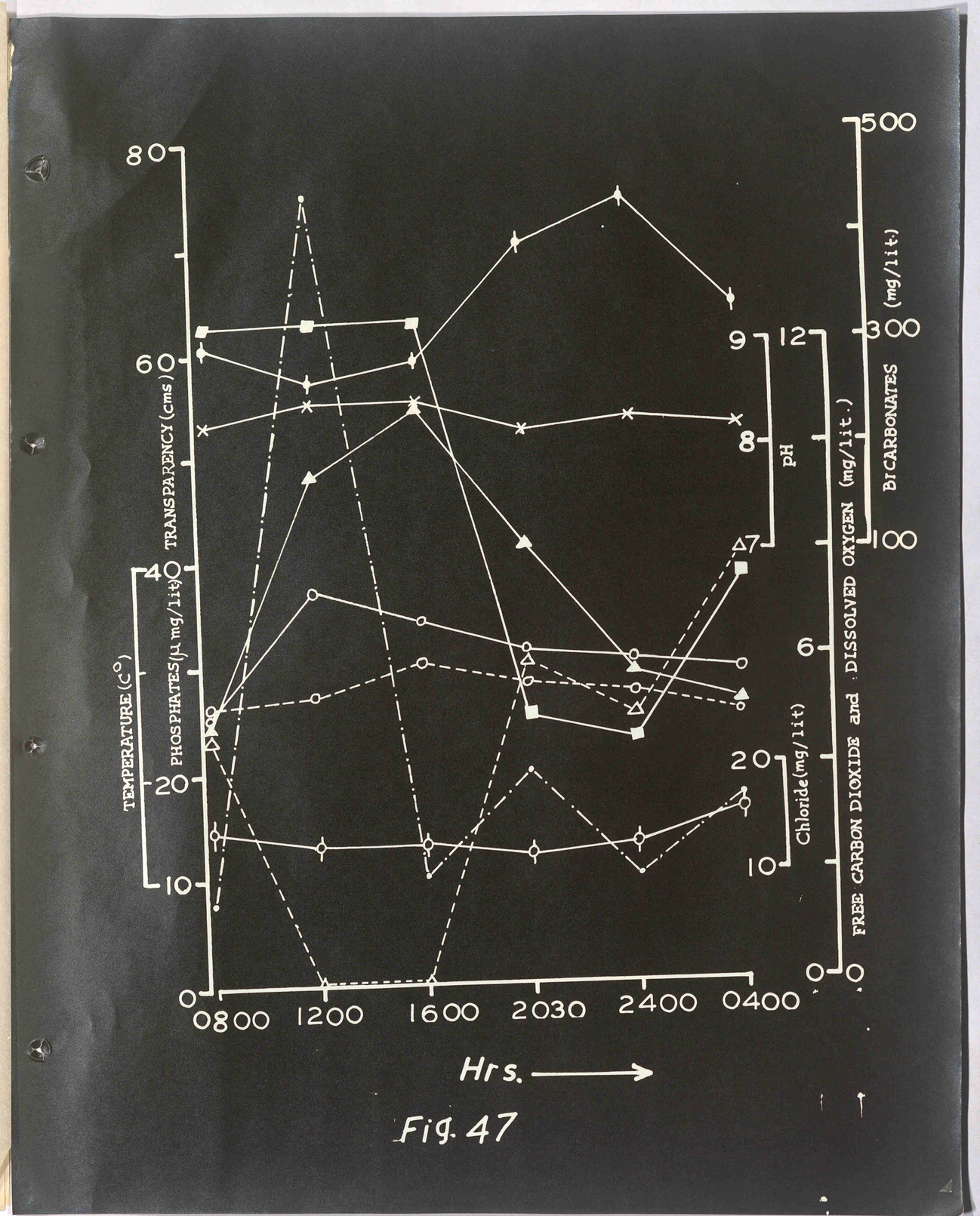


Fig. 47

Legend :

Free carbon dioxide

Dissolved oxygen

Bicarbonates

Chloride

Phosphate

pH

Transparency

Air temperature

Water surface temperature

Fig. 48. Diurnal changes in physico-chemical parameters at Station No. V in Gadigarh stream on 3rd - 4th July, 1975.

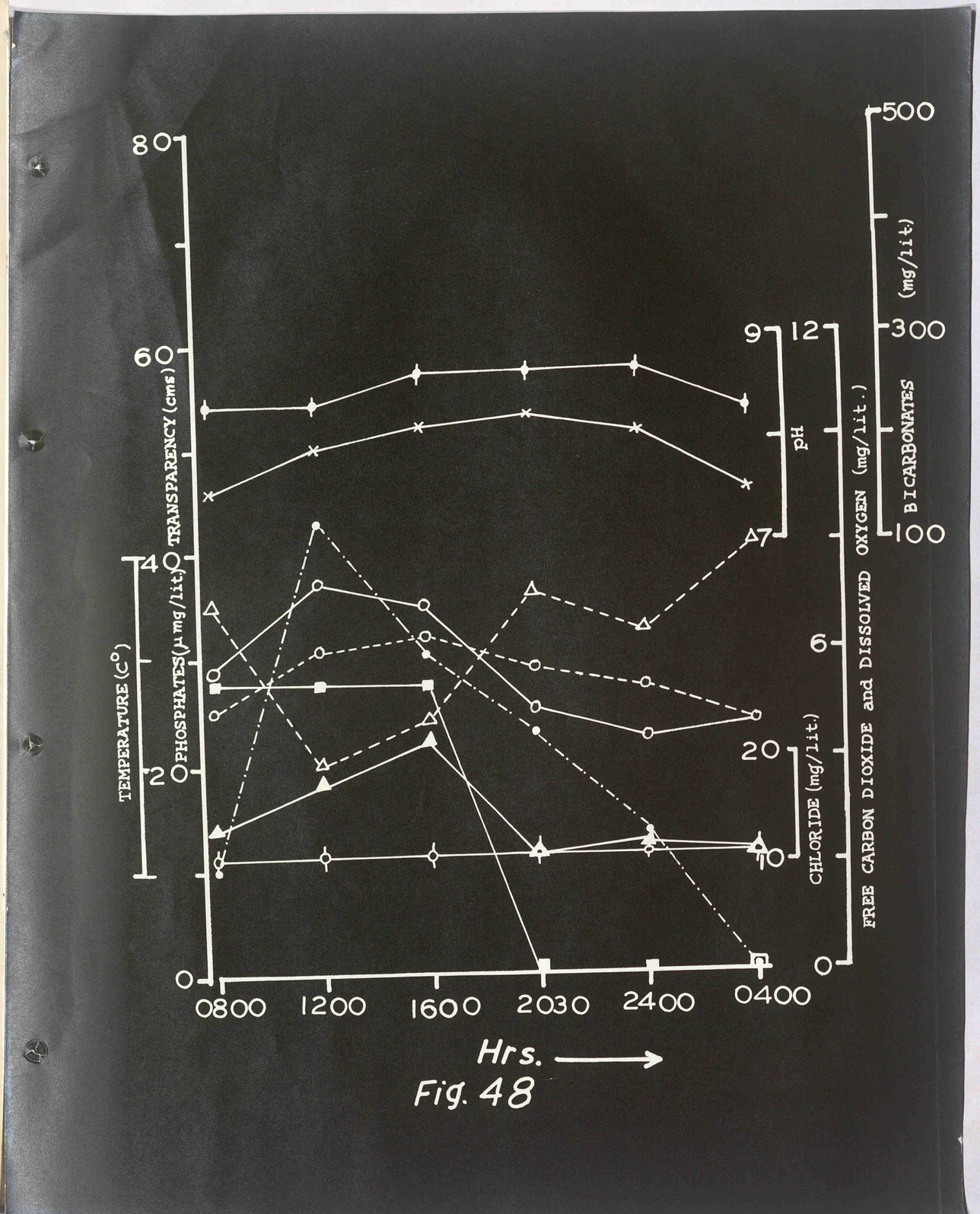


Fig. 48

Legend :

Free carbon dioxide	△- - - - -△
Dissolved oxygen	△——△
Bicarbonates	○——○
Chloride	○——○
Phosphate	•—•—•—•
pH	×——×
Transparency	□——□
Air temperature	○——○
Water surface temperature	○- - - -○

Fig. 49. Diurnal changes in physico-chemical parameters at Station No. V in Gadigarh stream on 26th – 27th Oct. 1975.

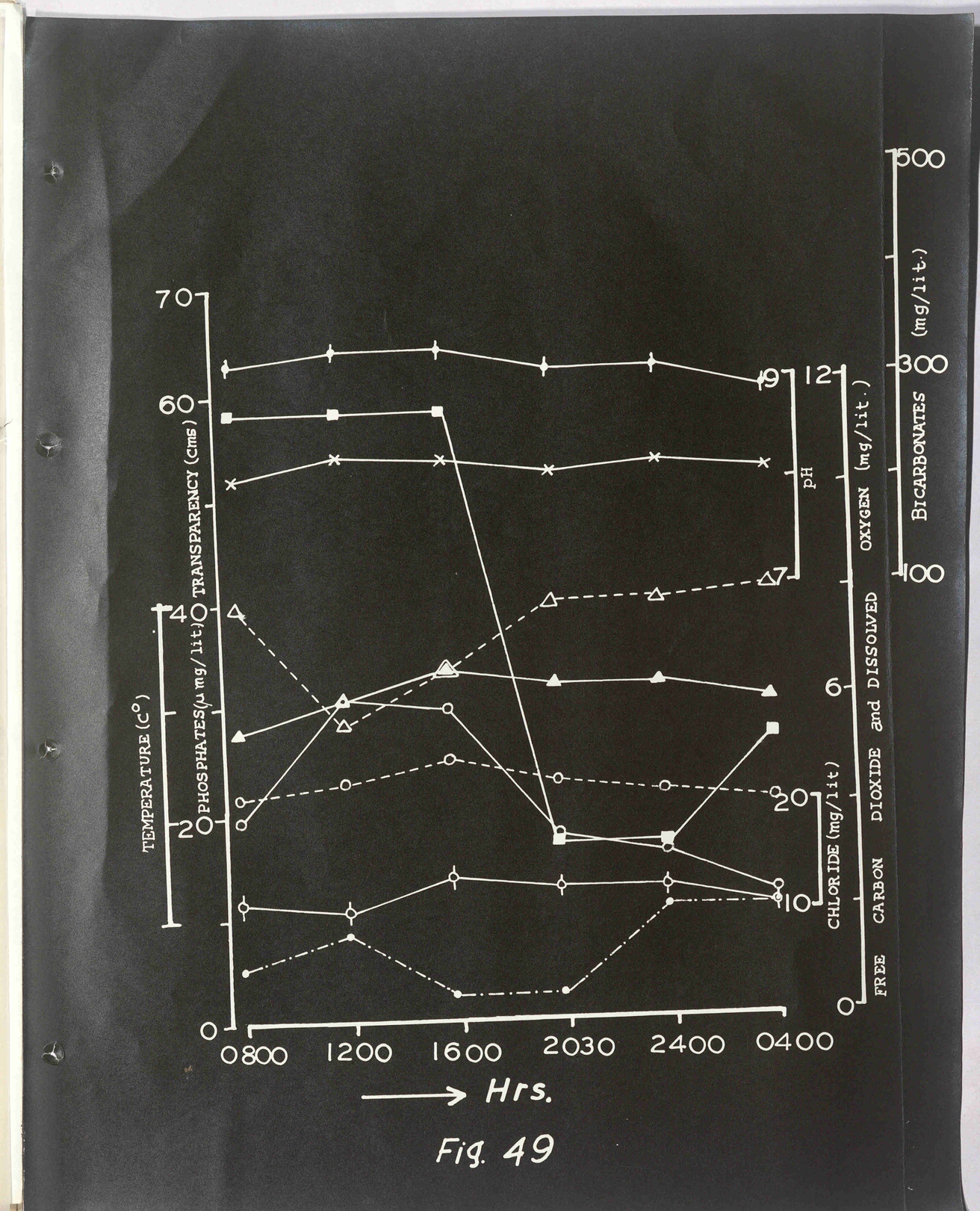


Fig. 49

Legend :

Free carbon dioxide △- - - - -△

Dissolved oxygen △——△

Bicarbonates ○——○

Chloride ○——○

Phosphate •—•—•—•

pH ×——×

Transparency □——□

Air temperature ○——○

Water surface temperature ○- - - -○

Fig. 50. Diurnal changes in physico-chemical parameters at Station No. V in Gadigarh stream on 3rd – 4th Dec. 1975.

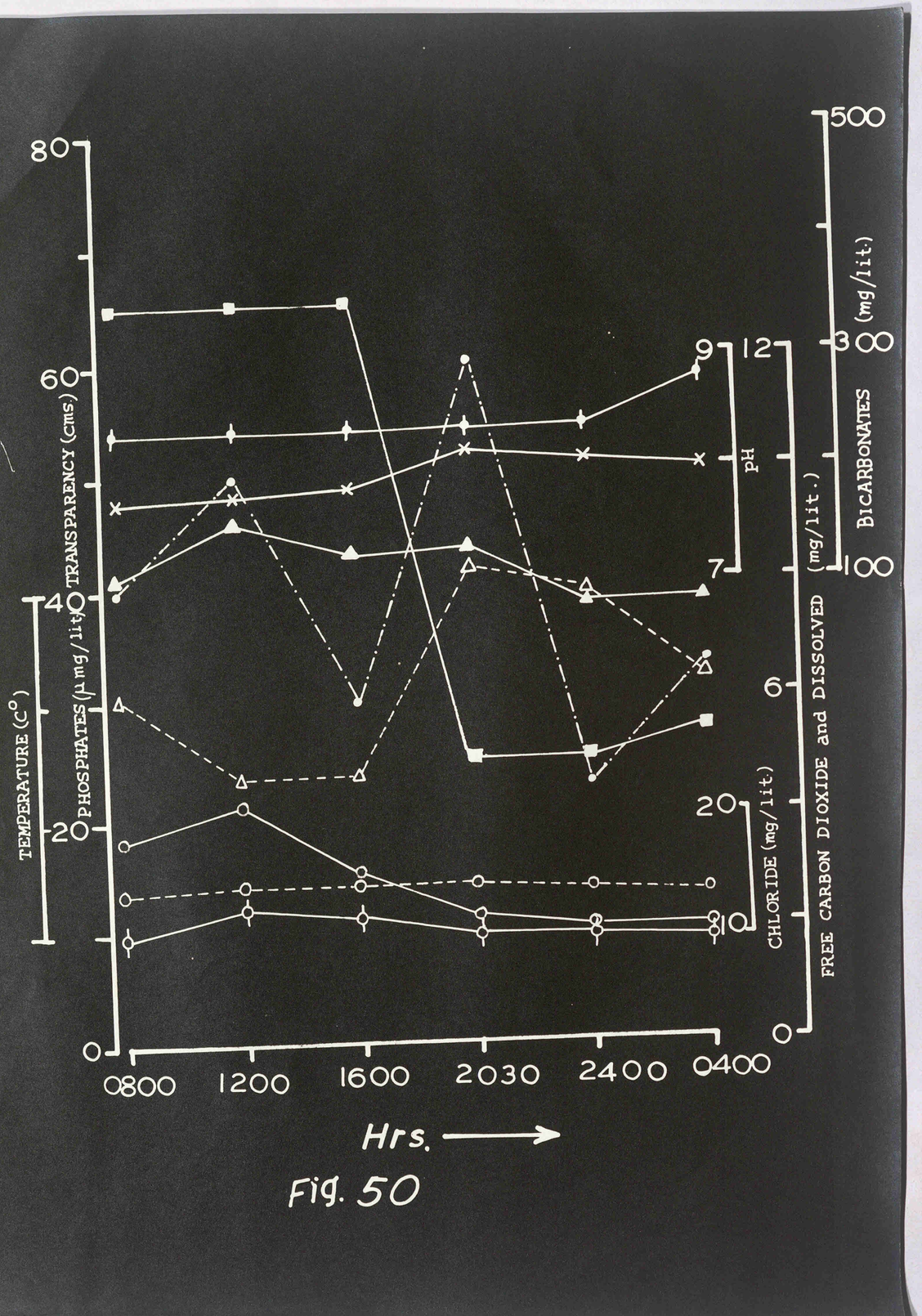


Fig. 50

Legend :

Free carbon dioxide	△- - - - -△
Dissolved oxygen	△ ——— △
Bicarbonates	○——— ○
Chloride	○——— ○
Phosphate	•—•—•—•
pH	×——— ×
Transparency	□——— □
Air temperature	○——— ○
Water surface temperature	○ - - - - ○

Fig. 51. Diurnal changes in physico-chemical parameters at Station No. V in Gadigarh stream on 23rd-24 Feb. 1976.

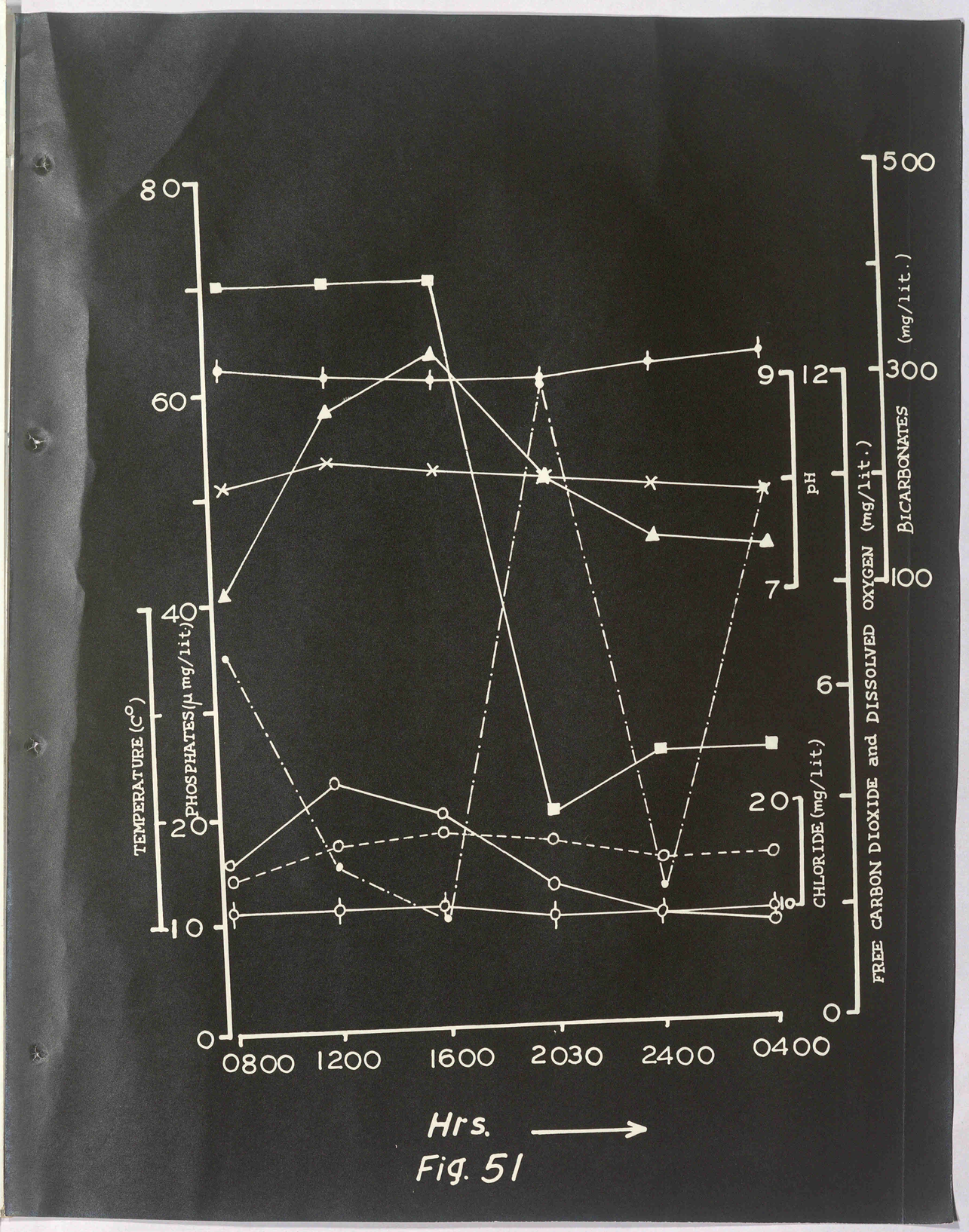


Fig. 51

ZOOPLANKTON

Types of migrations:

Welch (1952), Hutchinson (1967), and Raymont (1967) have reviewed the literature pertaining to diurnal zooplanktonic migrations from bottom layer towards surface during night or vice versa.

Hutchinson (1967) and Costa and Cummins (1969) define twilight migrations as those where more individuals are found at surface during evenings or early mornings. Present study has revealed the abundance of cladocera and copepoda during October, December and February in evenings and mornings which pattern collectively conforms to more or less twilight movements (Tables LXI - LXIII ; Figs. 54 - 56).

However, in July a single midnight peak of zooplankton conforms to nocturnal migration, replacing twilight migration as described by Hutchinson (1967). This replacement of twilight by nocturnal migration during July may be attributed to the fact that, the particular day on which this observation was made, happened to be a cloudy day,

which caused the advancement of twilight peak (as observed during present investigations) (Fig. 53) to a period between 1200 - 1600 hours, that day, thus simulating the dusk effect. Such an increase of plankton on the surface of water during a cloudy day has also been recorded by Costa and Cumminis (1969). In the opinion of present investigator this advancement may result in the disturbance of the bio-clock functioning in planktons, consequent upon which the dawn peak advances by a few hours, so as to be recorded near midnight, rather than the following dawn (Fig. 53).

Another type of nocturnal migration as described by Hutchinson (1967) has been recorded in Gadigarh stream during May (1975); when zooplankton starts vertical migration upwards, reaching a peak on surface before dawn, after which their downward migration commences. A similar type of migration has been observed by Blanc (1898) in lake Constance, Fordyce (1900) for Leydigia fimbriata in a pond 3 meters deep in Nebraska, and by Southern and Gardiner (1926 and 1932) for Eudiaptomus gracilis and Eurytemora velox in Lough Derg.

When migratory behaviour of copepoda or cladocera (the main constituents of zooplankton in

this stream) is looked into separately, it is observed that in July, though both show a midnight peak but after midnight while Copepoda decline in number, the Cladocera increase numerically on the surface. Differential behaviour of the two groups was highlighted during December at 2400 hour and 400 hours after midnight when Copepods were the twilight migrants; while Cladocera were altogether absent.

Causes of migration:

Russell (1927), Clarke (1933), Worthington (1931), Welch (1952), George (1966), Raymont (1967), Ummerkutty (1967), Costa and Cumminis (1969), Sumitra - Vijayaraghavan (1971b) have suggested food, pH, dissolved gases, light and gravity as factors controlling diurnal migrations of zooplankton.

Food as a cause for diurnal migration of zooplankton has been suggested by Eyden (1923), who stated that zooplankton during night feed on the surface; while during the day they sink due to increase in their weight. Worthington (1931), suggested that most of the zooplanktonic species are filter feeders (feeding on the nannoplankton which

are most abundant in the upper layers) this specific attraction for nannoplankton [redacted], thus is the ulterior reason for their preference to migrate to upper layers.

If we consider the feeding of zooplankton as an impelling factor, then their peak should coincide with or succeed the peak of phytoplankton on the surface. But in Gadigarh the maximum zooplankton on surface are recorded during night, a time when phytoplankton are numerically poor (George, 1966; Hutchinson 1967; Khan et al.1970; [redacted] and Kant and Kachroo, 1975) who have all observed maximum surface phytoplankton during the day and minimum during the night. Ummerkutty (1967) has also suggested that phytoplankton are of least importance in determination of migratory behaviour of zooplankton. Welch (1952) too has ruled out food as guiding factor in diurnal zooplanktonic migration. Thus in conclusion it may be stated that food does not appear to be the only important guiding factor for the diurnal zooplanktonic migrations.

Hutchinson (1967) quoting Langford observed that low oxygen or high carbon dioxide response at the bottom in a gradient tank produced upward

movements of Cyclops and Daphnia. Loeb (1893, 1904) and George (1966) concluded that increase of carbon dioxide in water during night causes an upward movement of Cyclops and Daphnia, and decrease of carbon dioxide coupled with warmth of water during day impels downward migration of zooplankton. Early morning peak of zooplankton (presently observed) may be correlated with the effect of increased carbon dioxide and decreased oxygen (Tables LIV - LVII ; Figs. 47 - 50). However, high carbon dioxide and low oxygen tension in Gadigarh stream cannot be accepted as the only important factors influencing zooplanktonic migration, because of the observations of evening peak, when carbon dioxide content in water is much less than what it is during early mornings.

Most of the previous workers like Welch (1952), Hutchinson (1967), Raymont (1967), Costa and Cummins (1969), Sumitra - Vijayaraghavan (1971b), and Khan et al. (1971) considered light to be an important factor in guiding zooplanktonic migrations. Welch (1952) suggested that the real diurnal planktonic migrations occur as a geotropic response, and as a reaction to changing light intensity during the course of a day. Light intervals effect the geotropic responses of the animals more than they

cause phototrophic reactions. Fading light intensities bring about negatively Geotropic movements whereas increasing light induces a positive Geotropic movements leading to the downward migration.

The presence of maximum number of zooplankton during diurnal studies are recorded in the evenings (before or after sunset), and/or early in the morning before sunrise is a phototactic response. The trough or depression in early part of dark night in some cases may fit into the paradigmatic case discussed by Cushing (1951) and Siebeck (1960) where the migrants after reaching the surface get randomly distributed or disoriented and sink to the bottom by midnight. Raymont (1967) citing Russell believed that this trough or depression is caused by random wandering of the animals (occurring in the absence of any light stimulus). Cushing (c. f. Raymont, 1967) also believed that such midnight sinking is common. He explained on the basis of photokinesis theory that movement in the absence of light is negligible and thus the plankton may sink. Where sinking occurs and plankton are more or less evenly distributed (during night), a rise towards the surface may follow at, or just before dawn. This "dawn rise", has been regarded as response to poor light intensity

occurring at dawn and is comparable to twilight effect.

Thus from the above studies it may be concluded that light appears to play an important role in inducing the negative and positive geotropism in zooplankton, so as to bring about their diurnal variations. But, the midnight peak of zooplankton observed during July and early morning peak at 400 hours during December and February (in the absence of light), casts some doubts on the impelling role of light. In conclusion it may be pointed out that dissolved gases are the important factors for diurnal variations of zooplankton with role of light remaining obscure in this direction.

Table LIX. Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during May 7th, 8th , 1975.

Organisms	Time (hrs) 8.00	12.00	16.00	20.30	24.00	4.00
Protozoa	100	50	50	100	50	-
Rotifera	-	100	100	-	-	-
Copepoda						
Cyclops spp.	75	50	175	100	150	500
Mesocyclops spp.	100	50	50	25	50	50
Macrocyclops spp.	-	-	25	-	75	125
Eucyclops spp.	-	-	-	-	-	-
Nauplius	125	-	--	25	-	50
Unidentified	50	-	-	50	125	125
Cladocera						
Simocephalus spp.	150	100	50	175	100	475
Scaphöleberis spp.	-	-	-	-	-	-
Moina spp.	-	-	-	-	-	-
Ceriodaphnia spp.	-	25	-	50	-	-
Diaphanosoma spp.	-	-	-	-	-	50
Macrothrix spp.	50	25	50	100	100	150
Pleuroxus spp.	-	-	-	-	25	100
Leydigia spp.	-	-	-	-	-	-
Camptocercus spp.	-	-	-	-	-	-
Unidentified	50	--	-	25	25	25

Table LX. Diurnal variations in zooplanktonic abundance at Station V in Gadigarh sstream during 3rd and 4th July, 1975.

Organisms	Time (hrs) 8.00	12:00	16.00	20.30	24.00	4.00
Protozoa	-	-	-	-	-	-
Rotifera	-	-	-	-	-	-
Copepoda						
Cyclops spp.	175	300	550	200	575	225
Mesocyclops spp.	100	350	150	475	800	200
Macrocyclops spp.	-	50	-	50	50	50
Eucyclops spp.	-	-	75	75	-	-
Nauplius	-	250	50	-	-	-
Unidentified	-	25	150	125	50	100
Cladocera						
Simocephalus spp.	-	75	100	125	425	200
Scapholeberis spp.	-	-	25	-	-	-
Moina spp.	-	-	25	-	25	75
Ceriodaphnia spp.	-	-	-	-	-	25
Diaphanosoma spp.	50	325	425	-	-	550
Macrothrix spp.	25	100	25	175	425	125
Pleuroxus spp.	-	-	-	-	-	-
Leydigia spp.	-	-	-	-	-	25
Camptocercus spp.	-	-	-	25	-	-
Unidentified	25	50	50	75	100	100

Table LXI. Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during October 26th & 27th, 1975.

Organisms	Time (hrs) 8.00	12.00	16.00	20.30	24.00	4.00
Protozoa	-	-	-	-	-	-
Rotifera	-	-	-	-	-	-
Copepoda						
Cyclops sps.	-	-	-	-	-	-
Mesocyclops sps.	-	-	-	-	-	-
Macrocyclops sps.	-	-	-	-	-	-
Eucyclops sps.	-	-	-	-	-	-
Nauplius	-	-	-	-	-	-
Unidentified	150	25	125	200	150	200
Cladocera						
Simocephalus sps.	-	-	-	-	-	-
Scapholeberis sps.	-	-	-	-	-	-
Moina sps.	-	-	-	-	-	-
Ceriodaphnia sps.	-	-	-	-	-	-
Diaphanosoma sps.	-	-	-	-	-	-
Macrothrix sps.	-	-	-	-	-	-
Pleuroxus sps.	-	-	-	-	-	-
Leydigia sps.	-	-	-	-	-	-
Camptocercus sps.	-	-	-	-	-	-
Unidentified	-	-	-	-	-	-

Table LXII. Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during December 3rd & 4th, 1975.

Organisms	Time (hrs) 8.00	12.00	16.00	20.30	24.00	4.00
Protozoa	-	-	-	-	-	-
Rotifera	-	-	-	-	-	-
Copepoda						
Cyclops spp.	50	25	25	150	25	150
Mesocyclops spp.	100	25	50	75	75	275
Macrocyclops spp.	-	-	-	-	-	-
Eucyclops spp.	-	-	-	-	-	-
Nauplius	100	25	25	-	-	50
Unidentified	100	25	150	175	200	150
Cladocera						
Simocephalus spp.	25	25	-	-	-	-
Scapholeberis spp.	-	-	-	-	-	-
Moina spp.	-	-	-	-	-	-
Ceriodaphnia spp.	-	-	-	-	-	-
Diaphanosoma spp.	-	-	-	-	-	-
Macrothrix spp.	-	-	-	-	-	-
Pleuroxus spp.	-	-	-	-	-	-
Leydigia spp.	-	-	-	-	-	-
Camptocercus spp.	-	-	-	-	-	-
Unidentified	25	25	100	-	-	-

Table LXIII. Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during February 23rd & 24th, 1976.

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Organisms	Time (hrs) 8.00	12.00	16.00	20.30	24.00	4.00
Protozoa	-	-	-	-	-	-
Rotifera	-	-	-	-	-	-
Copepoda						
Cyclops spp.	200	525	850	1025	625	600
Mesocyclops spp.	100	125	1050	300	525	650
Macrocyclops spp.	25	-	-	-	-	-
Eucyclops spp.	150	25	500	175	200	325
Nauplius	25	25	125	25	25	75
Unidentified	550	75	175	50	125	100
Cladocera						
Simocephalus spp.	1575	775	1200	700	500	1975
Scapholeberis spp.	-	-	-	-	-	-
Moina spp.	150	100	50	-	25	-
Ceriodaphnia spp.	75	-	-	-	-	-
Diaphanosoma spp.	-	-	-	-	-	-
Macrothrix spp.	-	-	-	-	-	-
Pleuroxus spp.	250	150	150	-	-	-
Leydigia spp.	25	-	200	-	-	-
Camptocercus spp.	125	50	50	-	150	100
Unidentified	50	125	200	25	75	300

Fig. 52. - Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during May 7th and 8th, 1975.

Fig. 53. - Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during July 3rd and 9th.

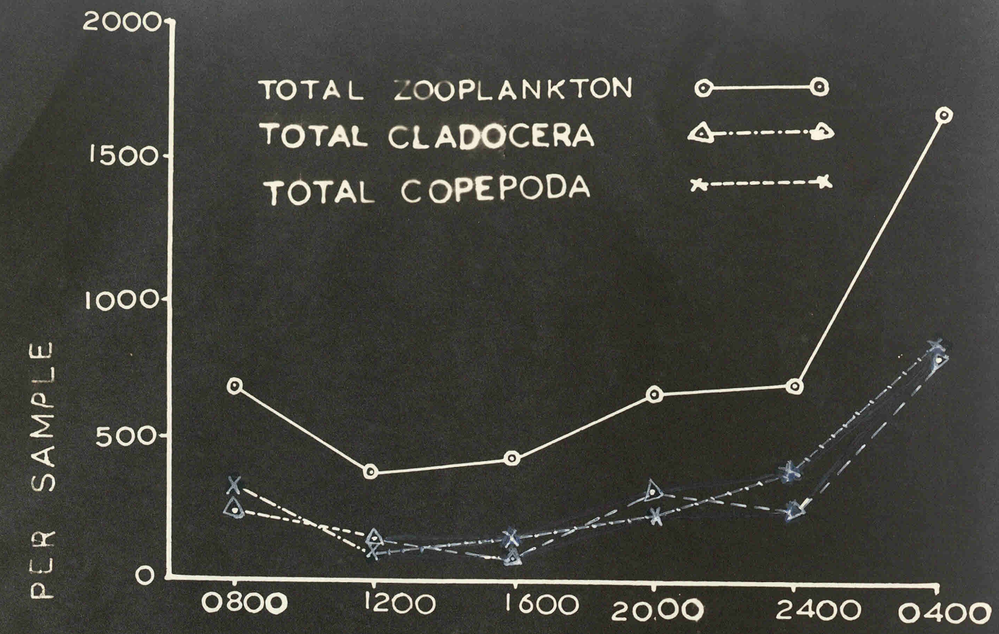


Fig. 52

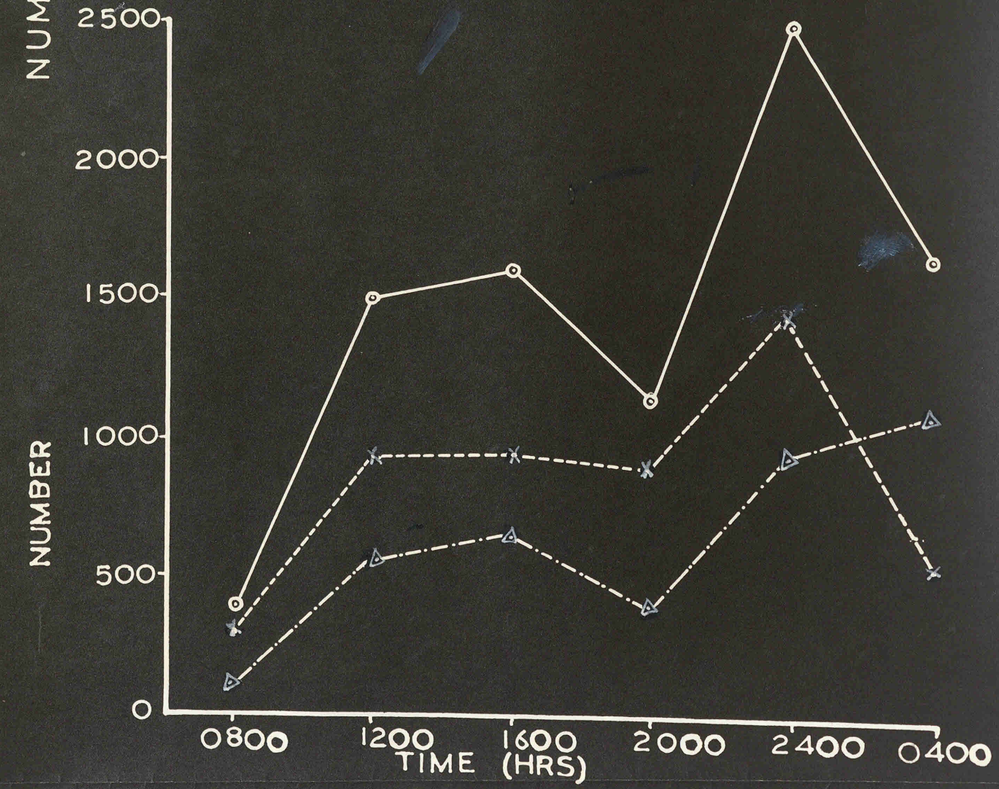


Fig. 53

Fig. 54. - Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during October 26th and 27th.

Fig. 55. - Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during December 3rd and 4th.

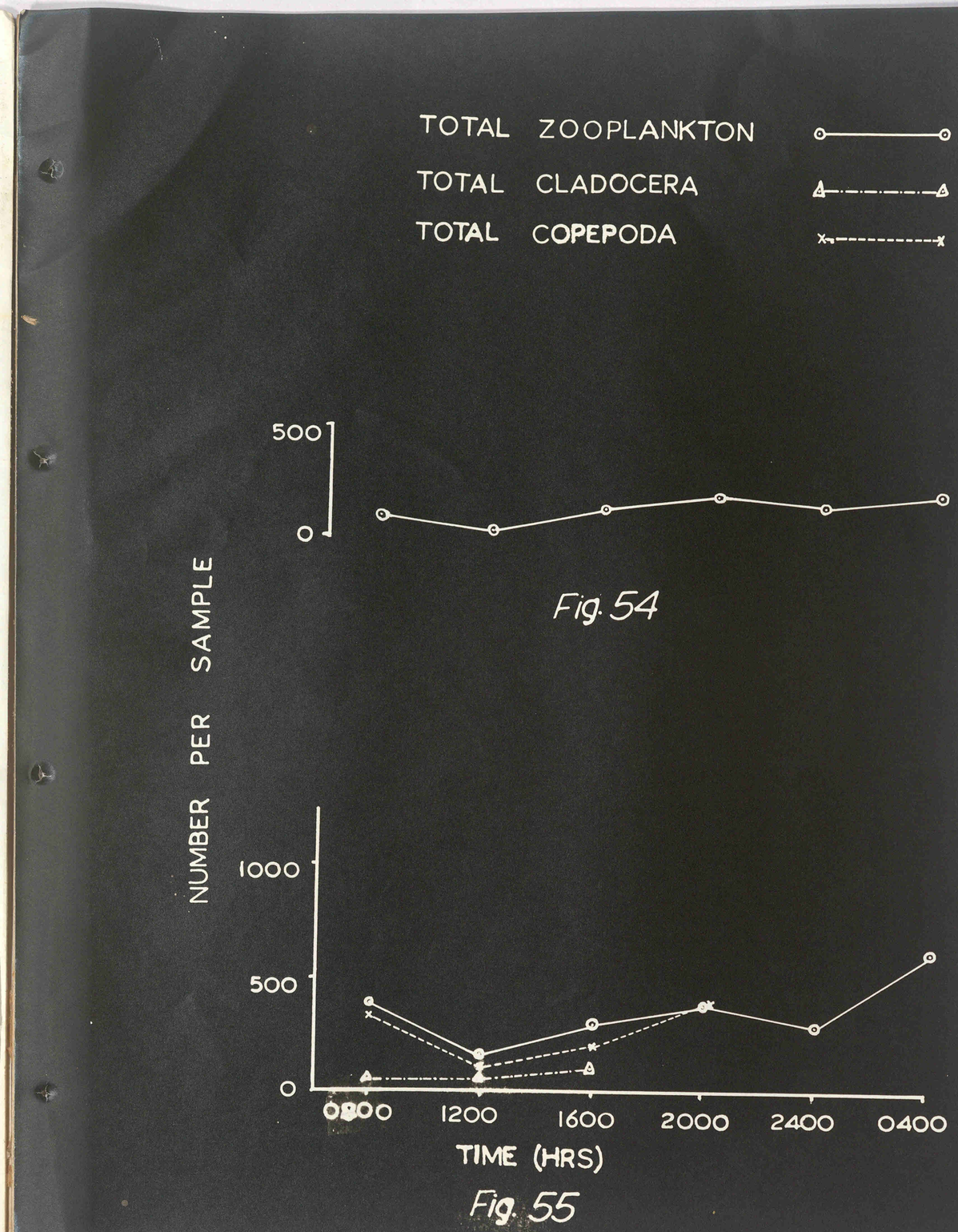


Fig. 54

Fig. 55

Fig. 56. - Diurnal variations in zooplanktonic abundance at Station V in Gadigarh stream during February 23rd and 24th.

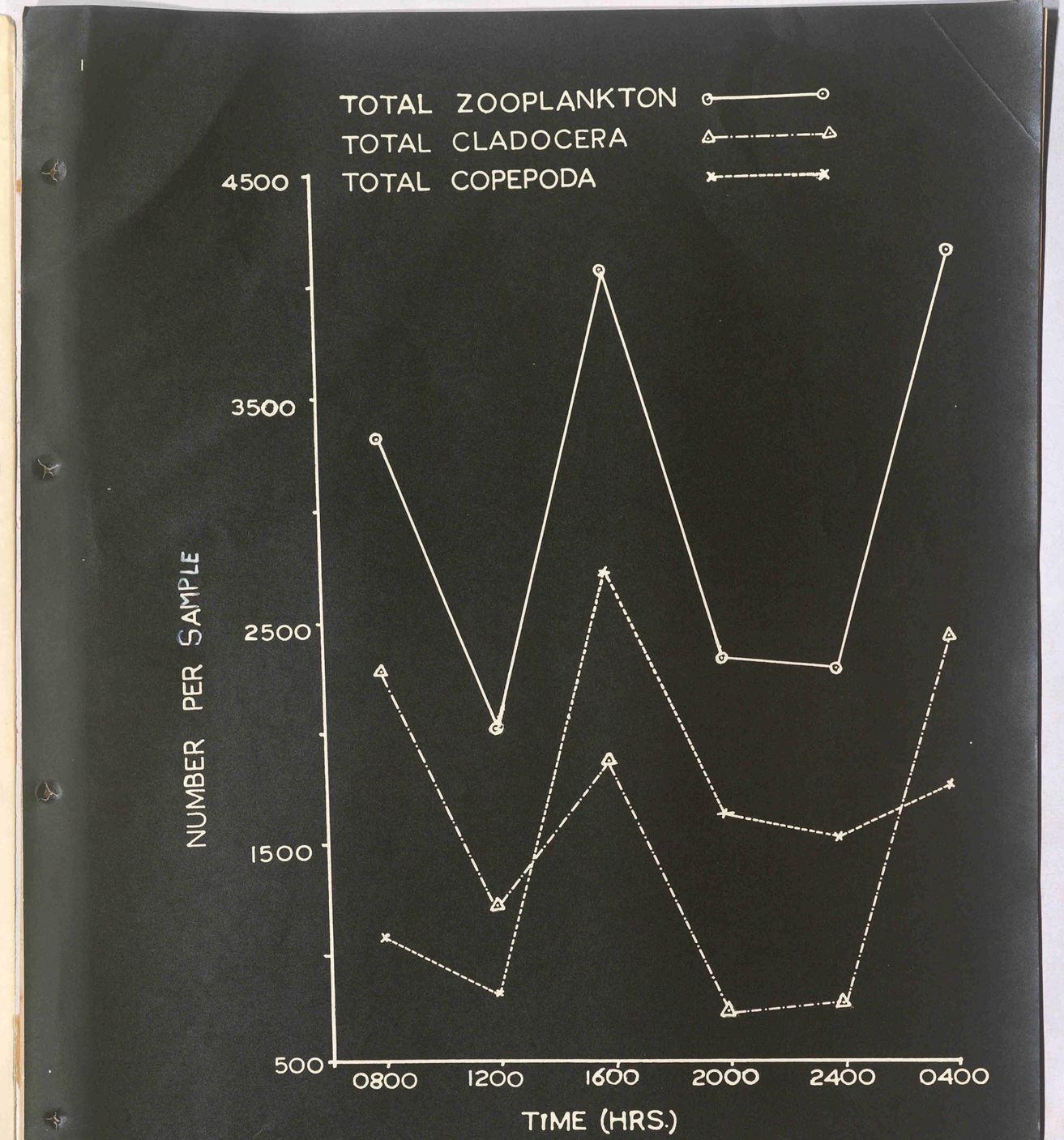


Fig. 56

BIOTIC RELATIONSHIPS OF SOME ECONOMICALLY IMPORTANT INHABITANTS OF THE STREAM

BIOLOGY OF MACROBRACHIUM DAYANUM (HENDERSON) AND MACROBRACHIUM LAMARREI (H. MILNE EDWARD)

1. OBSERVATIONS

1.1. Habit and habitat: Two species of prawns viz. Macrobrachium dayanum and M. lamarrei among other animals, occur in biotic complex of Gadigarh stream. Both these species have been observed inhabiting the stream mainly at its inlet, outlet, and along the littoral region of the stream, wherever aquatic vegetation abounds.

1.2. Food and feeding habits: Analysis of the stomach contents of young and mature individuals of both the sexes (in the two species viz. Macrobrachium dayanum and Macrobrachium lamarrei) has revealed that these prawns are detriti - omnivore (Tables LXIV and LXVII). No marked difference based on age and sex, has been observed in the feeding habits of either species. The food in varying percentages is contributed by detritus, plant matter (algae, diatoms and macrophytes), animal matter (insects and their larval forms, crustaceans, molluscs and annelids) and sand. The average monthly percental contributions of these items to the diet inventory of Macrobrachium dayanum and Macrobrachium lamarrei is represented in Tables LXIV and LXVII respectively.

1.3. Sex ratio: The percentage occurrence of two sexes of both the species for different months is represented in Tables LXVI and LXIX. It has been observed that the female prawns outnumbered the males during all the months of the two years of study, except in December, 1974 when the netted female prawns of Macrobrachium dayanum and Macrobrachium lamarrei were decidedly fewer than their males.

1.4. Total length and fecundity relationship: The number of eggs produced by 45 female specimens of Macrobrachium dayanum and 24 of M. lamarrei varies from 50 - 193 (Table LXV) and 60 - 277 (Table LXVII) respectively.

The mean number of eggs produced by 45 specimens of M. dayanum and 24 specimens of M. lamarrei works to be 98.58 and 116.08 respectively.

Forty five specimens of M. dayanum and twenty four of L. lamarrei ranging in length from 4.7 - 6.5 cm and 4.4 - 6.4 cm have been arranged in four and five length groups respectively. The length groups and the mean number of eggs produced by each group of two species are given below:

	M. dayanum		M. lamarrei	
	Mean		Mean	
Group	Length (cm)	Eggs. No.	Length (cm)	Eggs No.
I	4.92	79.13	4.61	83.00
II	5.41	101.00	4.96	116.40
III	5.82	110.40	5.58	140.33
IV	6.35	144.00	6.00	186.00
V	-	-	6.40	170.00

The regression equation calculated by the method of least square comes to be

Macrobrachium dayanum $Y = -137.4584 + 43.7495 X$

Macrobrachium lamarrei $Y = -151.9093 + 52.8232 X$.

Coefficient of correlation being 0.9852 and 0.9379 respectively, suggests a positive relationship.

In order to further substantiate Present findings on a true relationship, regression coefficients were also estimated and tested statistically. By applying 't test' for this purpose it was found that coefficients were significantly different at 5 % level.

Macrobrachium dayanum t = 8.1491
Table value of t at 5 % = 4.303

Macrobrachium lamarrei t = 4.6813
Table value of t at 5 % = 3.182

1.5. Total weight and fecundity relationship: Forty five specimens of M. dayanum and twenty four of M. lamarrei ranging in weight from 1.12 g - 4.13 g and 0.60 - 2.28 g respectively, have been grouped in five and four weight groups. The weight groups and mean number of eggs produced by each group of two species are as under.

	M. dayanum		M. lamarrei	
	Mean		Mean	
Group	Length (cm)	Eggs No.	Length (cm)	Eggs No.
I	1.40	86.85	0.79	98.47
II	1.87	96.89	1.36	152.40
III	2.52	101.67	2.00	180.00
IV	3.59	104.50	2.28	170.00
V	3.89	146.33	-	-

Regression equation was found to be for

Macrobrachium dayanum Y = 61.0769 + 17.3968 X

Macrobrachium lamarrei Y = 69.8870 + 49.9723 X

Coefficient of correlations of M. dayanum and M. lamarrei have been found to be 0.8171 and 0.9177 respectively.

By applying 't test' (as discussed earlier) coefficients have not been observed significantly different at 5 % level.

Macrobrachium dayanum t = 2.4545
Table value of t at 5 % = 3.182

Macrobrachium lamarrei t = 3.2679
Table value of t at 5 % = 3.303

1.6. Breeding: Each mature individual of M. dayanum and M. lamarrei breeds only once during the breeding season which in both the species extends from late March to end of July. Towards the end of March, females with eggs in their brood pouches start appearing in the nets. Their numbers rise considerably in the following two months when in the month of June, their numbers fall to only a few per catch. In July, the month of starting monsoons, the number of gravid females netted is very rare.

2. DISCUSSION

2.1. Food and feeding habits: A seasonal study on the food of Macrobrachium dayanum and M. lamarrei leads to the conclusion that both are detriti-omnivores, feeding mostly on detritus, with plant matter, animal matter and sand ranking next in order of preference and quantification (Tables LXIV and LXVII). Dominance of detritus in the gut contents has also been recorded for other species ofMacrobrachium viz. M. rosenbergii by Rao (1967) and for M. malcomsonii by Rajayalakshmi, (1968); both these species inhabiting Hooghly estuary and River Godavari. Detritivore habit of prawns (not belonging to genus Macrobrachium)have been recorded by Menon (1951, 1953), Gopalakrishnan (1952), Panikar and Menon (1956), and Kuttyamma (1974).

Presence of detritus and some bottom dwelling annelids in the food of M. dayanum and M. lamarrei positively indicate a bottom feeding habit of these decapods. Kuttyamma (1974) on the basis of the presence of polychaetes, amphipods, molluscs, protozoans, nematodes, sand and mud in the stomach contents of Metapenaeus dobsoni, M. affinis, M. monoceros, Penaeus monodon, and P. indicus

designated these as benthic feeders. Dall, (1968) suggested that mud contains bacterial colonies, and filamentous algae in which protozoans, copepods, nematodes and other fauna are abundant. He further suggested that in a densely populated shrimp ground, large food masses may be insufficient to support a healthy population and this deficiency is likely to be made up by shifting its feeding on benthic epiflora and epifauna. Presence of higher amount of detritus in food (even during the peak period of aquatic vegetation) possibly indicates the food preference in M. dayanum and M. lamarrei in favour of detritus, rather than a mere shift to it on account of deficiency of other food items as has been previously suggested by Dall (1968) for Australian commercial penaeid shrimps, Penaeus esculentes, P. merguiensis, P. plebejus, Metapenaeus bennettae and M. macleayi.

Comparatively higher amount of vegetation observed in the stomach contents of M. dayanum and M. lamarrei during April - June goes to indicate only the higher rate of decomposing vegetation during this period (as already discussed May and June, precede peak period of vegetation). Similarly, a slight increase of animal matter in the dietary of

M. lamarrei observed during the month of April may be due to the relatively greater abundance of animals observed in the environment.

Comparative study of food has shown that M. lamarrei differs in its dietary from M. dayanum in only getting slightly higher contribution of animal and plant matter. However, it may be concluded that general similarity of feeding habits and preference for detritus by both, engage them in a direct interspecific competition in the niche.

2.2. Fecundity: Although Macrobrachium dayanum is a larger species (with stout legs) yet it is less fecund than comparatively smaller M. lamarrei. These results are in line with those of Koshy and Tiwari (1975). But the average number of eggs carried by 45 specimens of M. dayanum and 24 of M. lamarrei (i.e., 98.58 and 116.08 respectively as counted during the present investigations) is much higher than the count(66.8 and 87.5)recorded earlier by Koshy and Tiwari (1975)from Calcutta. This variability at the outset appears to be a result of ecological variation, unless the reduced ovular count in these species reported from eastern part of the country could be an outcome of multiple brooding habit, not elaborated by Koshy and Tiwari (1975) in their communication.

Table LXIV. Seasonal variation in each food item of Macrobrachium dayanum (Henderson) (Qualitative studies).

S.No. Period	Plant (%)	Animal (%)	Detritus (%)	Sand (%)
1974				
1. April	27.00	5.50	60.00	7.50
2. May	30.25	3.50	56.26	10.00
3. June	14.51	4.38	74.23	6.88
4. September	14.50	12.50	68.00	5.00
5. October	18.75	2.50	68.50	10.25
6. November	16.58	5.43	72.14	5.86
7. December	10.33	7.33	71.33	11.00
1975				
8. January	19.71	8.00	63.86	8.43
9. February	13.16	10.84	67.66	8.33
10. March	18.97	-	71.29	9.76
11. April	14.17	8.17	72.17	5.50
12. May	14.00	1.72	76.46	7.82
13. June	13.00	0.50	75.00	11.50
14. July	10.00	-	80.00	10.00
15. August	8.50	6.00	73.00	12.50
16. September	14.00	4.00	77.40	4.60
17. October	15.00	-	80.00	5.00
18. December	22.50	10.00	65.00	2.50
1976				
19. January	14.00	5.50	73.17	7.33
20. March	25.00	1.00	70.00	4.00

Table LXV. Total length, weight and number of eggs in brood pouch of Macrobrachium dayanum (Henderson).

S.No.	Total length (cm)	Total weight (g)	Number of eggs
1.	4.7	1.50	89
2.	4.7	1.62	60
3.	4.8	1.80	83
4.	4.8	1.45	50
5.	4.8	1.91	75
6.	4.8	1.40	70
7.	4.9	1.38	85
8.	4.9	1.20	70
9.	5.0	2.68	115
10.	5.0	3.59	72
11.	5.0	1.56	100
12.	5.1	2.30	76
13.	5.1	1.70	90
14.	5.1	1.44	65
15.	5.1	1.75	87
16.	5.2	1.20	84
17.	5.2	1.56	62
18.	5.2	1.50	93
19.	5.2	1.75	107
20.	5.2	2.13	98
21.	5.3	2.10	118
22.	5.3	2.40	95
23.	5.3	2.10	82
24.	5.3	2.00	104
25.	5.4	1.85	94
26.	5.4	2.13	100
27.	5.5	1.82	78
28.	5.5	1.74	88
29.	5.5	1.81	107
30.	5.5	1.78	50
31.	5.6	1.80	63
32.	5.6	2.55	89
33.	5.6	1.74	192
34.	5.6	2.62	87
35.	5.6	1.30	193
36.	5.6	2.42	137
37.	5.7	1.78	128
38.	5.8	1.12	108
39.	5.8	2.69	125
40.	5.8	2.40	103
41.	6.0	2.58	88
42.	6.3	3.70	95
43.	6.3	3.59	137
44.	6.3	4.13	163
45.	6.5	3.85	181

Table LXVI. Percentage of different sexes in *Macrobrachium dayanum* (Henderson).

S.No. Period	Specimens studied	Number		Percentage	
		Femal	Male	Female	Male
1974					
1. April	12	9	3	75.00	25.00
2. May	13	8	5	61.54	38.46
3. June	18.00	13	5	72.22	27.78
4. September	7	6	1	85.71	14.29
5. October	28.	19	9	67.86	32.14
6. November	18	14	4	77.78	22.22
7. December	9	3	6	33.33	66.66
1975					
8. January	11	7	4	63.64	36.36
9. February	9	6	3	66.66	33.33
10. March	27	19	8	70.37	29.63
11. April	24	16	8	66.66	33.33
12. May	13	9	4	69.23	30.77
13. June	8	4	4	50.00	50.00
14. July	5	3	2	60.00	40.00
15. August	7	5	2	71.43	28.57
16. September	28	21	7	75.00	25.00
17. October	7	5	2	71.43	28.57
18. December	12	9	3	75.00	25.00
1976					
19. January	7	7	0	100.00	00.00
20. March	8	4	4	50.00	50.00

Table LXVII. Seasonal variation in each food item of *Macrobrachium lamarrei* (H. Milne Edward) (Qualitative studies).

S.No. Period	Plant (%)	Animal (%)	Detritus (%)	Sand (%)
1974				
1. June	7.50	12.50	72.50	7.50
2. July	18.00	-	72.50	9.50
3. September	15.00	-	80.00	5.00
4. October	15.00	10.70	68.00	6.30
5. November	11.45	6.16	76.78	5.61
6. December	18.09	9.83	65.00	7.09
1975				
7. January	15.76	12.53	64.82	6.88
8. February	19.00	12.49	62.50	6.00
9. March	16.89	13.00	61.33	8.78
10. April	25.63	17.18	52.64	4.55
11. May	23.76	12.63	58.13	5.50
12. June	26.00	2.50	65.50	6.00
13. August	12.33	6.00	76.66	5.00
14. September	13.80	4.00	76.20	6.00
15. December	19.00	3.00	70.00	8.00
1976				
16. January	16.00	2.33	75.00	6.66
17. February	22.99	4.66	66.00	6.33

Table LXVIII. Total length, weight and number of eggs in brood pouch of *Macrobrachium lamarrei* (H.Milne.Edward).

S.No.	Total length(cm)	Total weight(g)	Number of eggs
1.	4.4	0.65	82
2.	4.5	0.70	60
3.	4.5	0.68	81
4.	4.5	0.84	100
5.	4.5	0.66	88
6.	4.6	0.68	92
7.	4.6	0.60	83
8.	4.7	0.74	94
9.	4.8	0.78	80
10.	4.8	0.70	80
11.	4.8	0.82	73
12.	4.9	0.88	170
13.	4.9	0.85	123
14.	4.9	0.65	90
15.	5.0	0.98	116
16.	5.1	1.40	83
17.	5.4	1.10	176
18.	5.5	1.10	86
19.	5.6	1.36	129
20.	5.6	1.21	277
21.	5.7	2.00	180
22.	5.7	1.52	87
23.	6.0	1.30	186
24.	6.4	2.28	170

Table LXIX. Percentage of different sexes in *Macrobrachium lamarrei* (H. Milne Edward).

S.No. Period	Specimens studied	Number		Percentage	
		Female	Male	Female	Male
1974					
1. June	8	4	4	50.00	50.00
2. July	10	6	4	60.00	40.00
3. September	6	4	2	66.67	33.33
4. October	24	15	9	62.50	37.50
5. November	32	18	14	56.25	43.75
6. December	15	7	8	46.67	53.33
1975					
7. January	24	14	10	58.33	41.67
8. February	27.	20	7	74.07	25.93
9. March	21	13	8	61.90	38.10
10. April	13	8	5	64.29	35.71
11. May	23	16	7	69.57	30.43
12. June	9	6	3	66.67	33.33
13. August	7	4	3	57.14	42.86
14. September	6	3	3	50.00	50.00
15. December	8	8	0	100.00	00.00
1976					
16. January	8	5	3	62.50	37.50
17. February	7	5	2	71.43	28.57

Fig. 57. - Relationship between total length and fecundity in Macrobrachium dayanum (Henderson) and M. lamarrei (H. Milne Edward).

Fig. 58. - Relationship between total weight and fecundity in Macrobrachium dayanum (Henderson) and M. lamarrei (H. Milne Edward).

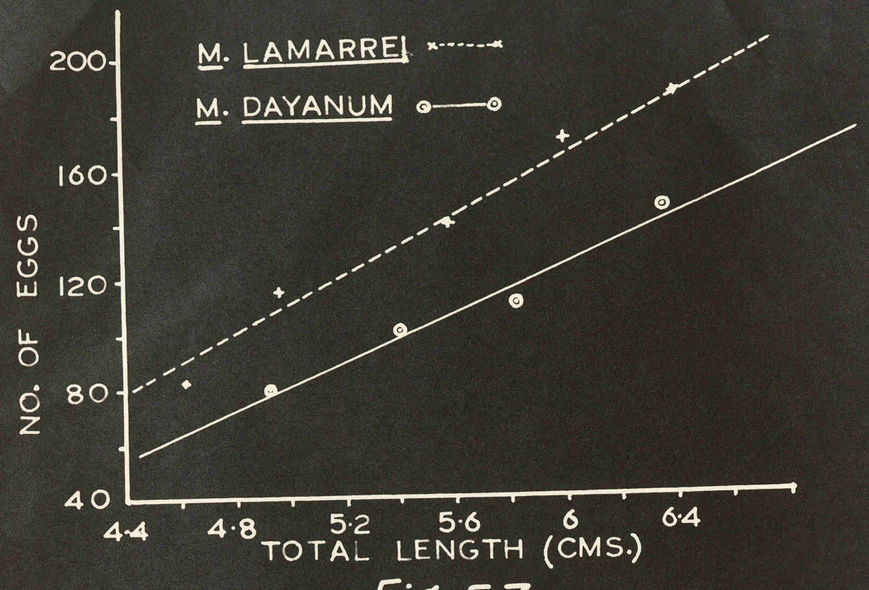


Fig. 57

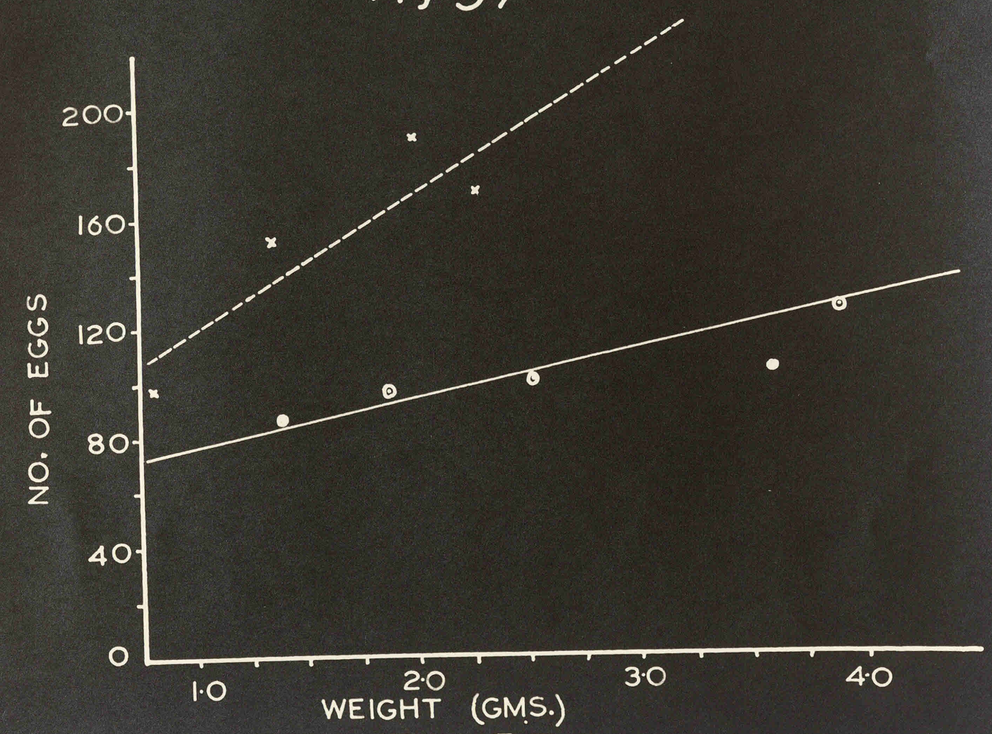


Fig. 58

FOOD AND FEEDING HABITS OF FISHES

Twelve consistently netted fishes out of a total of 42 fish species inhabiting Gadigarh stream have been investigated for qualitative and quantitative variations in food (Tables LXX - VIIC); others were similarly investigated for qualitative studies as and when available (Table VIC). Fishes thus investigated are Puntius sophore, P. ticto, P. conchonius, Rasbora rasbora, Danio rerio, Chela (Chela) cachius, Lepidocephalichthys guntea, Noemacheilus botium, Heteropneustes fossilis, Mastocembelus armatus, Badis badis and Channa punctatus.

A mere comparison of results on food and feeding habits of fishes investigated during the present investigations with those on same fishes worked out from elsewhere may not give proper insight into the problem concerning development of pisciculture in this area. In order to obtain a better knowledge concerning the problem of food and feeding of fishes, a discussion along the following lines may prove useful:

1. classification of fishes on the basis of their food and feeding habits.
2. feeding variations in relation with availability of food.

3. feeding variations in relation to physico-chemical and biotic factors.

4. interspecific and intraspecific competition in a community within an ecosystem.

1. Classification of fishes on the basis of their food and feeding habits:

Fishes are generally classified as herbivorous, carnivorous and omnivorous. Detritophagic are fishes feeding on detritus. Some workers follow classification as surface feeder, column feeder, and bottom feeders (Job, 1940; Mookerjee et al. 1946; Das and Moitra, 1955, and Jhingran, 1975). Kaliyamurthy and Rao (1972) use the terms benthos feeder, and plankton feeders.

The present study has indicated that some fish species inhabiting Gadigarh stream show a mixed pattern of feeding, being herbivorous at one time, omnivorous at another, and some are exclusively carnivorous. A comparison of food for fish species investigated from this study area with those investigated from other parts of the country have revealed a great variation in their feeding habits. Intraspecific variations in feeding preferences under varying ecological conditions is already known

(Das and Moitra, 1955; [redacted] Nikolsky, 1963 and Jyoti and Malhotra 1975), in view of which the differences in feeding habits, as discussed in relation to presently investigated fish species seems relevant.

Puntius sophore and P. ticto have been assigned to be omnivorous by Chacko and Kuriyan (1947) and P. sophore by Das and Moitra (1955); while Sewell and Chaudhuri (1912), Wilson (1917), Raj (1930), Chatterjee (1934), Prasad and Hora (1936) Hora and Mukerjee (1938) and Job (1943 and 1944) considered them as larvivorous. But during the present investigations, both these fish species have been observed to be herbivorous, tending rarely towards omnivory. The herbivorous feeding habit of these fishes as recorded by present investigator is in the line with observations of Fernando et al. (1969) from Ceylon, and Natarajan et al. (1975) from Konar and Tillaiya reservoirs.

Puntius sarana as observed in Gadigarh stream is omnivorous, as also reported earlier by Chacko and Kuriyan (1947), Das and Moitra (1955), Fernando et al. (1969) and Sinha (1972); however, Mookerjee et al. (1946) and Bhatnagar (1963) on the basis of their observations from Bengal and

Tungabhadra reservoir respectively concluded that this species is herbivorous.

Noemacheilus botium is confirmed as an omnivorous fish, thereby substantiate what has already been reported for this and allied species from Indian waters (Srivastava 1959[b] and Jyoti and Malhotra 1975). Conversely Fernando et al. (1969) reported Noemacheilus botium from Ceylon to be herbivorous.

Osteobrama cotio recorded by Parameswaran et al. (1971) is an omnivore with zooplankton as the dominent constituent of its food. During the present investigations O. cotio is confirmed to be an omnivore; but with plant matter forming main component of its diet and animal matter ranking next (Table VIC), thus Confirming a similar observation that has been recorded by Natarajan et al. (1975) for this species.

Glossogobius giuris is a carnivore as reported by Alikunhi et al. (1951), Bhowmick (1965) and Natarajan et al. (1975). However, Mookerjee [illegible] (1947) observed it as an omnivore feeding on animals and plants in the ratio of 7 : 3.

In the present studies fishes like Danio rerio, Rasbora rasbora, Badis badis,

Chela (Chela) cochius, Oxygaster bacaila carry protozoa, cladocera, copepoda, decapod crustacea, insects and their larvae beside algae and diatoms in their stomach contents and hence merit the title of "surface feeders" in accordance with the criteria laid by Job (1940), Mookerjee et al. (1946), and Das and Moitra (1955).

Present study has also indicated that the food of Channa punctatus, C. marulius, Ompok bimaculatus, Wallago attu, Xenentodon cancila, Glossogbius giuris, Nandus nandus, Mystus seenghala, M. bleekeri, M. vittatus, Mastocembelus armatus, M. pancalus, Osteobrama cotio, Puntius sarana, P. conchonius, P. ticto, and P. sophore consists of insects, crustaceans, fishes, algae, diatoms, macrophytes, detritus, sand and mud which is more or less similar to that recorded by Das and Moitra (1955) for mid feeders or column feeders and as such all the above named fishes could be placed in the category of column feeders.

Bapat and Bal (1950), Das and Moitra (1955), Motwani and Karamchandani (1958), Kaliyamurthy and Rao (1970) and Jyoti and Malhotra (1975) have linked the presence of detritus, sand mud, molluscs and rotten

plants with the bottom feeding nature of fishes studied by them. All of these food items have been recorded from the gut contents of Lepidocephalichthys guntea, Noemacheilus botium, and Heteropneustes fossilis during present investigations (Tables XVIIC, XVC and XIIIC) which can thus be classified as bottom feeders. Morphological adaptation of ventral mouth also supports this designation.

Puntius sophore and P. ticto show a sustained presence of detritus and sand in their food (Tables LXXI and LXXIII) although terminal position of mouth does not support this indication of bottom feeding habit. Presence of detritus in food of these fishes may be due to their browsing upon the aquatic vegetation and the habit of feeding with mouth downwards (tail up) as observed in the laboratory during the present studies. Browsing habit for these fish species has also been reported by Natarajan et al. (1975). Algal growth is known to entrap detritus (Spence and Hynes, 1971) which may inturn account for its intake along with algae while browsing.

Surface and column feeders in Gadigarh stream include herbivores, omnivores and

carnivores; but bottom feeders are only omnivores. On the contrary Das and Moitra (1955) observed omnivorous and carnivorous fishes from among surface feeders. They also observed herbivorous, omnivorous and carnivorous fishes from among bottom feeders and herbivorous and carnivorous amongst the column feeders.

2. Feeding variations in relation with availability of food:

Planktonic crustacea that have been observed to contribute to the gut contents of Badis badis, Danio rerio, Lepidocephalichthys guntea are cladocera and copepoda. A low or high contribution or complete absence of planktonic crustacea in guts of Badis badis, Danio rerio and Lepidocephalichthys guntea corresponded with its position in nature. In Rasbora rasbora (an omnivore fish) planktonic crustacea have been recovered from Rebruary - April only, which is perhaps due to the abundance of these organisms in the environment during this period.

Decapod crustacea (Macrobrachium sp. and Caridina sp.) have been observed in the food of Channa punctatus (Table VIIC); being maximum during April. Continuous presence of decapod crustacea is due to the continued availability as well as suitable size of these forms which fish could swallow easily. A study of the biology of these crustaceans has shown that they are present in the stream throughout the year increasing numerically during February, March and April which accounts for their higher percentages in food of Channa punctatus during the months of April.

Recovery of decapod crustacea from the food of Badis badis in May, September October & December (1974) and January, June & July March, (1975) appears to be accidental. It may not be unlikely that this fish has an attraction for these animals but the large size of prey (in comparison with small mouth of the fish) makes them unengulfable.

Records of rotifers and ostracods in food of Lepidocephalichthys guntea and ostracods in food of Badis badis only on few occasion is due to the rarity of these organisms in the environmeht.

Annelids, irrespective of their seasonal fluctuations, made a very low contribution to the food of Lepidocephalichthys guntea, Noemacheilus botium and Mastocembelus armatus (Tables LXXXIII - LXXXV & XIC) suggesting that they are a non-preferred diet.

Heteropneustes fossilis, Badis badis, and Channa punctatus eat molluscs (Tables XIC, IXC & VIIC). In Channa punctatus and Badis badis, the presence of molluscs in their stomach appears accidental as is evident from the very low percentage of their occurrence in these fishes. But the preponderance of molluscs in the alimentary canal of Heteropneustes fossilis (either complete or broken into fragments) throughout the period of present investigations is suggestive of the fact that molluscs are preferred over other organisms; this fish is thus designated as molluscivore. Regular presence of molluscs in the dietary can be related with their continuous occurrence in the environment.

Recovery of aquatic insects from food of Channa punctatus, Badis badis, Rasbora rasbora Danio rerio, Chela (Chela) cachius, Noemacheilus botium Mastocembelus armatus, and Lepidocephalichthys guntea

is due to the continuous presence of these animals in the stream.

Algae form another important component of diet of Puntius ticto, P. conchonius, P. sophore, Rasbora rasbora, Chela (Chela) cachius, Lepidocephalichthys guntea and Noemacheilus botium. In Lepidocephalichthys guntea and Noemacheilus botium no seasonal relationship between algae and food items could be established. In Puntius ticto, P. conchonius and P. sophore algae forms almost a regular food item showing its increased presence somewhere between January - April. Comparatively increased contribution of algae during this period in food appears to be concurrent with increased algal production in the stream.

3. Feeding variations in relation with physico-chemical and biotic factors:

A look at Tables LXX, LXXII, LXXIV, LXXVI, LXXVIII, LXXXII, XIIC, XC, VIIIC shows that in majority of fishes like Puntius sophore, P. conchonius P. ticto, Rasbora rasbora, Danio rerio, Chela (Chela) cachius, Lepidocephalichthys guntea, Mastocembelus armatus, Badis badis, and Channa punctatus there occurs

a fall in the rate of feeding intensity as measured from study of entero-somatic index (Figs. 59, 60, 61, 62, 63, 64, 65, 68, 69, and 70) during May and June. The feeding intensity in most of the investigated fishes reaches peak twice a year. The first peak is established somewhere between February - April and the second between October - December. These changes in feeding intensity are attributed to the individual or combined effect of (i) temperature and oxygen, (ii) condition of gonads, and (iii) availability of food.

Temperature as an important factor affecting growth, production and digestion in organism is well known. Nikolsky (1963) has stated that each fish species has its own temperature optimum and any rise in the temperature within its optimal range would lead to an increase in the rate of digestion.

In the fishes presently investigated, it is observed that the feeding rate increases with the increase in temperature after winter i.e. a continuous increase in feeding sets in after January reaching a maximum by February, March or April in most of the fishes. This suggests temperature range from 15.7° - 26.0°C (at the various stations of the stream)

as the optimal temperature range for increased food intake. This higher feeding in relation with optimum temperature is further confirmed through a second feeding peak (October - December) when the temperature range in stream varies from 15.4°C - 24.9°C. Abrupt rise in temperature of 32° - 35°C (beyond optimum) during May - June accounts for a fall in feeding rate of presently investigated fishes.

Oxygen tension has been reported to have a direct effect on food consumption and growth of fishes by Hermann et al. (1962), Stewart (1962) and Fisher (1963) who have reported a marked change in gross food conversion in relation to oxygen.

The fall in feeding rate during May - June may be due to low oxygen concentration in water recorded during these months. A perusal of Tables XXXIII - XXXIX; Figs. 22 - 28 indicates that oxygen concentration during the months of May - June shows a wide range of variation from 1.92 mg per liter to 8.06 mg per liter; a factor which could be responsible for low feeding intensity in fishes. Similarly higher feeding intensity observed from February - April and October - December appears to be influenced by increased oxygen values recorded during these months (Tables XXXIII-XXXIX; Figs. 22 - 28).

Among biotic factors spawning in fishes is responsible for their low feeding observed during May and June, when most of the fishes in this stream mature sexually. Prior to spawning these fishes need more food both for gonadial development and preparation to withstand impending spawning starvation; this thus accounts for intensive feeding observed from February to April. Intensive feeding from October - December may be the after effect of spawning. Complete cessation or decrease in feeding during spawning period has earlier been recorded by Radhakrishnan (1957), Balan (1963), Toor (1964), Pandian (1966), Malhotra (1967), Sreenivasan (1974).

This high or low feeding intensity may also be determined by the availability of food in the stream. As already discussed the maximum production of organisms in stream has been recorded from February to April followed by a decrease from June to September and a rise again in the months of October - December. Thus the higher or lower value of enterosomatic index recorded during February to April, October to December and May and June is obviously correlated.

4. Interspecific and intraspecific competition in a community within an ecosystem:

An observation on Tables LXXI, LXXIII, LXXV, LXXVII, LXXIX, XIXC, XVIIC, XVC, XIIIC, XIC, IXC, VIIC, and VIC indicates that there are very complex relationships between various fishes inhabiting the Gadigarh stream, with respect to their feeding. The exclusively carnivorous fishes from Gadigarh stream, viz. Wallago attu, Nandus nandus, Mystus seenghala, Ompok bimaculatus and Glossogobius giuris compete for smaller fish as food; with Channa punctatus and C. marulius this competed food item ranks third in order of preference.

Although fishes like Mastocembelus pancalus, M. armatus, Oxygaster bacaila, Channa punctatus, C. marulius, Badis badis, Mystus vittatus and M. bleekeri, Danio devario show first preference for insects, yet they engage in feeding competition with omnivore fishes such as Rasbora rasbora, D. rerio, Chela (Chela) cachius, Noemacheilus botium, Lepidocephalichthys guntea where insects are important dietary contributors.

Carnivore fishes like Ompok bimaculatus, Channa punctatus, C. marulius, Badis badis and omnivore

fishes such as Rasbora rasbora, Mystus vittatus Osteobrama cotio, Danio rerio, Lepidocephalichthys guntea, and Noemacheilus botium by feeding on crustaceans at one or the other stage, thus compete with one another.

Heteropneustes fossilis in which molluscs are an important dietary item show competition for the food with Mystus vittatus, Badis badis and Channa punctatus but in the last three fishes the extent of molluscivory is limited to be of any significant value observed during the course of present investigations.

Interspecific and intraspecific competition for aquatic plants have been observed in herbivorous fishes like Puntius ticto, P. conchonius, P. sophore, [illegible] and Omnivorous fishes such as Rasbora rasbora, Danio rerio, D. devario, Mystus vittatus, Puntius sarana, Osteobrama cotio, Chela (Chela) cachius, Lepidocephalichthys guntea, Noemacheilus botium, and Heteropneustes fossilis.

From the present study it appears that fishes by way of interspecific and intraspecific competition keep a check on populations of Competiting species; and such a competition may be of very high

selective value in favour of maintaining healthy populations of fish in this community. A knowledge of the principles of intraspecific nutritional relationships is very important in the planning and acclimitization of the new species of fishes in various water masses as reported by Nikolsky(1963).

Table LXX. Seasonal variation in feeding of *Puntius sophore* (Ham.) (Quantitative studies)

S.No. Period	Length (cm)	Weight (g)	Wt. of alinantry canal with food (g)	Wt. of alinantry canal without food (g)	Wt. of food (g)	E.S.I
1974						
1. April	4.2	0.75	0.080	0.024	0.056	7.467
2. October	3.8	0.59	0.063	0.019	0.044	7.458
3. November	4.8	1.86	0.102	0.029	0.073	3.925
4. December	4.9	1.84	0.134	0.038	0.096	5.127
1975						
5. January	4.5	1.39	0.066	0.025	0.041	2.950
6. February	4.2	1.15	0.088	0.025	0.063	5.478
7. March	4.7	1.32	0.107	0.030	0.077	5.833
8. April	5.5	2.35	0.132	0.032	0.100	4.255
9. May	5.4	2.22	0.103	0.034	0.069	3.108
10. June	4.2	1.50	0.085	0.025	0.060	4.000
11. July	8.1	8.27	0.439	0.096	0.343	4.148
12. August	5.0	2.04	0.126	0.031	0.095	4.657
13. September	5.1	1.89	0.097	0.025	0.072	3.810

Table LXXI. Seasonal variation in each food item of Puntius sophore.(Ham. Buch.)

(Qualitative Studies)

S.No.	Period	Algae (%)	Diatom (%)	Macro-vege-tation (%)	Unidenti-fiable insects (%)	Detritus (%)	Sand (%)
	1974						
1.	April	7.5	-	15.0	-	75.0	2.5
2.	October	5.0	-	10.0	-	76.25	8.75
3.	November	40.84	1.66	40.0	-	16.25	1.25
4.	December	25.0	12.5	22.5	-	37.5	2.5
	1975						
5.	January	23.75	2.5	10.0	-	50.0	13.75
6.	February	53.34	-	20.0	-	23.34	3.34
7.	March	70.0	-	-	-	25.0	5.0
8.	April	38.25	8.13	15.75	3.75	28.75	9.87
9.	May	51.25	14.38	3.12	-	25.62	5.62
10.	June	82.0	14.0	-	-	1.6	2.4
11.	July	10.0	-	50.0	-	30.0	10.0
12.	August	14.16	25.0	36.66	-	18.34	5.84
13.	September	-	-	10.0	-	80.0	10.0

Table LXXII. Seasonal variation in feeding of *Puntius ticto* (Ham.) (Quantitative studies)

S.No.	Period	Fish: Length (cm)	Fish: Weight (g)	Wt. of alimentry canal: with food (g)	Wt. of alimentry canal: without food (g)	Wt. of food (g)	E.S.I
	1974						
1.	February	3.7	0.88	0.061	0.021	0.040	4.545
2.	March	4.7	1.35	0.126	0.036	0.090	6.667
3.	June	3.6	0.89	0.070	0.0208	0.050	5.618
4.	July	4.1	1.080	0.082	0.027	0.055	5.093
5.	August	3.7	0.710	0.049	0.020	0.029	4.085
6.	September	2.5	0.15	0.013	0.07	0.006	4.000
7.	October	3.8	0.86	0.077	0.019	0.058	6.744
8.	November	3.4	0.59	0.056	0.017	0.039	6.610
9.	December	3.6	0.64	0.050	0.018	0.032	5.000
	1975						
10.	January	3.5	0.60	0.050	0.017	0.033	5.500
11.	February	3.8	0.78	0.057	0.020	0.037	4.744
12.	March	3.60	0.72	0.062	0.018	0.044	6.111
13.	April	4.9	1.50	0.099	0.030	0.069	4.600
14.	May	5.3	2.01	0.110	0.042	0.068	3.383
15.	September	3.8	0.65	0.037	0.017	0.020	3.077
16.	November	4.7	1.31	0.080	0.025	0.065	4.962

Table LXXIII. Seasonal variation in each food item of Puntius ticto (Ham. Buch.) (Qualitative studies).

S.No. Period	Algae (%)	Diatoms (%)	Macro-vege-tation (%)	Detritus (%)	Sand (%)
1974					
1. February	71.88	3.75	14.38	8.75	1.25
2. March	47.5	-	2.5	50.0	-
3. June	57.5	10.0	1.25	27.5	3.75
4. July	9.16	4.16	15.84	68.34	2.50
5. August	47.5	4.16	30.84	17.5	-
6. September	20.0	-	5.0	70.0	5.0
7. October	15.62	-	11.25	68.75	4.38
8. November	42.5	7.5	5.0	40.84	4.16
9. December	20.0	40.0	10.0	30.0	-
1975					
10. January	23.34	15.34	4.68	54.16	2.50
11. February	19.78	19.16	4.66	51.66	4.84
12. March	52.5	-	12.5	35.0	-
13. April	34.86	23.81	5.38	32.17	3.76
14. May	57.5	-	2.5	35.0	5.0
15. September	25.0	-	10.0	60.0	5.0
16. November	75.0	12.5	10.0	[illegible]	2.5

Table LXXIV. Seasonal variation in feeding of *Puntius conchonius* (Ham.) (Quantitative studies)

S.No. Period	Fish		Wt. of alimentry canal			E.S.I
	Length (cm)	Weight (g)	with food (g)	without food (g)	Wt. of food (g)	
1974						
1. April	1.9	0.42	0.036	0.018	0.016	3.810
2. May	3.0	0.53	0.040	0.016	0.024	4.528
3. September	4.1	0.93	0.100	0.023	0.077	8.280
4. October	3.5	0.76	0.078	0.018	0.060	7.894
5. November	3.2	0.86	0.062	0.023	0.039	4.535
6. December	4.0	0.98	0.122	0.025	0.097	9.898
1975						
7. January	3.1	0.64	0.045	0.014	0.031	4.844
8. February	4.1	0.86	0.045	0.020	0.025	2.907
9. March	4.2	1.65	0.096	0.025	0.071	6.762
10. April	2.9	0.56	0.038	0.015	0.023	4.107
11. May	3.2	0.76	0.058	0.024	0.034	4.474
12. June	4.8	1.44	0.085	0.030	0.055	3.819
13. July	3.9	0.95	0.162	0.025	0.137	14.421
14. August 1	7.1	3.2	0.108	0.045	0.063	1.969
1976						
15. January	6.2	3.8	0.128	0.042	0.086	2.263

Table LXXV. Seasonal variation in each food item of Puntius conchonius (Ham. Buch.) (Qualitative studies).

S.No. Period	Algae (%)	Diatoms (%)	Macro-vegetation (%)	Unidentifiable insecta (%)	Copepoda (%)	Detritus (%)	Sand (%)
1974							
1. April	73.56	25.0	-	-	-	1.44	-
2. May	58.33	-	-	16.67	-	20.0	5.0
3. September	50.00	-	-	-	-	50.0	-
4. October	55.00	-	15.0	-	-	30.0	-
5. November	92.5	-	-	-	-	7.5	-
6. December	40.0	-	8.33	-	-	46.67	5.0
1975							
7. January	100.0	-	-	-	-	-	-
8. February	10.0	60.0	-	-	-	20.0	10.0
9. March	70.0	-	-	30.0	-	-	-
10. April	80.0	10.0	-	-	-	10.0	-
11. May	20.0	-	55.0	-	10.0	15.0	-
12. June	17.5	5.0	15.0	-	-	50.0	12.5
13. July	72.31	7.0	5.38	-	-	13.8	1.51
14. August	30.0	-	25.0	-	-	40.0	5.0
1976							
15. January	100.0	-	-	-	-	-	-

Table LXXVI. Seasonal variation in feeding of *Rasbora rasbora* (Ham.) (Quantitative studies).

S.No. Period	Fish		Wt. of alimentary canal		Wt. of food (g)	E.S.I
	Length (cm)	Weight (g)	with food (g)	without food (g)		
1974						
1. April	5.5	1.48	0.071	0.021	0.050	3.378
2. May	6.3	2.34	0.119	0.043	0.076	3.248
3. September	4.1	1.04	0.042	0.023	0.019	1.827
4. October	4.2	0.73	0.055	0.027	0.028	3.836
5. November	4.2	1.05	0.064	0.036	0.028	2.667
6. December	3.8	0.98	0.042	0.028	0.014	1.429
1975						
7. January	4.0	0.67	0.026	0.016	0.010	1.493
8. February	4.6	0.97	0.047	0.024	0.023	2.371
9. March	6.2	3.46	0.177	0.069	0.108	3.121
10. April	6.2	1.99	0.108	0.036	0.072	3.618
11. May	6.4	1.93	0.083	0.035	0.048	2.487
12. June	6.0	1.58	0.06	0.030	0.030	1.899
13. July	5.1	1.37	0.083	0.048	0.035	2.555
14. August	4.6	1.02	0.051	0.024	0.027	2.647
15. December	5.8	2.22	0.135	0.037	0.098	4.414
1976						
16. February	5.1	1.01	0.047	0.028	0.019	1.881

Table LXXVII. Seasonal variation in each food item of Rasbora rasbora (Ham.) (Qualitative studies).

S.No.	Period	Algae (%)	Di atoms (%)	Macro vege tation (%)	Detri tus (%)	Clado cera (%)	Cope poda (%)	Deca pod crus tacea (%)	Coleo ptera (%)	Hemi ptera (%)	Ephi mero ptera (%)	Di ptera (%)	Un identi fiable insecta (%)
	1974												
1.	April	86.0	-	6.0	-	-	-	-	-	8.0	-	-	-
2.	June	52.0	-	18.0	-	-	-	-	-	-	-	-	30.0
3.	September	24.0	-	1.0	-	-	-	25.0	-	-	-	-	50.0
4.	October	-	-	-	-	-	-	-	-	-	-	-	100.0
5.	November	25.0	-	12.5	-	-	-	17.5	-	-	-	-	45.0
6.	December	23.33	-	8.33	-	-	-	33.33	-	-	-	-	35.0
	1975												
7.	January	65.0	-	12.5	-	-	-	12.5	-	-	-	-	10.0
8.	February	31.67	1.67	6.67	-	-	23.33	-	3.33	-	33.33	-	-
9.	March	30.0	7.5	2.5	-	7.5	12.5	-	-	-	-	30.0	10.0
10.	April	33.75	-	7.5	1.25	25.0	-	-	-	-	-	-	32.5
11.	May	60.0	-	3.33	-	-	-	3.33	-	-	-	33.33	-
12.	June	35.0	2.5	-	-	-	-	12.5	-	-	-	-	50.0
13.	July	-	-	50.0	50.0	-	-	--	-	-	-	-	-
14.	August	-	-	-	-	-	-	-	-	-	-	-	100.0
15.	December	-	-	-	-	-	-	100.0	-	--	-	-	-
	1976												
16.	February	66.53	-	-	-	-	-	-	-	-	-	-	33.33

Table LXXVIII. Seasonal variation in feeding of *Danio rerio* (Ham. Buch.) (Quantitative studies).

S.No.	Period	Fish: Length (cm)	Fish: Weight (g)	Wt. of alimentary canal: with food (g)	Wt. of alimentary canal: without food (g)	Wt. of food (g)	E.S.I
	1974						
1.	June	2.8	0.18	0.0091	0.0050	0.0041	2.278
2.	July	3.1	0.25	0.010	0.0060	0.0040	1.60
3.	August	2.7	0.14	0.0084	0.0055	0.0029	2.071
4.	September	3.1	0.26	0.100	0.0072	0.0028	1.077
5.	October	3.0	0.20	0.0100	0.0058	0.0042	2.600
6.	November	2.5	0.15	0.0143	0.0074	0.0069	4.600
7.	December	2.6	0.13	0.0073	0.0044	0.0029	2.231
	1975						
8.	January	2.6	0.16	0.0053	0.0030	0.0023	1.438
9.	February	2.8	0.19	0.0081	0.0042	0.0039	2.737
10.	March	2.3	0.18	0.010	0.0049	0.0051	2.833
11.	April	3.8	0.27	0.0166	0.0060	0.0106	3.926
12.	May	3.3	0.28	0.114	0.0053	0.0061	2.179
	1976						
13.	January	3.1	0.17	0.0066	0.0040	0.0026	1.529
14.	February	2.5	0.20	0.0050	0.0024	0.0026	1.300
15.	March	3.2	0.35	0.0090	0.0038	0.0052	1.486

Table LXXIX. Seasonal variation in each food item of Danio rerio (Ham. Buch.) (Qualitative studies).

S.No. Period	Algae (%)	Di atoms (%)	Proto zoa (%)	Clado cera (%)	Cope poda (%)	Arach nida (%)	Hemi ptera (%)	Coleo ptera (%)	Odo nata (%)	Di ptera (%)	Un identi fiable insecta (%)	Un identi fiable matter (%)
1974												
1. March	-	-	2.0	-	5.0	-	-	10.0	-	-	70.0	13.0
2. May	20.0	2.0	-	-	-	-	-	70.0	-	-	-	8.0
3. July	-	--	-	--	-	-	-	-	-	-	100.0	-
4. October	-	-	-	-	-	-	-	-	-	-	100.0	-
5. November	50.0	-	-	--	-	-	-	-	-	-	-	50.0
6. December	-	-	-	-	100.0	-	-	-	-	-	-	-
1975												
7. January	-	-	-	2.5	15.0	-	-	-	-	-	82.5	-
8. February	-	-	1.66	1.66	36.66	-	33.33	-	-	-	26.66	-
9. March	-	-	-	40.0	60.0	-	-	-	-	-	-	-
10. April	-	-	5.0	10.0	2.5	5.0	[illegible]	-	2.5	37.5	17.5	20.0
11. May	-	-	-	-	-	-	-	-	-	70.0	-	30.0
12. June	-	--	-	-	60.0	-	-	-	15.0	-	25.0	-
13. July	10.0	2.0	2.0	-	5.0	8.0	-	68.0	5.0	8.0	-	-
14. August	-	-	-	--	-	-	-	-	-	-	100.0	-
15. September	-	-	-	-	-	-	-	33.5	50.0	16.5	--	-

Table XXC. Seasonal variation in feeding of Chela (Chela) cachius (Ham. Buch.) (Quantitative studies).

S.No.	Period	Fish Length (cm)	Fish Weight (g)	Wt. of alimentary canal with food (g)	Wt. of alimentary canal without food (g)	Wt. of food (g)	E.S.I
	1975						
1.	February	4.2	0.53	0.043	0.016	0.027	5.094
2.	March	4.5	0.33	0.028	0.014	0.014	4.242
3.	April	4.3	0.22	0.030	0.017	0.013	5.909
4.	May	4.1	0.53	0.020	0.012	0.008	1.509
5.	June	4.6	0.67	0.030	0.020	0.010	1.492
6.	July	3.8	0.32	0.012	0.010	0.002	0.625
7.	August	4.4	0.60	0.028	0.013	0.015	2.500
8.	September	5.6	1.25	0.030	0.018	0.012	0.960
9.	October	3.6	0.35	0.019	0.010	0.009	2.571
10.	November	6.2	0.56	0.043	0.024	0.019	3.393
11.	December	3.5	0.24	0.036	0.019	0.017	7.083
	1976						
12.	January	4.0	0.44	0.021	0.012	0.009	2.045

Table LXXXI. Seasonal variation in each food item of Chela (Chela) cachius (Ham. Buch.) (Qualitative studies).

S.No. Period	Algae (%)	Diatoms (%)	Macro vege tation (%)	Coleo ptera (%)	Di ptera (%)	Un identi fiable insecta (%)	Det ritus (%)	Un identi fiable matter (%)
1975								
1. February	-	100.0	-	-	-	-	-	-
2. March	50.0	-	-	-	-	50.0	-	-
3. April	30.0	5.0	-	10.0	40.0	-	15.0	-
4. May	38.0	2.0	5.0	25.0	15.0	15.0	-	-
5. June	20.0	15.0	5.0	-	-	50.0	-	10.0
6. July	-	-	-	-	-	-	-	-
7. August	-	-	-	-	-	-	-	100.0
8. September	47.0	-	-	-	30.0	-	-	23.0
9. October	-	10.0	-	-	50.0	-	-	40.0
10. November	-	-	-	100.0	-	-	-	-
11. December	20.0	-	2.0	60.0	-	-	-	18.0
1976								
12. January	35.0	30.0	7.0	-	-	17.0	-	11.0

Table LXXXII. Seasonal variation in feeding of Lepidocephalichthys guntea (Ham. Buch)

S.No.	Period	Length (cm)	Weight (g)	Wt. of alimentary canal with food (g)	Wt. of alimentary canal without food (g)	Wt. of food (g)	E.S.I
	1974						
1.	October	7.5	2.62	0.036	0.011	0.025	0.954
2.	November	6.1	1.97	0.022	0.010	0.012	0.609
3.	December	6.2	1.67	0.025	0.015	0.010	0.599
	1975						
4.	January	7.1	2.89	0.038	0.016	0.022	0.761
5.	February	7.3	2.76	0.048	0.023	0.025	0.906
6.	March	6.0	1.85	0.028	0.016	0.012	0.649
7.	April	5.3	1.75	0.033	0.011	0.022	1.257
8.	May	7.3	2.14	0.023	0.012	0.011	0.514
9.	June	7.9	3.81	0.048	0.020	0.028	0.735
10.	July	6.1	1.58	0.200	0.010	0.010	0.633
11.	August	5.9	1.48	0.025	0.011	0.014	0.946
12.	September	6.4	1.59	0.026	0.011	0.015	0.943
13.							
	1976						
13.	February	5.7	1.54	0.058	0.013	0.045	2.922

Table LXXXIII. Seasonal variation in each food item of Lepidocephalichthys guntea (Ham. Buch.) (Qualitative studies).

S.No.	Period	Algae (%)	Diatoms (%)	Macro vegetation (%)	Protozoa (%)	Rotifera (%)	Cladocera (%)	Copepoda (%)	Ostracoda (%)	Diptera (%)	Annelida (%)	Detritus (%)	Sand (%)
	1974												
1.	October	10.0	1.0	5.0	1.0	-	-	-	-	5.0	2.0	60.0	16.0
2.	November	5.0	-	10.0	1.0	-	10.0	5.0	-	24.0	-	33.0	12.0
3.	December	10.0	-	25.0	-	-	2.0	3.0	-	10.0	-	40.0	10.0
	1975												
4.	January	6.0	-	15.0	2.0	-	-	6.0	-	15.0	-	56.0	5.0
5.	February	8.0	-	13.0	1.0	-	5.0	5.0	5.0	15.0	1.0	44.0	3.0
6.	March	10.0	1.0	9.0	2.0	-	-	2.0	-	20.0	1.0	44.0	11.0
7.	April	-	1.0	20.0	-	-	-	8.0	-	-	-	67.0	3.0
8.	May	10.0	2.0	7.0	-	-	5.0	2.0	-	-	2.0	60.0	12.0
9.	June	1.0	-	10.0	2.0	1.0	-	2.0	-	10.0	4.0	65.0	5.0
10.	July	-	-	10.0	-	-	-	-	-	45.0	-	40.0	5.0
11.	August	-	-	5.0	-	-	-	-	-	60.0	-	25.0	15.0
12.	September	-	-	10.0	-	-	-	-	-	30.0	-	50.0	10.0
	1976												
13.	February	5.0	-	10.0	-	-	10.0	5.0	-	24.0	2.0	42.0	2.0

Table LXXXIV. Seasonal variation in feeding of Nemacheilus botia (Ham. Buch.) (Quantitative studies).

S.No.	Period	Fish		Wt. of alimentary canal			E.S.I
		Length (cm)	Weight (g)	with food (g)	without food (g)	Wt. of food (g)	
	1974						
1.	September	4.8	0.75	0.018	0.010	0.008	1.067
2.	October	5.2	1.06	0.028	0.017	0.011	1.038
3.	November	5.1	1.40	0.050	0.020	0.030	2.143
4.	December	4.4	0.63	0.028	0.020	0.008	1.270
	1975						
5.	January	7.0	3.8	0.090	0.032	0.058	1.526
6.	February	4.5	0.93	0.039	0.017	0.022	2.366
7.	March	5.0	1.15	0.052	0.022	0.030	2.609
8.	April	5.3	1.03	0.034	0.019	0.015	1.456
9.	May	4.7	0.61	0.027	0.015	0.012	1.967
10.	June	4.4	0.86	0.044	0.022	0.022	2.558

Table LXXXV. Seasonal variation in each food item of *Nemacheilus botia* (Ham. Buch.) (Qualitative studies).

S.No.	Period	Algae (%)	Di atoms (%)	Macro vege tation (%)	Proto zoa (%)	Clado cera (%)	Cope poda (%)	Coleo ptera (%)	Di ptera (%)	Anne lida (%)	Detritus (%)	Sand (%)
	1974											
1.	September	10.0	2.0	15.0	1.0	2.0	2.0	-	15.0	-	40.0	13.0
2.	October	-	-	10.0	2.0	-	10.0	-	20.0	-	48.0	10.0
3.	November	10.0	3.0	-	-	-	-	-	50.0	2.0	30.0	5.0
4.	December	-	-	-	-	-	-	-	57.0	-	38.0	5.0
	1975											
5.	January	-	-	-	-	-	-	-	85.0	-	12.5	2.5
6.	February	4.66	-	5.33	-	-	-	-	76.66	-	10.0	3.33
7.	March	1.66	0.66	-	1.66	-	-	-	59.33	-	33.33	3.33
8.	April	-	2.0	10.0	2.0	-	-	-	15.0	1.0	60.0	10.0
9.	May	8.0	-	5.0	2.0	5.0	-	10.0	-	-	55.0	15.0
10.	June	-	-	10.0	-	-	-	-	75.0	1.0	14.0	-

Table XIVC. Seasonal variation in feeding of *Meteropneustes fossilis* (Bloch) (Quantitative studies).

S.No.	Period	Fish		Wt. of alimentary canal		Wt. of food (g)	E.S.I
		Length (cm)	Weight (g)	with food (g)	without food (g)		
	1974						
1.	February	13.3	21.36	1.34	0.51	0.83	3.886
2.	March	14.2	18.25	0.76	0.20	0.56	3.068
3.	April	9.6	6.99	0.17	0.10	0.07	1.001
4.	May	15.0	16.12	1.00	0.43	0.57	3.536
5.	June	12.5	15.24	0.56	0.18	0.38	2.493
6.	July	17.0	38.84	2.40	0.54	1.86	4.789
7.	August	9.9	6.63	0.30	0.22	0.08	1.207
8.	September	11.0	8.10	0.51	0.21	0.30	3.704
9.	October	9.8	7.46	0.48	0.19	0.29	3.887
10.	November	11.1	10.73	0.43	0.12	0.31	2.889
11.	December	15.5	21.2	1.21	0.52	0.69	3.255
	1975						
12.	January	11.6	13.32	0.65	0.36	0.29	2.177
13.	February	11.0	10.7	0.41	0.20	0.21	1.963
14.	August	10.0	9.28	0.52	0.38	0.14	1.509

Table XIIIC. Seasonal variations in each food item of Heteropneustes fossilis (Bloch) (Qualitative studies).

Year	1974											1975		
Month	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Aug
Food Items														
Algae (%)	2	-	5	30	5	10	-	-	2.5	-	-	-	20	-
Diatoms (%)	-	-	-	-	-	-	-	-	5	-	-	-	40	-
Macrovegetation (%)	-	-	-	8	5	10	-	5	-	-	-	-	-	7
Decapod crustacea (%)	15	-	-	-	-	-	-	5	-	2.5	-	2.5	-	-
Hemiptera (%)	2.5	3	-	-	-	-	-	-	-	-	-	-	-	-
Ephemeroptera (%)	-	10	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera (%)	-	12	-	2	5	10	-	-	7.5	-	-	-	-	18
Odonata (%)	2.5	30	-	-	-	-	-	-	-	-	-	-	-	-
Diptera (%)	5	-	-	-	-	15	-	-	-	-	-	-	10	-
Unidentifiable insects (%)	-	-	-	18	-	-	-	10	10	-	-	7.5	-	-
Viviparus (%) Sps.	7.5	-	-	22	10	-	-	-	-	27.5	-	18.75	-	-
Melanoides sps. (%)	10	-	-	2	-	30	-	-	-	20	-	-	-	-
Lymnaea sps. (%)	21.25	-	-	-	-	-	-	-	75	-	-	-	-	-
Gyraulus sps. (%)	-	25	-	7	70	25	-	70	-	-	-	30	-	-
Bivalves (%)	20	20	-	-	-	-	-	-	-	22.5	-	6.25	-	-
Unidentifiable molluscs (%)	-	-	25	-	-	-	-	-	-	17.5	60	15	-	40
Fish (%)	6.25	-	-	-	-	-	-	-	-	-	-	-	-	-
Sand (%)	-	-	2.5	1	5	-	-	5	-	1.25	-	-	-	12
Unidentifiable matter (%)	12.5	-	67.5	10	-	-	100	10	-	8.75	40	20	30	23

Table XIIC. Seasonal variation in feeding of Mastocembelus armatus (Lacepede) (Quantitative studies).

S.No.	Period	Fish: Length (cm)	Fish: Weight (g)	Wt. of alimentary canal: with food (g)	Wt. of alimentary canal: without food (g)	Wt. of food (g)	E.S.I
	1974						
1.	June	15.0	22.86	1.53	0.27	1.26	5.512
2.	July	11.4	9.75	0.16	0.11	0.05	0.513
3.	August	11.0	5.86	0.14	0.08	0.06	1.024
4.	September	10.9	5.70	0.12	0.10	0.02	0.351
5.	October	11.5	5.20	0.11	0.07	0.04	0.769
6.	November	9.3	2.99	0.08	0.07	0.01	0.334
7.	December	5.7	0.47	0.05	0.02	0.03	6.383
	1975						
8.	January	12.3	7.90	0.12	0.09	0.03	0.380
9.	February	12.8	7.35	0.19	0.08	0.11	1.497
10.	March	13.5	10.2	0.05	0.04	0.01	0.098
11.	April	10.0	3.86	0.13	0.05	0.08	2.073
12.	May	11.3	6.19	0.12	0.09	0.03	0.485
13.	September	12.2	7.95	0.13	0.07	0.06	0.755
	1976						
14.	February	12.3	7.35	0.19	0.08	0.11	1.497

Table XIC. Seasonal variation in each food item of Mastacembelus armatus (Lacep.) (Qualitative studies).

S.No. Period	Algae (%)	Macro vege tation (%)	Ephe mero ptera (%)	Coleo ptera (%)	Di ptera (%)	Un identi fiable insecta (%)	Anne lida (%)	Detritus (%)	Sand (%)	Un identi fiable matter (%)
1974										
1. June	-	-	-	50.0	50.0	-	-	-	-	-
2. July	2.5	-	-	-	-	60.0	1.0	26.5	10.0	-
3. August	6.0	10.0	-	-	48.0	-	-	21.0	10.0	5.0
4. September	-	-	-	-	-	100.0	-	-	-	-
5. October	-	-	15.0	-	30.0	[illegible].0	-	-	-	55.0
6. November	-	-	-	-	-	50.0	-	20.0	-	30.0
7. December	100	-	-	-	[illegible]-0	-	--	-	-	-
1975										
8. January	-	10.0	-	-	90.0	-	-	-	-	-
9. February	-	-	-	-	-	80.0	-	-	-	20.0
10. March	-	-	30.0	-	30.0	--	-	-	-	40.0
11. April	5.0	-	5.0	-	40.0	50.0	-	-	-	-
12. May	4.33	-	-	-	-	50.0	1.0	34.66	10.0	-
13. October	100	-	-	-	[illegible]-0	-	-	-	-	-
1976										
14. February	2.0	8.0	-	-	-	85.0	1.0	[illegible]0.0	4.0	-

Table XC. Seasonal variation in feeding of *Badis badis* (Ham. Buch.) (Quantitative studies).

S.No.	Period	Fish		Wt. of alimentary canal			E.S.I
		Length (cm)	Weight (g)	with food (g)	without food (g)	Wt. of food (g)	
	1974						
1.	April	2.5	0.23	0.015	0.006	0.009	3.913
2.	May	2.6	0.14	0.017	0.009	0.007	2.917
3.	August	3.6	0.44	0.023	0.010	0.013	2.407
4.	September	2.90	0.56	0.022	0.013	0.009	1.607
5.	October	3.3	0.51	0.022	0.011	0.011	2.157
6.	November	3.2	0.54	0.028	0.016	0.012	2.222
7.	December	3.4	0.55	0.027	0.013	0.014	2.545
	1975						
8.	January	3.6	0.88	0.038	0.019	0.019	2.159
9.	February	3.5	0.71	0.029	0.017	0.012	1.690
10.	March	3.3	0.57	0.027	0.012	0.015	2.632
11.	April	3.3	0.49	0.021	0.013	0.008	1.633
12.	May	3.9	0.76	0.028	0.018	0.010	1.316
13.	June	4.05	0.94	0.030	0.019	0.011	1.170
14.	July	3.8	0.56	0.022	0.012	0.010	1.786

Table IXC. Seasonal variation in each food item of Badis badis (Ham. Buch.) (Qualitative studies).

S.No. Period	Algae (%)	Di atoms (%)	Macro vege tation (%)	Clado cera (%)	Cope poda (%)	Ostra coda (%)	Deca pod crus tacea (%)	Hemi ptera (%)	Ephe mero ptera (%)	Coleo ptera (%)	Odo nata (%)	Di ptera (%)	Un identi fiable insecta (%)	Moll usca (%)	Un identi fiable matter (%)
1974															
1. April	-	-	-	1.50	6.0	-	-	-	5.0	-	12.5	75.0	-	-	-
2. May	-	-	1.0	1.33	2.5	0.84	14.84	17.66	18.66	10.0	2.0	31.16	-	-	-
3. August	-	-	-	-	20.0	-	-	-	10.0	-	-	20.0	50.0	-	-
4. September	-	-	-	-	-	-	67.5	-	-	-	22.5	-	-	-	10.0
5. October	-	--	-	-	7.5	0.2	18.0	6.25	2.8	-	13.0	45.0	-	1.0	5.75
6. November	-	-	-	-	39.9	0.32	-	-	0.62	-	-	33.12	16.66	8.12	1.25
7. December	-	-	0.5	-	21.16	0.16	8.33	-	-	-	-	55.75	8.33	-	5.75
1975															
8. January	-	-	-	11.72	12.72	-	7.14	-	1.0	-	-	50.28	-	2.0	15.14
9. February	-	-	-	11.22	16.89	-	-	-	-	-	2.78	64.11	-	-	5.0
10. March	-	-	-	22.0	21.33	-	45.0	-	-	-	-	3.33	-	-	8.33
11. April	-	0.84	-	-	25.0	-	-	-	-	10.0	--	50.33	10.0	-	3.84
12. May	2.5	1.25	-	-	-	-	-	-	-	75.0	-	-	21.25	--	-
13. June	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-
14. July	-	-	5.0	-	-	-	80.0	-	-	-	-	-	-	-	15.0

Table VIIIC. Seasonal variatio-n in feeding of *Channa punctatus* (Bloch) (Quantitative studies).

S.No. Period	Fish		Wt. of alimentary canal			E.S.I
	Length (cm)	Weight (g)	with food (g)	without food (g)	Wt. of food (g)	
1974						
1. February	7.5	5.37	0.32	0.12	0.20	3.724
2. March	8.3	7.23	0.34	0.15	0.09	1.245
3. April	7.9	5.56	0.29	0.09	0.20	3.597
4. May	7.0	4.21	0.16	0.06	0.10	2.375
5. June	9.0	9.99	0.48	0.25	0.23	2.302
6. July	6.8	4.72	0.22	0.11	0.11	2.331
7. September	9.0	10.72	0.40	0.15	0.25	2.332
8. October	5.9	2.98	0.21	0.09	0.12	4.027
9. November	5.8	2.62	0.14	0.09	0.05	1.908
10. December	6.3	4.15	0.26	0.17	0.09	2.169
1975						
11. January	6.2	2.55	0.17	0.12	0.05	1.961
12. February	6.6	4.0	0.15	0.09	0.06	1.500
13. March	6.7	4.09	0.15	0.09	0.06	1.467
14. April	7.1	4.57	0.22	0.11	0.11	2.407
15. May	8.0	7.64	0.45	0.32	0.13	1.702
16. July	7.8	4.18	0.18	0.12	0.06	1.435
17. August	7.0	3.88	0.20	0.12	0.08	2.062
18. September	6.0	3.54	0.15	0.09	0.06	1.695
19. October	6.4	2.74	0.11	0.05	0.06	2.190
20. November	5.8	2.11	0.10	0.06	0.04	1.896
21. December	6.7	3.69	0.16	0.08	0.08	2.168

Table VIIC. Seasonal variation in each food item of Channa punctatus (Cuv. and Val.) (Qualitative studies).

S.No.	Period	Algae (%)	Cladocera (%)	Copepoda (%)	Decapod crustacea (%)	Hemiptera (%)	Ephemeroptera (%)	Coleoptera (%)	Odonata (%)	Diptera (%)	Unidentifiable insecta (%)	Mollusca (%)	Fish (%)	Unidentifiable matter (%)
	1974													
1.	February	-	-	-	-	3.12	1.25	37.5	33.96	9.16	-	2.5	-	12.5
2.	March	-	-	-	-	1.25	-	12.5	7.5	2.5	-	-	60.0	16.25
3.	April	-	-	-	-	-	-	19.58	3.75	10.42	12.5	5.0	-	48.75
4.	May	0.5	1.25	0.5	20.0	1.25	1.25	-	32.5	0.25	-	25.0	-	17.5
5.	June	18.33	-	-	-	6.66	-	-	8.33	1.66	48.33	-	-	16.66
6.	July	-	-	-	-	-	-	-	3.33	-	21.66	-	-	75.0
7.	September	-	-	-	-	-	-	-	-	-	-	-	-	100.0
8.	October	-	-	-	-	-	-	-	-	-	-	-	100.0	-
9.	November	-	-	-	-	6.66	-	6.66	5.84	1.66	45.83	-	-	33.33
10.	December	-	-	-	13.0	-	-	40.0	5.0	-	6.5	-	10.0	25.5
	1975													
11.	January	-	--	-	30.56	-	2.22	19.86	30.28	3.47	5.56	1.25	6.81	-
12.	February	-	27.5	-	-	1.0	13.66	15.75	11.0	16.84	-	0.75	2.5	11.0
13.	March	1.07	-	2.5	33.04	-	-	17.32	14.64	1.07	8.75	-	-	21.61
14.	April	-	2.10	-	55.0	-	1.66	-	-	-	30.0	-	-	3.33
15.	May	-	3.0	1.5	48.5	-	-	11.5	20.75	5.0	-	-	3.0	6.75
16.	July	-	-	-	22.5	-	25.0	-	-	-	-	-	-	52.5
17.	August	-	-	-	50.0	-	-	-	-	-	-	-	50.0	-
18.	September	-	-	-	25.0	-	-	-	-	-	28.75	-	33.75	12.5
19.	October	-	-	-	50.0	-	-	5.0	45.0	-	-	-	-	-
20.	November	-	-	-	-	15.0	-	-	5.0	-	30.0	30.0	-	20.0
21.	December	-	-	-	17.5	-	-	70.0	-	12.5	-	-	-	-

Table VIC. Qualitative food composition of some occasionally available fishes.

Name of Fish	Algae (3)	Di-atoms (%)	Macro-vege tation (%)	Clado cera (%)	Cope poda (%)	Deca pod crus tacea (%)	Ephe mero ptera (%)	Coleo ptera (%)	Odo nata (%)	Di-ptera (%)	Un identi fiable insecta (%)	Moll usca (%)	Fishes (%)	Detritus (%)	Un identi fiable matter (%)
Xenentodon cancila (Ham.)	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-
Wallago attu (Bloch.Sch)		-	-	-	-	-	-	-	-	-	-	-	100	-	-
Ompok himaculatus (Bloch)	-	-	-	-	-	14.29	-	-	13.57	0.71	-	-	71.43	-	-
Nandus nandus (Ham.Buch)	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-
Glossogobius giuris (Ham.)	-	-	-	-	-	-	-	16.67	-	16.67	-	-	66.67	-	-
Oxygaster bacaila (Ham. Buch)	-	-	-	-	-	-	10	25	50	-	-	-	-	-	15
Mystus seenghala (Sykes)	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-
Mystus bleekeri (Day)	-	-	-	-	-	-	5	18.5	10	62.5	-	-	-	4	-
Mystus vittatus (Bloch)	6.45	-	-	-	-	-	-	9.09	1.36	17.73	20.0	5	1.82	-	38.55
Danio devario (Ham. Buch)	13.33	0.67	20	-	-	-	-	-	-	-	43.33	-	-	-	16.67
Mastocembelus pancalus (Ham)	-	-	-	-	-	-	-	5	10	50	35	-	-	-	-
Osteobrama cotio (Heckel)	4	34	20	5	5	-	-	6	5	-	-	-	-	-	21
Puntius sarana (Ruskell)	50.75	-	28.33	-	-	-	-	-	-	-	20.91	-	-	-	-
Channa marulius (Ham.)	-	-	-	5	2	20	20	19	-	10	4	-	20	-	-

Fig. 59. - Seasonal variations in enterosomatic index in Puntius sophore.

Fig. 60. - Seasonal variations in enteromomatic index in Puntius ticto.

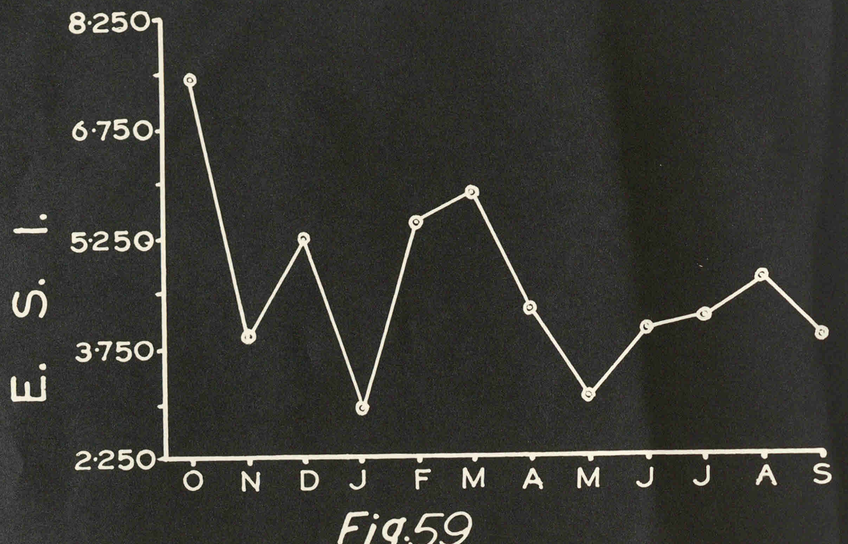


Fig.59

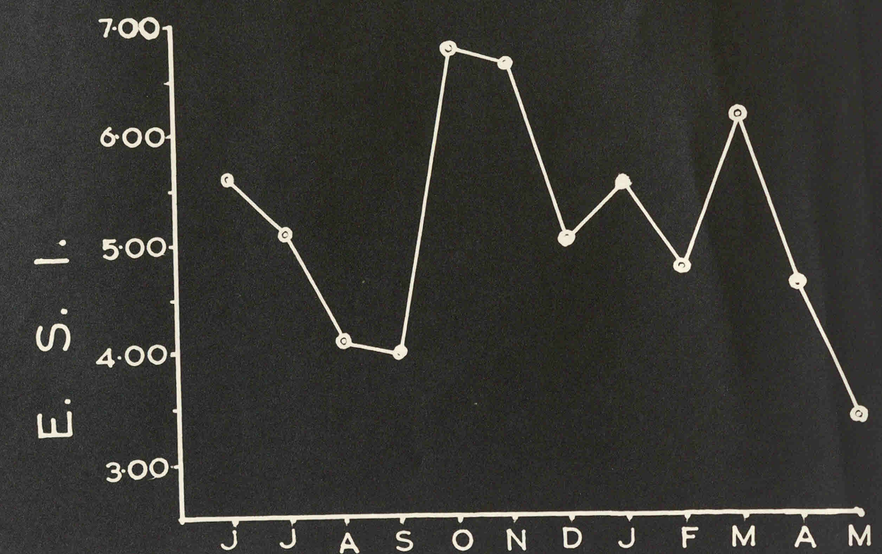


Fig.60

Fig. 61. - Seasonal variation in enterosomatic index in Puntius conchonius.

Fig. 62. - Seasonal variation in enterosomatic index in Rasbora rasbora.

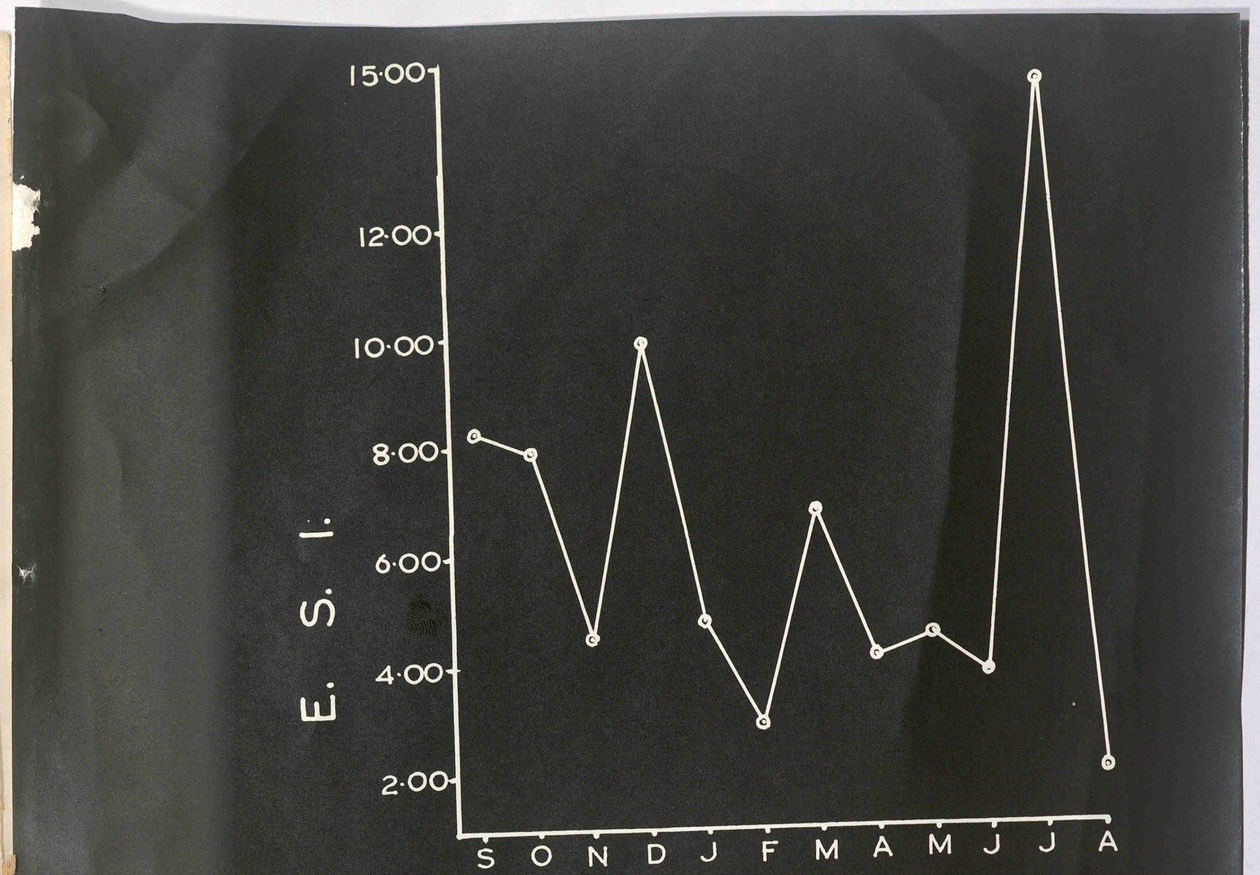


Fig. 61

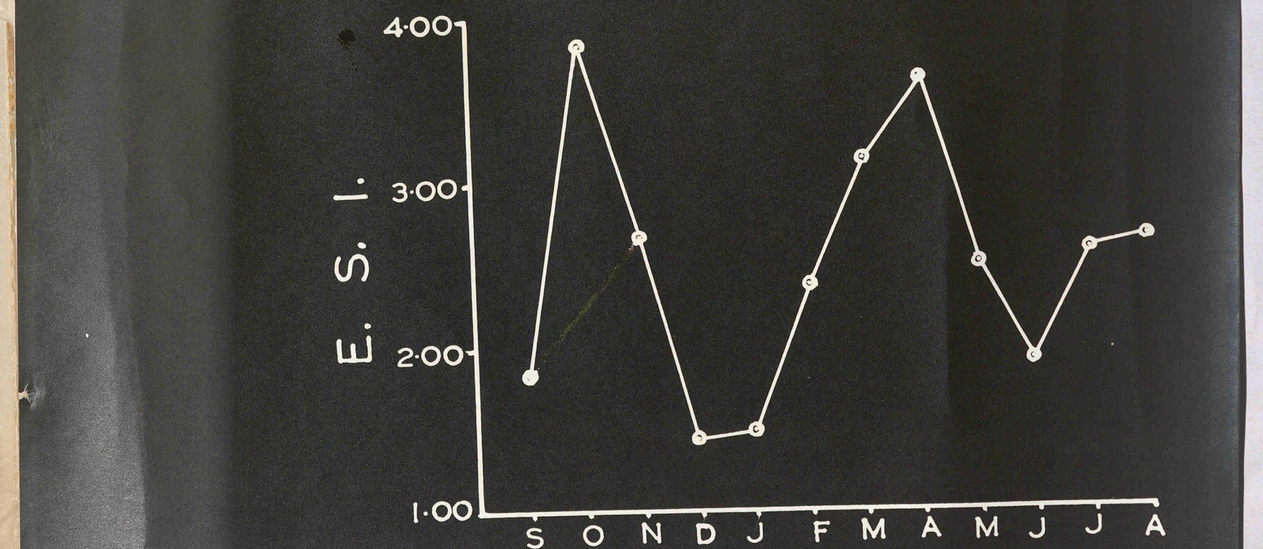


Fig. 62

Fig. 63. - Seasonal variation in enterosomatic index in Danio rerio.

Fig. 64. - Seasonal variation in enterosomatic index in Chela (Chela) chchius.

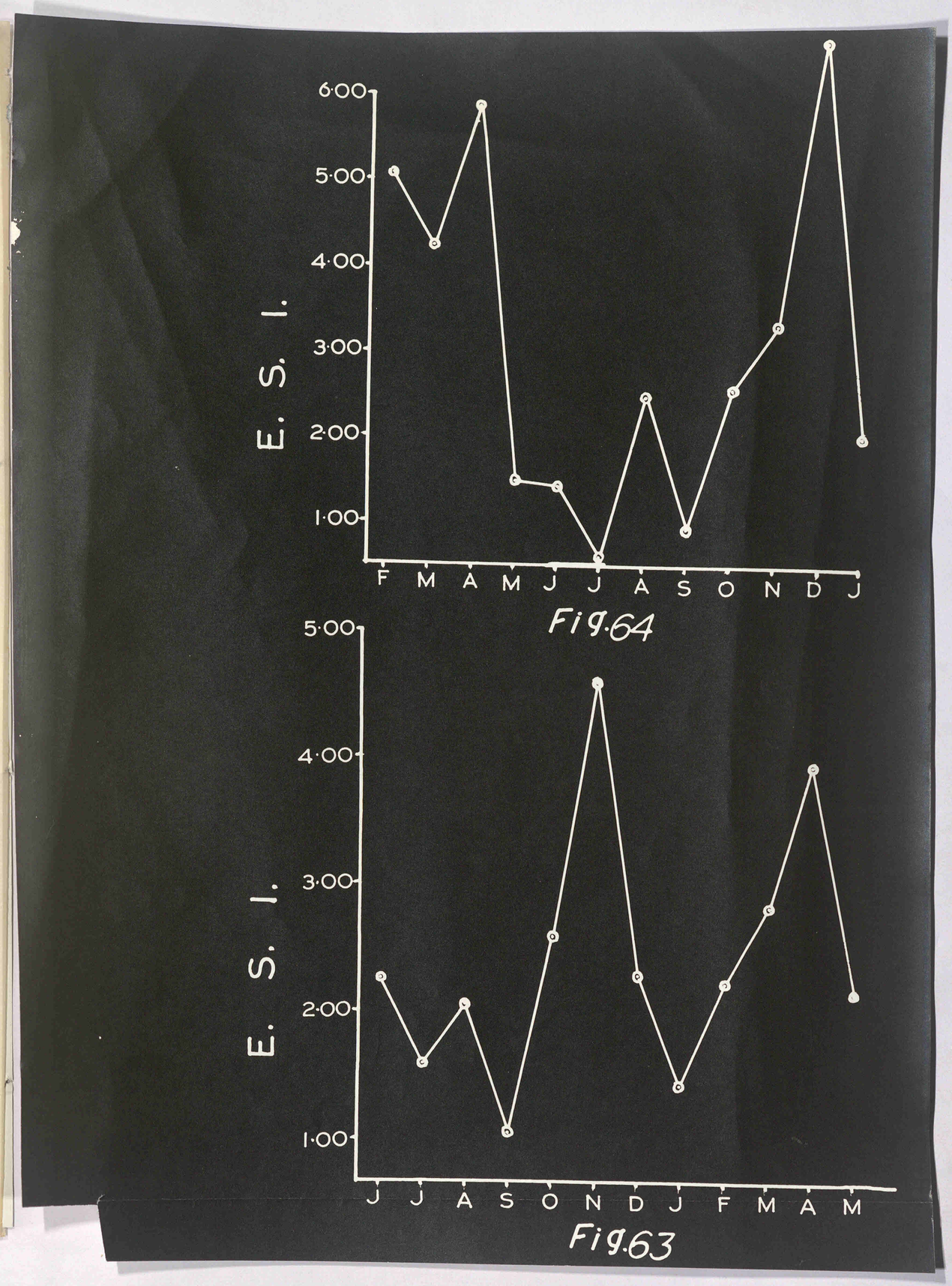


Fig. 65. - Seasonal variation in enterosomatic index in Lepidocephalichthys guntea.

Fig. 66. - Seasonal variation in enterosomatic index in Noemacheilus botium.

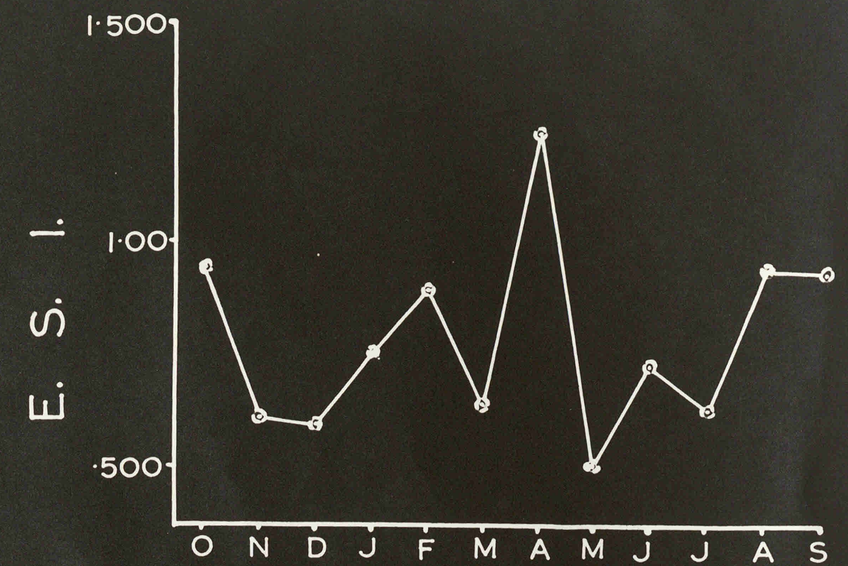


Fig.65

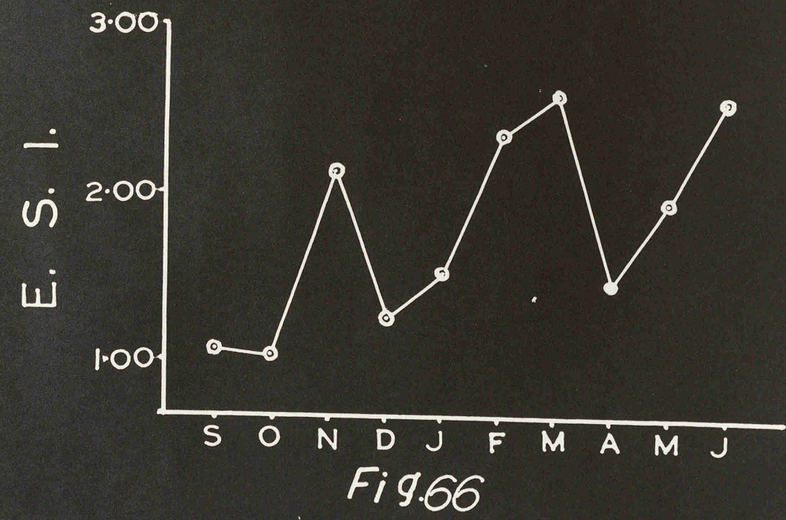


Fig.66

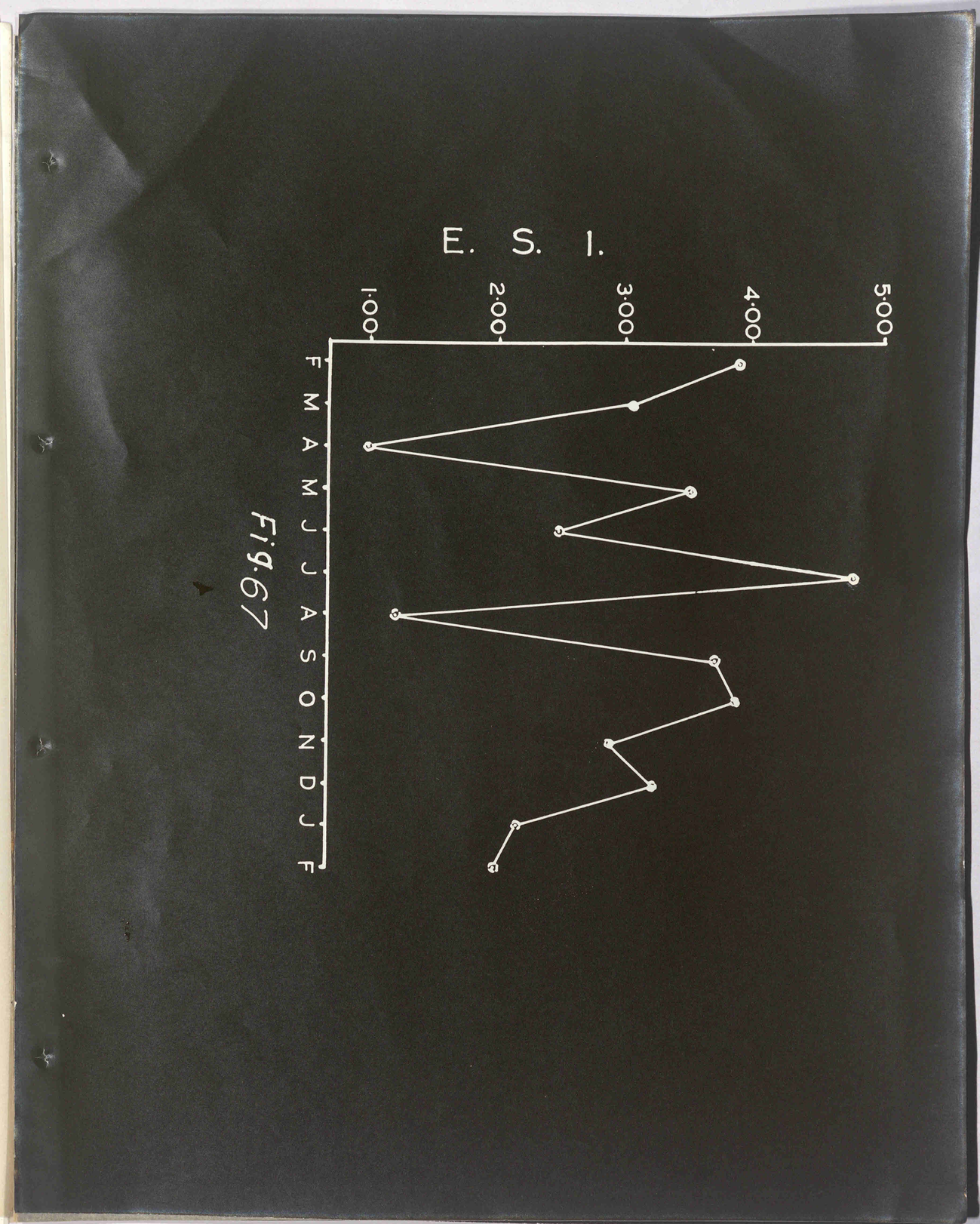


Fig. 67. - Seasonal variation in enterosomatic index in Heteropneustes fossilis.

Fig. 68. - Seasonal variation in enterosomatic index in Mastocembelus armatus.

Fig. 69. - Seasonal variation in enterosomatic index in Badis badis.

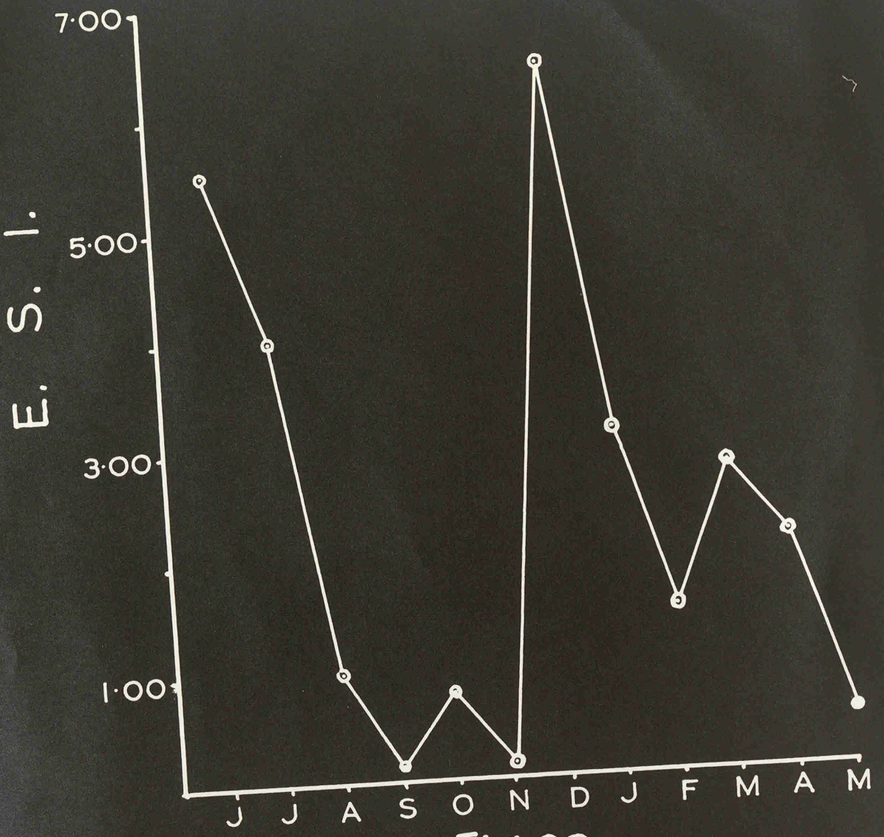


Fig.68

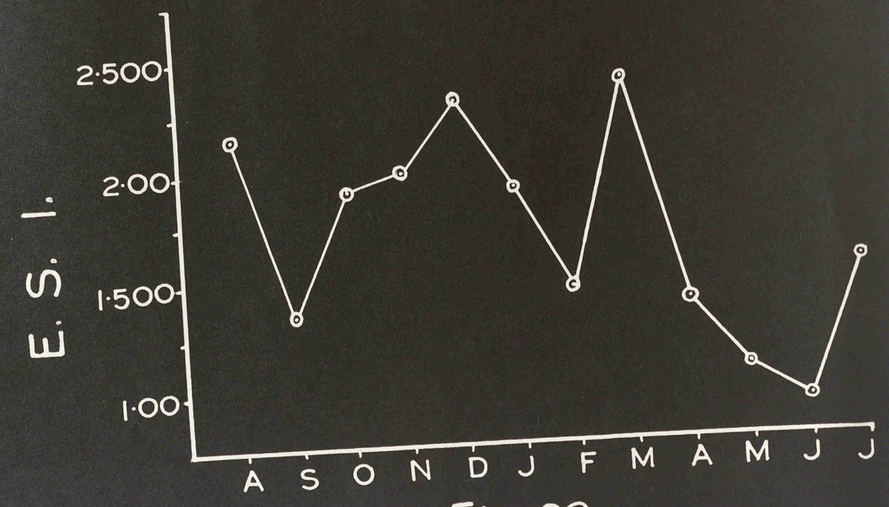


Fig.69

Fig. 70. - Seasonal variation in enterosomatic index in Channa punctatus.

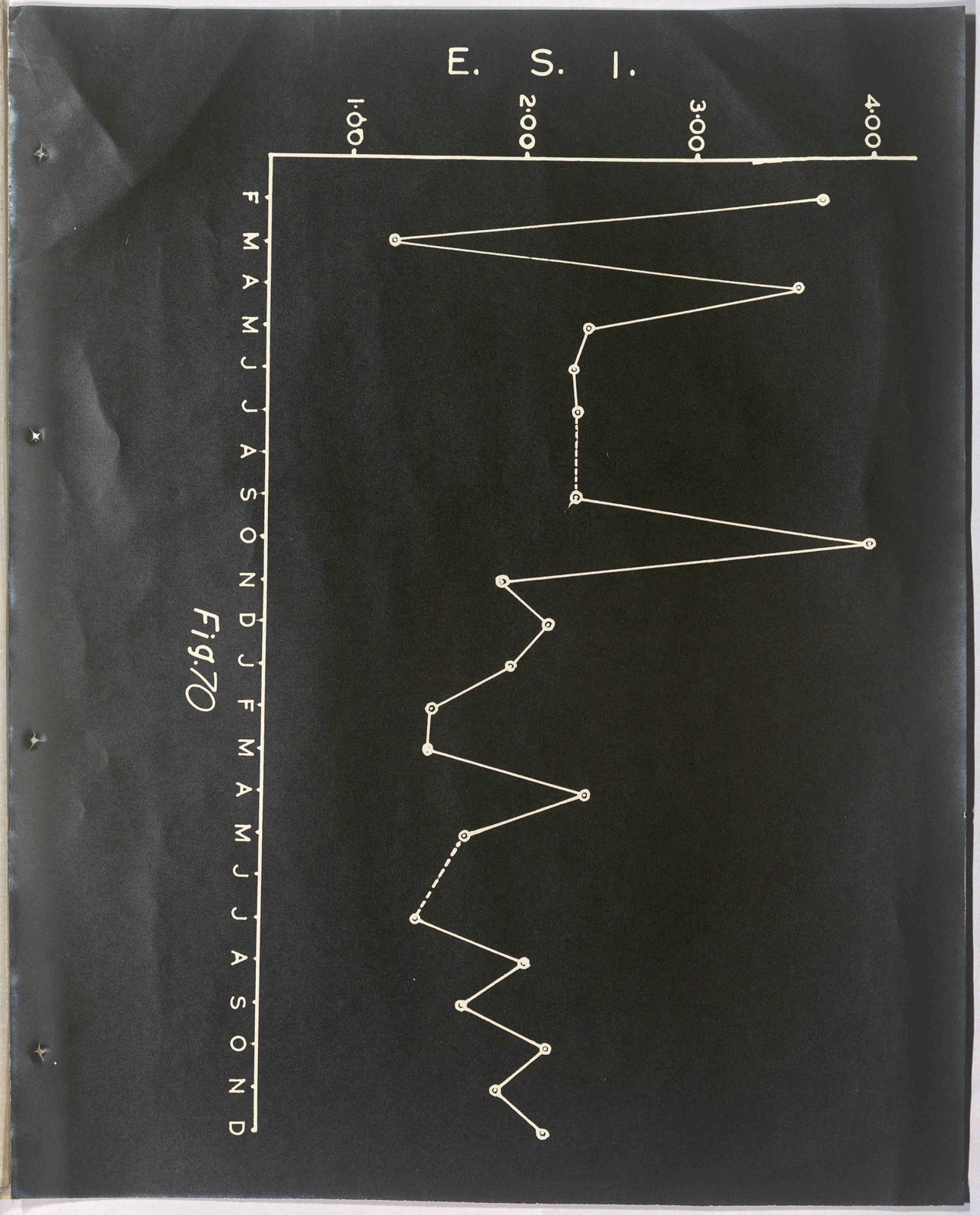


Fig.70

FISH DISEASES AND PREDATORS

A. PARASITE AND THE DISEASES CAUSED BY THEM

Fishes like any other living organisms, are prone to both ecto- and endoparasitic invasions in nature. The following ectoparasites and the diseases caused by them have been recorded in the fish fauna of Gadigarh stream during the course of present investigation.

1. Protozoan : The following protozoan parasites have been observed infecting the fishes inhabiting the Gadigarh stream.

1.1. Myxobolus sp. : White cysts on skin each containing numerous Myxobolus spores have been observed in large number of fishes (Table VC) inhabiting Gadigarh stream.

1.2. Henneguya sp. : White-yellow coloured cysts on the skin below the scales have been recorded from only one specimen of Labeo bata (Fig. 75) measuring 16.2 cm from Station VII in April, 1975.

DISCUSSION

Van Dujin (1967) has reviewed the literature on the infection from a number of hosts and the symptoms described by him for various protozoan diseases are in line with those observed during the present investigations.

Contrary to the conclusions of Tripathi (1953) and Pal (1975) that older specimens of the same species are not as easily susceptible to disease as the young ones are, the present investigations have shown protozoan infection only in specimen from the hosts of older age groups in the fishes of this stream.

Pal (1975) recorded that protozoan infection starts appearing in the ponds with the onset of monsoons and reaches its maximum intensity during the months of October and November. A second peak with approach of summer has also been recorded by Pal (1975). In the course of present investigations only premonsoon infection has been recorded (except for the few specimens caught during November.

The present studies therefore, reveal that the myxosporidean disease in the fishes of this stream is highly incident during May and June, when the water temperature ranges from 29°C to 32°C, suggestive of this range of temperature as optimum for the disease prolificity.

It has been observed that generally the fishes in Gadigarh stream show a light infection, which could be attributed to the lotic nature of the water body as has also been suggested by Ray (1933). The fact that most diseased fishes have been collected from Station VII (which marks the confluence of Gadigarh stream with Ballole canal), suggests of the probability that diseased fishes from the canal migrate into the stream to seek protection for themselves in the vegetation and hence contributes to higher incidence of diseased fish from this section of the stream.

2. Crustacean: The following crustaceans have been observed to parasitize the fishes of Gadigarh stream as detailed below:

2.1. Argulus sp.: This parasite has been

observed to infect the following hosts:

Badis badis: A single infected specimen was collected from Station V in October, 1974.

Puntius conchonius: Two infected specimens collected from Station VI in April, 1975.

Puntius sophore: Two infected specimens (one each) from Station VI & VII in April, 1975.

Puntius ticto: A single infected specimen collected from Station IV in June, 1975.

2.2. Lernaea sp.: This parasite has been observed to parasitize mostly Channa punctatus and singly Heteropneustes fossilis in Gadigarh stream. The infected specimens of Channa were recorded from all the stations of the stream. The site of the infection was found to be the bases of pectoral, pelvic, dorsal and anal fins. In some specimens infection from the eye orbit has also been recorded.

The only specimen of Heteropneustes fossilis bearing a parasite at the base of the dorsal fins was caught in April (1975). The overall study has shown a maximum infection to occur during or before monsoons.

2.3. Ergasilus sp.: Gills of a single specimen of Tor sp. netted in the month of July, 1975

from Gadigarh stream at Station VII were infected with Ergasilus sp.

DISCUSSION

Nikolsky (1963), Sinderman (1970), and Jhingran (1975) state that crustacean parasites cause ulceration of skin by sucking the juices and result in exhaustion and death of the parasitized fishes. Argulus sp., Lernea sp., and Ergasilus sp. have been recovered from various fish hosts during the present investigations, but the infestation seemed to be rather light.

3. Fungi : In October, 1973 one fungal infected specimen of Mastocembelus pancalus (Fig.76) was collected from Station VII. Anterior part of the living fish was hidden below the submerged stones, and infected posterior part of fish was exposed. The fish was in distress and moved its body slowly, possibly to hide itself. It was so severely infected by the disease that it had barely any strength left to move away when it was hand picked. Most part of the fish behind the anus had rotted due to fungal infection. On examination it has been observed that fungus belonged to genus Saprolegenia.

DISCUSSION

Previous reports on fungal infection in fishes (Chidambaram, 1942; Nikolsky, 1963; Van Dujin, 1967; Huet, 1970; Sinderman, 1970, and Jhingran, 1975) reveal the non-occurrence of any host-fungal specificity. Most of the above mentioned workers have agreed that fungal infection is secondary, the body of a fish getting primarily injured mechanically or biologically yielding later to fungal infection. Biological injuries may be caused due to sucking of blood by parasites (Argulus, Lernea and leeches) interspecific and intraspecific combats, and by predators.

The present study cannot definitely establish the secondary nature of fungal infection, because none of the crustacean infected hosts carried simultaneously the infection of fungus; neither does the catch of a single fungal infected specimen of Mastocembelus help much to assess the exact mode of its infection. But from the fact that fungal infection was exhaustive and profuse in the specimen, all that one can say is that the specimen may in either case be destined to die following emaciation.

FISH PREDATORS

In the course of present investigations it has been observed that Lethocercus indicus from insects, Natrix piscator, and Trionyx gangeticus from reptiles are common fish predators inhabiting Gadigarh stream.

From the present study it has been established that man is the most destructive predator in stream. On a number of occasion fish mortality by use of D. D. T and bleaching powder was observed in the stream. Use of these chemicals not only kill the fishes, but even, eradicate the fish population from the area, along with other aquatic animals which are of direct and indirect importance for the fishery development.

Table VC. *Myxobolus* infection in various fishes inhabiting Gadigarh stream.

S.No.	Period	Name of host	Station	Fish: Number	Fish: Length (cm)	Site of infection	Degree of infection	Symptoms	Effect on host
	1974								
1.	November	*Esomus danrica* (Ham. Buch.)	III & VII	1	5.2	Barbels	Heavy	White cysts	Normal movements
				3	4.2	Barbels	Heavy	White cysts	Normal movements
					5.0	Barbels	Light	White cysts	Normal movements
					5.7	Barbels	Light	White cysts	Normal movements
	1975								
2.	May	*Puntius sarana* (Ham. Buch.)	VII	1	4.8	Dorsal and caudal fin rays	Light	White cysts	Normal movements
		P. sophore	V	1	6.0	Skin	Light	White cysts	Normal movements
		Mastocembelus armatus (Lac.)	V	1	12.5	Dorsal fin rays	Light	White cysts	Normal movements
3.	June	*Labeo dero* (Ham. Buch.)	IV	3	10.5	Skin	Heavy	White cysts	Normal movements
					5.4	Skin	Light	White cysts	Normal movements
					4.2	Skin	Light	White cysts	Normal movements
		Puntius conchonius (Ham. Buch.)	I	1	6.5	Infront of dorsal fin	Heavy	White bursted blisters	Restless slowly moving its body at times hiding below aquatic vegetation
4.	September	*Cirrhinus reba* (Ham. Buch.)	VII	2	14.0	Skin	Rare	White cysts	Normal movements
					10.5	Skin	Rare	White cysts	Normal movements

Fig. 71. - Myxobolus infection on barbels of Esomus danrica (Ham. Buch).

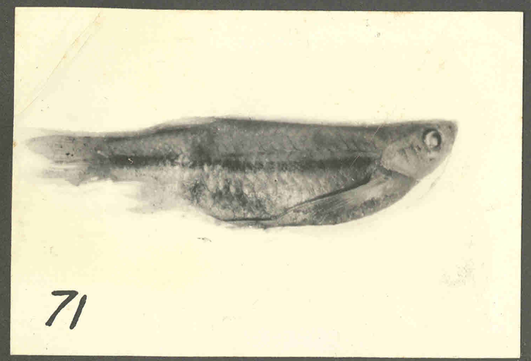
Fig. 72. - Myxobolus infection on dorsal fins of Puntius sarana (Ham. Buch.)

Fig. 73. - Myxobolus infection on body of Labeo dero (Ham. Buch.)

Fig. 74. - Myxobolus infection on Cirrhinus reba (Ham. Buch).

Fig. 75. - Henneguya infection on the body of Labeo bata.

Fig. 76. - Saprolegenia infection on the body of Mastocembelus pancalus.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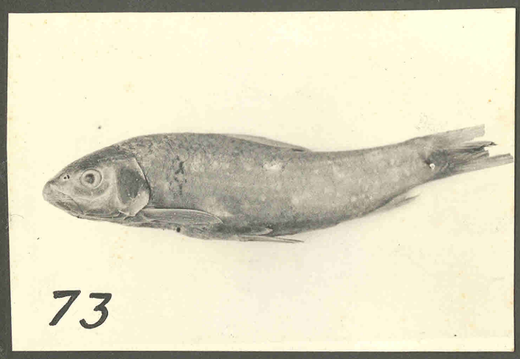
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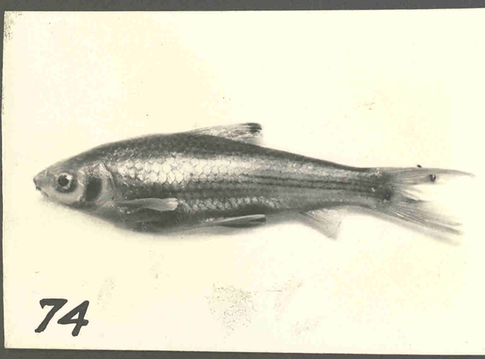
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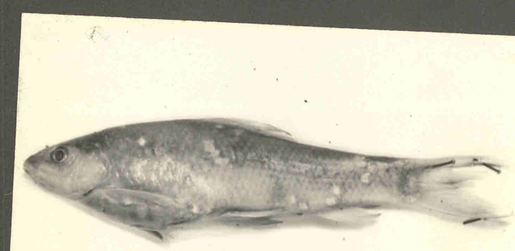
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GENERAL DISCUSSION

Water and soil constitute the abiotic environment of aquatic organisms, and a delicate balance exists between physico-chemical constituents and biota of this environment. Various abiotic factors (viz. dissolved gases and salts) undergo marked seasonal and diurnal fluctuations.

PHYSICO-CHEMICAL

Soil and water:

Soil of Gadigarh stream is generally rich in sand particles. Soil is alkaline in nature (pH 7.2 - 8.65), and this alkalinity increases during monsoons. Conductivity of soil and its total soluble salts are inversely proportional to pH as also pointed out by Bear (1965). During summer a decline in pH value of soil is attributed to decomposition of aquatic vegetation, as previously recorded by Banerjea (1967), and Dhar (1976).

Total available soil phosphate values are higher during summer and lower during winter; probably due to differential microbial activity in the soil.

Soil nitrogen and temperature exhibit a variable inter se relationship, being inverse at higher temperature and direct at lower.

Since Gadigarh stream is mostly spring fed, its carbon dioxide, calcium, and magnesium increase considerably after rains, (which increase the output of springs); and as pointed out by

Ganapati (1943), Welch (1952), Barnes (1965), Bombowna (1965), and Odum (1971) springs are a rich source of salts, upwelling these from the subterrene. Increase of carbon dioxide during the rains is due to its addition through rain water. (Chakrabarty et al. (1959) Verma at al. 1968, and Schwoerbel 1970). Paradoxically during heavy monsoons the salt concentration in water declines because of dilution effect operating simultaneously. Such an effect of dilution has been projected by Welch (1952), Chakrabarty et al. (1959), Reed (1962), and Verma and Shukla (1968).

Transparency of water is inversely proportional to turbidity, which in this stream is contributed mostly by suspended inorganic matter, the latter increasing considerably in monsoons (Welch 1952; Reed 1962; Pahawa and Mehrotra 1966, Ray et al. 1966 and Jhingran 1975). Seasonally speaking, water temperature is highest in May and lowest in December and January. Widest diurnal variation between maximum and minimum temperature is recorded in the month of July; and minimum in December. Premonsoon rains may contribute to the fluctuations during July; when on the higher

side, increase in inorganic suspended matter results in increased absorption of heat (Reed, 1962), and on the lower side clouds help in bringing about an appreciable decline in water temperature. Thus while high temperature would impoverish water of its oxygen concentration, a lowered oxygen tension during low temperature regime (in winter) is on the other hand a consequence of lowered photosynthesis (because there is an overall decrease of plant biomass on account of shorter day length). Similar observations have been made by Hussainy (1965) and Verma et al. (1967).

Decrease of oxygen in presence of excess of suspended matter is in line with the conclusions of Welch (1952). Inverse relationship of free carbon dioxide and dissolved oxygen observed during the diurnal and seasonal studies (April to June) is in line with observations of Welch (1952).

Carbon dioxide helps in conversion of carbonates of calcium and magnesium into their bicarbonate as also pointed out by Welch (1952), and Bombowna (1965). This may explain a near direct relationship of carbon dioxide, calcium and bicarbonates observed from September - November, and February - April.

pH of water has been seen to steadily increase towards alkalinity during active photosynthesis (observed through diurnal studies) and in the month of April (through seasonal studies). Lack of any wide variation of pH observed during seasonal studies is due to buffering effect of salts in the stream as has also been mentioned by Welch (1952), Hutchinson (1957), and Hussainy (1965).

BIOTIC

Qualitative composition:

Biotic diversity in Gadigarh stream is due to its slow speed and alluvial soft bottom. According to characterization of Huet (1970) the stream is initially limnocrene because water from bottom springs first fills depression, and become limnophile only afterwards when water flows slowly. Because of its slow speed, it deposits more loam, silt, sand and clay on its bottom, thereby supporting rooted and non-rooted vegetation. (Typha sp., Hydrilla sp., Potamogeton sp., Utricularia sp., Chara sp., Nitella sp., Batrachospermum sp., Spirogyra sp., etc.). This vegetation supports many components of biota (protozoans, crustaceans, annelids

molluscs, insects, and fishes etc.). The large amount of aquatic vegetation on decomposition also produces more detritus which attracts a large number of detrivores on the floor (annelids, Chironomid larvae, and molluscs, and prawns). Due to abundant food supply of different levels in the stream a large number of fishes get attracted and function as surface feeders, column feeders and benthic feeders as observed for other slow streams (Welch 1952; Huet, 1970, and Ananthan Krishnan et al. 1976).

In Gadigarh stream, the gravelly bottom (Station VII) is less productive than soft bottom (as of all other stations). This finding is in line with that of Ricker (1934) and does not support Reed (1962) who through his studies on river Saskatchewan holds that a gravelly bottom is more productive.

Biotic richness of a stream is due to transparency of its water (Berner 1951, Welch 1952, Cairns Jr. 1968, and Verma and Shukla, 1968). Since water of Gadigarh stream is transparent and sunshine penetrates down to its bottom, a higher photosynthesis enhances net primary production. This conclusion is supported by the fact that monsoons

is the least productive period, because of high inorganic turbidity (restricting high penetration) during this period.

Carpenter (1928), Ellis et al. (1946), Welch (1952), Alikunhi (1957), and Huet (1970), all stated that alkalinity of water makes it more productive and so has it been for Gadigarh stream (water pH 7.4 - 8.35, and soil 7.2 - 8.65).

Oxygen below 5 mg per liter is limiting or even lethal as also pointed out by Ellis et al. (1946), and this lethality is increased at higher temperature (Royce, 1972). This may explain lower secondary production in June, when oxygen concentration is as low as 1.92 mg per liter at some stations of the Gadigarh stream.

The concentration of carbon dioxide in Gadigarh stream (2.25 mg per liter - 14.85 mg per liter) is below the toxic level as discussed by Alikunhi (1957), and Royce (1972) and thus supports higher organic production.

Phosphates are always present in the stream and contribute to its greater production

as also pointed out by Welch (1952), Philips et al. (1955), Parker and Olson (1966), Odum (1971), Krammer et al. (1972), and Jhingran (1975).

Welch (1952), Macan (1963) and Huet (1970), [illegible] have concluded that larger populations of molluscs, crustaceans and fishes are calcium dependent (where it is utilized in formation of shell, carapace and bones). Fishes are known to obtain calcium not through food alone but also by direct absorption from the environment (Phillips et al. 1955 and 1957).

Huet (1970) states that water bodies with less than 8 mg per liter of calcium show a scarcity or complete absence of crustaceans and molluscs. Since calcium in Gadigarh at no stage falls below 35 mg per liter, it is not limiting and may account for richer molluscan and crustacean populations in this stream.

Calcium also accelerates the decomposition of detritus as pointed out by Tensley [illegible] (1939), and Egglishaw et al. (1967). Thus its presence may attract large number of detritivores, which explains the presence of

Chironomid larvae, annelids and molluscs in benthos of calcium rich Gadigarh stream.

Welch (1952) also relates the role of calcium to several physiological processes occurring in aquatic plants and thus its importance in primary productivity. These physiological processes may be (i) proper translocation of the carbohydrates, (ii) an integral component of plant tissues, (iii) facilitating the availability of other ions and, (iv) an antidoting agent reducing the toxic effects of single salt solutions of sodium and potassium; all these processes help augment primary production.

Magnesium being a necessary constituent of chlorophyll is consistently present in the stream, contributing to its productivity.

Relative abundance:

Secondary production in the stream is due to optimum conditions of temperature, favourable oxygen and food as indicated by abundance of aquatic insects, crustaceans etc. from February to April; annelids from April to May, and molluscs in the months of May and June. Temperature of water

in Gadigarh, as in other water bodies is the most important single factor influencing aquatic productivity (Kinne 1963, and Jensen et al. 1968). It governs the distribution of animals (Allen 1920; [illegible] and Byars 1960) and acts as a limiting factor in determining the reproductive rhythm and hatching periods (Semper 1881; Orton 1920; Yonge 1930; Thorson 1946; Yamamoto 1951, and Shyamsundri and Hanumantha Rao, 1974).

Optimum available food from February to April in Gadigarh determines greater secondary production. The greater primary production during this period depends on the availability of carbon dioxide, bicarbonates, phosphates, calcium and magnesium in water, which are basic needs towards secondary production. Optimum oxygen in water is responsible for better assimilation of food by animals as pointed out by (Hermen et al.1962; Stewart 1962, and Fisher 1963).

Decline in quality and quantity of aquatic organisms from July to September may be due to monsoons, which increase the flow and suspended matter, decrease transparency thereby limiting productivity. A similar mechanical effect of a sudden

influx of water has been recorded by Kofoid (1908), Allen (1920), Chandler and Weeks (1945), Welch (1952), and Chakrabarty et al.(1959).

TROPHIC LEVELS AND FOOD WEB

Organisms in an ecosystem are linked vertically through food chains and both horizontally and vertically through complicated food web. In Gadigarh stream food chains and a food web (as observed) are quite complex (Fig.77).

Odum (1971) suggested two types of food chains (i) grazing, which starting from a green plant base goes to a herbivore and ultimately to carnivores, (ii) detritus food chain which initiates from dead organic matter with associated microorganisms and goes to detritus feeders and then to carnivores. These food chains are not separated but are interconnected with one another and result in existence of complicated food web. Both, grazing as well as detritus food chains have been observed to function in Gadigarh stream.

Generally four trophic levels have been recognized viz. producer level, primary

consumer level, secondary consumer level, and tertiary consumer level. But the placement of omnivores in any system has remained obscure. The omnivores in Gadigarh stream may occupy simulatneously a primary consumer level and a level of secondary or tertiary consumer; because they consume primary producers, as well as primary and secondary consumers. But from the the point of being eaten themselves (in the ecosystem), they lie below the top carnivorous level. Such omnivores in Gadigarh stream are Macrobrachium dayanum, M. lamarrei, Caridina sp., Danio devario, Puntius sarana, Rasbora rasbora, Danio rerio, Osteobrama cotio, Chela (Chela) cachius, Mystusembelus armatus, Heteropneustes fossilis, Lepidocephalichthys guntea and Noemacheilus botium.

Cummins (1973) reviewing all the available work on food relationships discussed that aquatic insects have often been simultaneously classified as herbivores and omnivores. Herbivore trophic levels have further been split into algal feeders and detritus feeders.

Animal inhabitants of Gadigarh stream can be placed at various trophic levels on the basis of food recovered from their guts.

Trophic level I :

Primary producers in the stream trap solar energy, manufacture their food by absorption of nutrients from the soil (rooted plants) or from water (non-rooted plants). These primary producers inhabiting Gadigarh stream have been observed to range from microscopic filamentous algae and hydrophytes to littoral macrophytes.

Trophic level II :

Primary consumers of stream includes herbivores and herbi-detritivores. Analysis of gut contents of various organisms have shown that there are very few organisms feeding exclusively on green plants, but majority of animals of this trophic level have been observed to be herbi-detritivore. Therefore organisms feeding on detritus and aquatic plants have been categorized as primary consumers occupying trophic level II. Primary consumers in the existing food web in the stream have been observed to be, (i) Cladocerans (Simocephalus sp., Scapholeberis sp., Moina sp., Ceriodaphnia sp., Diaphanosoma sp., Macrothrix sp., Pleuroxus sp., Leydigia sp.,

and Camptocercus sps. , (ii) Copepoda (Cyclops sps., Mesocyclops sps., Macrocyclops sps., Eucyclops sps. (iii) Decapod crustacea (Paratelphusa (Barytelphusa), masonian (Henderson) (iv) Ephemeropteran lafvae, (v) Chironomus sps., (vi) annelids, (vii) molluscs, and (viii) fishes (Puntius ticto, P. conchonius, P. sophore, and Labeo dero).

Trophic level III :

Secondary consumers of the stream includes animals feeding on primary consumers. These secondary consumers in Gadigar stream are Coleopterans, Odonatal nymphs, Hemipterans and a fish Badis badis , Mastocembelus pancalus, M. vittatus, M. bleekeri, and Oxygaster bacaila.

Trophic level IV :

This includes large sized carnivores feeding on animals of trophic level II and III. The common inhabitants in the category in Gadigarh stream are Channa punctatus, C. marulius, Ompok bimaculatus, Glossogobius giuris, Xenentodon cancila, Wallago attu, Nandus nandus and Mystus seenghala.

Man and some carnivores (Natrix piscator, Trionyx gangeticus) may be the top predators functioning in the Gadigarh stream.

Thus it may be concluded that all the organisms in the stream are linked with one another through their food chains, resulting in existence of a functional and complicated food web.

The organisms constituting different trophic levels (in a web or chain) also interact with other biotic and abiotic factors (for their qualitative and quantitative} abundance in Gadigarh stream), and this thus conforms to a functional pattern operating in any other ecosystem.

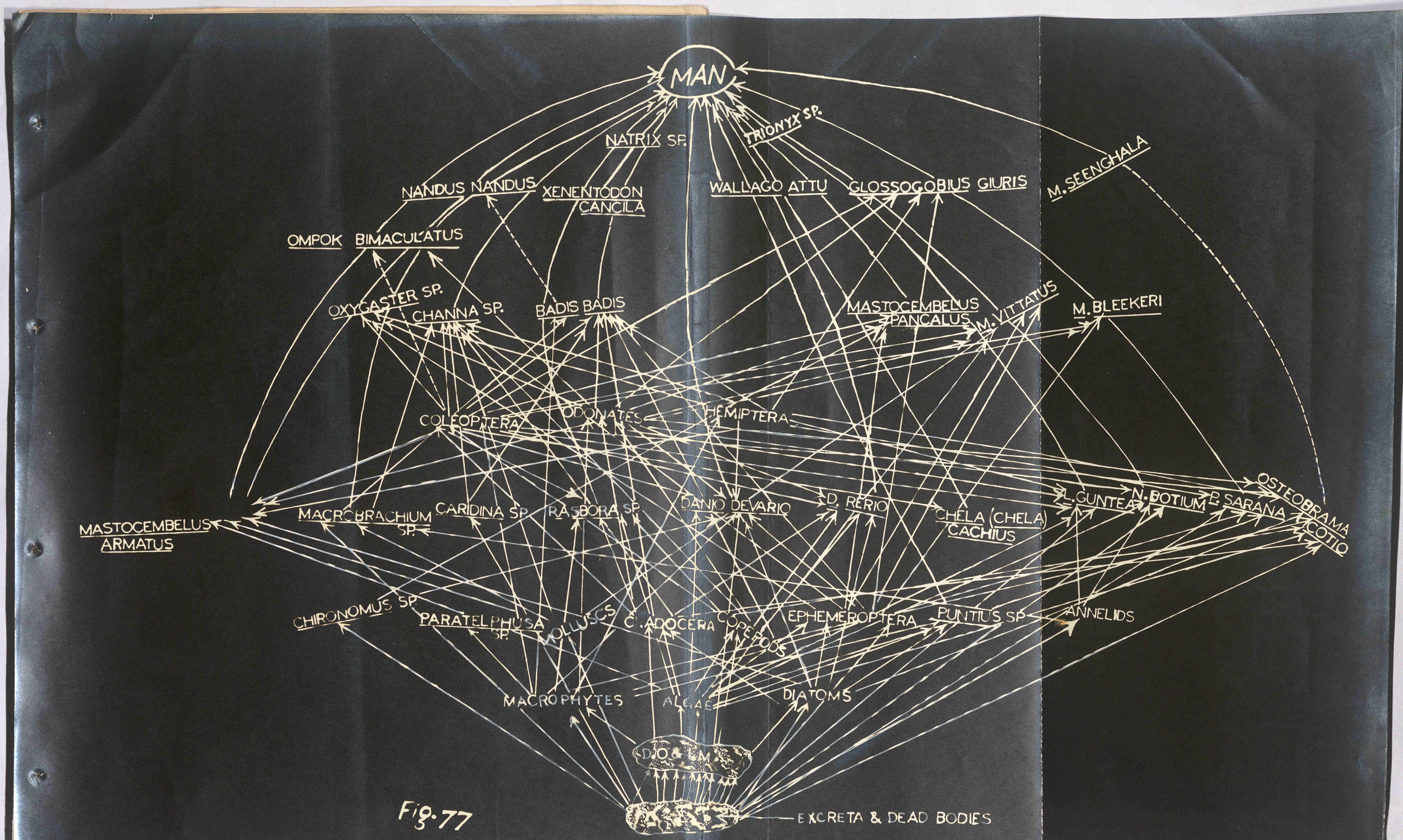
MAN
NATRIX SP.
TRIONYX SP.
NANDUS NANDUS
XENENTODON CANCILA
WALLAGO ATTU
GLOSSOGOBIUS GIURIS
M. SEENGHALA
OMPOK BIMACULATUS
OXYGASTER SP.
CHANNA SP.
BADIS BADIS
MASTOCEMBELUS PANCALUS
M. VITTATUS
M. BLEEKERI
COLEOPTERA
ODONATES
HEMIPTERA
MASTOCEMBELUS ARMATUS
MACROBRACHIUM SP.
CARIDINA SP.
RASBORA SP.
DANIO DEVARIO
D. RERIO
CHELA (CHELA) CACHIUS
L. GUNTEA
N. BOTIUM
P. SARANA
OSTEOBRAMA COTIO
CHIRONOMUS SP.
PARATELPHUSA SP.
MOLLUSCS
C. ADOCERA
COPEPODS
EPHEMEROPTERA
PUNTIUS SP.
ANNELIDS
MACROPHYTES
ALGAE
DIATOMS
D.O.& T.M.
EXCRETA & DEAD BODIES

Fig. 77

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

Gadigarh stream situated at a longitude 74° . 50' E and latitude 32° . 40' N is located at a distance of 12 km from Jammu city. This slow fresh water stream is fed by springs and the overflow from adjoining paddy fields, and finally discharges through Ballole nallah into river Tawi.

SEASONAL STUDIES

a) Physico-chemical

1. Bottom sediments: Bottom soil is soft and alluvial. Sand, silt, clay and loam in bottom sediments vary seasonally; maximum sand has been observed at Station IV (82.99 % in January, 1975) and minimum at Station III (3.1 % in August, 1975). While shore bottom is richer in sand, the mid bottom has more of clay and loam. Sand percentage in sediments decreases as moved downwards from Station I, and it increases at all stations during rains. Bottom soil colour varies from yellow to grey (5 YR and 10 YR hues being commonly met with), greyer soil have high percentage of detritus.

The overall study has shown that soil is alkaline in nature (pH 7.2 - 8.6). Soil pH is directly proportional to soil phosphates and inversely to soil nitrogen and bicarbonates. Soil phosphates are variable, being generally more in summer. They appear to be directly proportional to potassium of the soil and inversely to its nitrogen.

2. Water: Depth of water in the stream depends on inflow from rains, springs and canal. Transparency is minimum during monsoons because of inorganic suspended

matter, detritus, and plankton. Water temperature follows atmospheric temperature throughout the year.

Dissolved oxygen content follows a bimodal pattern (first rise during October - November followed by another during February - April). Higher water temperature and increased decomposition lowers dissolved oxygen in water.

Free carbon dioxide increases during and after the rainy season. Active photosynthesis results in decrease of carbon dioxide in water. Carbonates are absent in the stream. Bicarbonate is higher than reported for any other lotic water body of the country. Springs of the stream contribute to enrichment of carbon dioxide, bicarbonates, chlorides, phosphates, calcium and magnesium.

Seasonal fluctuation in phosphate and chloride content of stream water have been observed. Phosphate fluctuations are a consequence of organic decomposition. Chloride variation may be due to additions of animal excreta, and bleaching powder by fish poachers.

2. BIOTIC

2.1. Benthos: Chironomus larvae, annelids and molluscs constitute the benthic fauna of Gadigarh stream. Organic detritus and slow current account for oligochaete dominance in benthos. Among molluscs Viviparous bengalensis and Indonia sps. attain maximum abundance during May and June.

2.2. Zooplankton: Autogenetic zooplankton is represented by 4 genera of protozoa, 5 of rotifera, 9 of Cladocera and 4 of Copepoda. Cladocera are present only from December to July; while Copepoda are present throughout the year. Maximum diversity of organisms in zooplankton is observed from February to April, and minimum from August to September (when at some stations the zooplankton were even completely absent). Food, optimum temperature and higher concentration of dissolved oxygen and calcium appears to augment population of zooplankton.

2.3. Nekton: This ecological group in the stream is represented by 21 species of Coleoptera, 6 of Hemiptera, 1 of Caridina, 2 of Macrobrachium, 1 of Paratelphusa, 42 of fishes, 2 of amphibians, 4 of tortoises, and 1 of snakes.

2.4. Neuston: This ecological group is constituted by Hydrometra greeni, Metacoris communis and Gerres sp.

2.5. Periphyton: Constituted by 1 species of Hydra (occurring from December - April), occasionally Viviparus bengalensis, Lymnaea sp., Indoplanorbis exustus and Gyrulus convexisulculus are also observed to conform to this ecological definition.

DIURNAL STUDIES

a) Physico-chemical

Water: Transparency of water is maintained from sunrise to sunset. Diel fluctuation in water temperature are maximum in July (8.5°C) and minimum in December (1.1°C).

Dissolved oxygen is maximum at 1600 hours; its diel fluctuations are maximum (5.48 mg per liter) in May, and minimum (1.08 mg per liter) in October. Diel fluctuation in carbon dioxide is maximum (4.0 mg per liter) during July and minimum (3.4 mg per liter) during May. Maximum content of carbon dioxide is observed at 400 hours during the 24 hours period. Month of December is an exception in diel patterns of maximum oxygen and carbon dioxide.

Carbonate is recorded only once throughout the course of present investigation. Bicarbonate concentration is generally higher during night, its maximum diel fluctuation (134.08 mg per liter) occurs in May and minimum (38.01 mg per liter) in October.

Chloride is higher during days (except in May when higher concentration is recorded at night).

Diel fluctuation of water soluble phosphate does not conform to any regular pattern, its maximum concentration is observed around 1200 hours (during May and July), or midnight to early morning (during October), or 2000 hours (during December and February).

pH varies towards alkalinity during day and towards acidity at night.

b) Biotic

Zooplankton: Zooplankton (mainly composed of Copepoda and Cladocera) increases nocturnally at surface. Light, carbon dioxide and dissolved oxygen may be factors governing this pattern of diurnal migration.

BIOTIC RELATIONSHIPS OF SOME ECONOMICALLY IMPORTANT INHABITANTS OF THE STREAM

Prawns: Macrobrachium dayanum and M. lamarrei are the common prawns of the stream; abounding at inlet or outlet of different stations or along littoral zone of stream where the aquatic vegetation is abundant and bottom is soft. They are detriti-omnivores. Females outnumber males. Their breeding extends from late March to early July. A positive mathematical relationship between total length and fecundity is observed; while no such relationship exists between the total weight and fecundity.

Food and feeding habits of fishes: Puntius ticto, P. conchonius, P. sophore and Labeo dero are HERBIVOROUS. Rasbora rasbora, Puntius sarana, Osteobrama cotio, Heteropneustes fossilis, Lepidocephalichthys guntea, Noemacheilus botium, Danio rerio, Chela (Chela) cachius Mastocembelus armatus, Danio devario, and Mystus vittatus are OMNIVOROUS. Fishes like Xenentodon cancila, Ompok bimaculatus, Wallago attu, Mystus seenghala, M. bleekeri, Nandus nandus, Glossogobius giuris, Oxygaster bacaila, and Badis badis are categorized as CARNIVOROUS .

Danio rerio, Rasbora rasbora, Badis badis, Chela (Chela) cachius, and Oxygaster bacaila are designated as SURFACE FEEDERS; while Channa punctatus, C. marulius, Ompok bimaculatus, Wallago attu, Xenentodon cancila, Glossogobius giuris, Nandus nandus, Mystus seenghala, M. vittatus, M. bleekeri, Osteobrama cotio, Puntius conchonius, P. ticto, P. sophore, and P. sarana are recognized as COLUMN FEEDERS. Fishes like Lepidocephalichthys guntea, Noemacheilus botium and Heteropneustes fossilis are BOTTOM FEEDERS.

Presence or absence of a particular food item in gut reflects its abundance or scarcity in the environment.

Feeding intensity (enterosomatic index) appears to be under the influence of "exteroceptive factors" like water temperature, dissolved oxygen, and availability of food in the environment; while maturity of gonad is the "interoceptive factors" influencing food intake.

Interspecific and intraspecific competition for food is prevalent in the stream. Fish diseases and predators: Myxobolus sp., and Henneguya sp. are the only protozoan parasites observed.

Argulus, Ergasilus and Lernaea are the common crustacean parasites. Saprolegonia is observed on one case of Mastocembelus pancalus.

Lethocercus indicus from insects and Trionyx gangeticus and Natrix piscator among reptiles are the common fish predators inhabiting the stream.

Above all, as in other ecosystems, man is not only a top predator in Gadigarh stream, but also a bad modifier through use of chemicals like D.D.T and bleaching powder which upsets the delicate balances operating in this aquatic ecosystem.

On the basis of present limnological studies on Gadigarh stream (a representative of fresh water pool of sub-siwalik Indo-gangetic plain) it is concluded that this water body has a high productive potential both qualitatively and quantitatively which is also indicated by its richness in various nutrients (Calcium, magnesium and phosphate).

Thus, while taking a decision on aquaculture in this part of country the knowledge gained through present investigations will prove

helpful in selecting economically important animals (lamellidens, prawns, crabs and fishes) with different feeding habits; so that every available ecological niche is profitably occupied, and contributes towards the success of composite aquaculture, which in itself is a step towards amelioration of the quality of human diet.

Adam, S. N., and Honeysetts, J. L., (1964). Some effects of soil water logging on the cobalt and copper status of pasture grown in pots. Aust. J. Agric. Res., 15 : 357 - 367.

Alikunhi, K. H., (1957). Fish culture in India. No. 20 Farm Bulletin - 1, ICAR, New Delhi.

_____., Rao, G. L., and Jacob, P. K., (1951). Bionomics and development of Glossogobius giuris (Ham.). J. Madras Univ., 21 B : 238 - 248.

BIBLIOGRAPHY

Allen, W. E., (1920). A quantitative and statistical study of the plankton on the San - Jaoquin River and its tributaries in and near Stockton, California. Univ. Calif. Pub. Zool., 22 (1) : 1 - 292.

*Alm, G., (1922). Fiskens biologi i Yxtasjon Samt Jamforande under sokningar over botten fauna och fiskproduktion i svenska insjoar. - Medd. K. Lantbrukssty relsen, 253 : 1 - 188.

American Public Health Association, (1973). Standard methods for the examination of water and waste water. 12th Amer. Pub. Health Assoc. Inc. New York, pp. 874.

Anthan Krishnan, T. N., and Viswa Nathan, T. R., (1976). General animal ecology. Published by S. G. Wasani for the Macmillan Company of India, pp. 324.

*Apstein, C., (1896). Das Suss Wasser plankton. Methode und Resultade der quantitativen untersu chung. Kiel, pp. 200.

Arnold, P. W., (1954). J. Soil Sci., 5 : 116.

Ayer, R. P., (1949). On the embryology of Palaemon idae Heller. Proc. Zool. Soc. Bengal., 2 (2) : 101 - 148.

Baggae, P., and Jumpanen, K., (1968). Bottom fauna of lake Keitele, Central Finland in relation to hydrography and eutrophization. Annales Zoologici Fennici, 5 : 327 - 337.

_____., and Tulkki, P., (1967). Studies on hydrography and biota of recently isolated lakes. Inst. Skr., 223 : 13 - 34.

Balan, V., (1963). Biology of the silver belly, Leiognathus bindus (Val.) of the Calicut coast. Ind. J. Fish., 10 (1) : 118 - 134.

Bapat, S. V., and Bal, D. V., (1950). The food of young clupeids. Proc. Ind. Acad. Sci., 32 : 39 - 58.

Banerjea, S. N., (1967). Water quality and soil conditions of fish ponds in some states of India in relation to fish production, Ind. J. Fish., 14 (1 - 2) : 115 - 144.

Barnes, I., (1965). Geochemistry of Birch Creek, Inyo county, California, a travertine depositing creek in an arid climate : Geochim et Cosmochim. Acta., 29 (2) : 85 - 112.

Bear, F. E., (1965). Chemistry of the soil (2nd ed.) Oxford and IBH, Calcutta pp. 515.

Berner, L. M., (1951). Limnology of the lower Missouri river. Ecology, 32 : 1 - 12.

Bhatnagar, G. K., (1963). On some aspects of the Biology of Puntius kolus (Sykes) of the Tungabhadra reservoir. Ind. J. Fish., 10 (2) : 500 - 520.

_____., and Karamchandani, S. K., (1970). Food and feeding habits of Labeo fimbriatus (Bloch.) in River Narbada near Hoshangabda(U.P). J. Inland Fish Soc. India, 2 : 30 - 50.

*Bhowmick, M. L., (1968). Environmental factors effecting fish food in fresh water fishes, Kalyani, West Bengal. Unpublished thesis, Univ. of Kalyani, pp. 238.

Bhowmick, R. M., (1965). Studies on some aspects of the Glossogobius giuris (Ham.) with a note on the fishery in the Hooghly estuary. Proc. Indo - Pacific. Coun., 11 (2) : 99 - 115.

*Birge, E. A., (1898). Plankton studies on lake Mendota II. The crustacea of the plankton from July 1894 - December 1896. Trans. Wis. Acad. Sci. Arts. Lett., 11 : 274 - 451.

Black, C. A., (1965). Soil - plant relationships. John Willey and Sons, Inc., New York.

*Blanc, H., (1898). Le plankton nocturne du lac leman. Archs Sci. Phys. nat., 6 : 182.

Bollag J. M., and Drzymala, S., (1973). Biological versus chemical nitrite. Decomposition in soil. Soil Sci., 116 (1) : 44 - 50.

Bombowna, M., (1965a). Hydrochemical investigations of the Morskie Oko Lake and the Czarny Staw Lake above the Morskie Oko in the Tatra mountains. Limnol. Invest. in the Tatra Mt. and Dunajec River Basin Komitet Zagosp Ziem Gorskichpan Zeszyt No.11, Krakow, :pp.7 - 17.

_____., (1965b). Hydrochemical characteristics of the Roznow and Czchow reservoirs. Limnol. Invest. in the Tatra Mts. and Dunajec River Basin Komitet Zagosp Ziem Gorskichpan Zeszyt No. 11, Krakow : 215 - 233.

_____., (1969). Hydrochemical characteristics of the Toporowy Staw Nizni one of the dystrophic Tatra lakes. Acta Hydrobiol., 11(2) : 223 - 231.

_____., (1971). T he chemical composition of the water of streams par of the Polis High Tatra Mts., particularly with regard to the stream Such Woda. Acta Hydrobiol, 13 (4) : 379 - 391.

Boyd, C. E., (1970). Influences of organic matter on some characteristics of aquatic soils. Hydrobiolgia, 36 (1) : 17 - 21.

_____., (1975). Total alkalinity and hardness of surface waters in Albama and Mississippi. Agricult. Expt. Stn. Bull. No. 245 : 168.

_____., (1976). Chemical and textural properties of muds from different depths in ponds. Hydrobiologia, 48 (2) : 141 - 144.

Bremner, J. M., (1965). Total nitrogen In Methods of soil analysis Vol. 2. by C. A. Black-1965. Amer. Soc. Agronomy. Inc. Publ., U.S.A.

Broadbent, F. E., and Stojanovic, B. F., (1952). Proc. Soil Soc. Amer., 16 : 359.

Burns, C. W., (1968). Direct observations of mechanism regulating feeding behaviour of Daphnia in lake water. Int.Revug.ges.Hydrobiol, 53(1):83-100.

*Burton, G. M.,and Odum, F. P., (1945). Ecology. Brooklyn, 26 (2) : 182 - 194.

Butcher, R. W., Pentelow, F. T. K., and Woodley, J. W., (1930). Variations in composition of river waters. Int. Rev. Hydrobiol, 24 : 47 - 80.

Byars, J. A., (1960). A fresh water pond in New Zealand. Aust. J. Mar., and Fresh water Res., 11 (2) : 222 - 240.

Cairns, Jr. J., (1968). Suspended solids standards for the protection of aquatic organisms. Purdue University Engineering Bulletin, No. 129, Part I, pp. 16 - 27.

*Carpenter, K. E., (1928). Life in Indian water Sidgwick Jackson, London. pp. 267.

Carr, J. F., and Hiltunen, J. K., (1965). Changes in the bottom fauna of Western lake Erie from 1930 - 1961. Limnology and Oceanography, 10 (4) : 551 - 569.

*Chacko, P.I., and Ganapati, S. V., (1949). Some observations on the Adyar River, with special reference to its hydrobiological conditions. Indian Geogr. J., 24 (3).

_____., and Krishnamurthy, J. B., (1954). On the plankton of three fresh water ponds in Madras city, India. Symp. Mar. Freshw. Plankton Indo-Pacific Fish Council, Bankok, 103 - 107.

_____., and Kuriyan, G. K., (1948a). On the food of nine species of Barbus of Madras. Sci., and Cult., 13 (8) : 347.

_____., and _____., (1948b). On the bionomics of Catla catla (Cuv. and Val.) in South Indian waters. Curr. Sci., 17 (5) : 191.

_____., and Srinivasan, R., (1955). Observations on the hydrology of the major rivers of Madras state. South India. Cont. Fresh water Biol. Stn., Madras, 13 : 14.

_____., _____., and Evangeline, G., (1953). Hydrobiology of Malampuzha River with special reference to development of fisheries in the Malampuzha reservoir. Indian Comm. Journal, Madras, 8 (1): 118 - 124.

Chacko, P. I., Venkataraman, R. S., and Ranganathan, V., (1946). On the bionomics of the silver fish. Chela argentea (Day). Curr. Sci., 15 (6) : 167.

Chakravarty, M. M., (1943). Studies in Myxoporidia from common food fishes of Bengal. Proc. Ind. Acad. Sci., 18 B: 21 - 35.

Chakrabarty, R. D., Roy, P., and Singh, S. B., (1959). A quantitative study of the plankton and the physico-chemical conditions of the River Jumna at Allahabad. Indian. J. Fish, 6 (1) : 186 - 203.

_____., and Singh, S. B., (1963). Observations on some aspects of the fishery and biology of Mrigal. Cirrhina mrigala (Ham.) from Allahabad. Indian J. Fish., 10 (1) : 209 - 232.

Chandel, R. S., (1964). A hand book of agricultural statistics. Achal Parkashan Mandir Parmat (Kanpur) : 151.

Chandler, D. C., and Weeks, O. N., (1945). Limnological studies of western lake Erie. V. Relation of limnological and meterological conditions to the production of phytoplankton in 1942. Ecol. Monogr., 15 : 435 - 456.

Chanlet, E. T., (1973). Environmental protection. Mc Graw Hill Book Company, New York :569.

Chase, E. S., and Ferullo, A. F., (1958). Oxygen demand of leaves in water. Water and Sewage Work. 105 (5) : 204 - 205.

*Chatterjee, G. C., (1934). Biological control of malaria in rural areas of lower Bengal. Cont. Co-op. Anti Mal. Soc., Calcutta : 13 - 14.

Chidambaram, K., (1942). Fungus disease of Gourami Osphronemus goramy Lac. in a pond at Madras. Curr. Sci., 11 (7) : 289 - 290.

Clarke, G. L., (1933). Diurnal migration of plankton in the gulf of Maine and its correlation with changes in submarine irradiation. Biol. Bull., 65 : 402 - 436.

Costa, R. R., and Cummins, K. W., (1969). Diurnal vertical migration patterns of Leptodera kindtii (Focke) (crustacea, Cladocera) in a shallow eutrophic reservoir. Int. Rev. Hydrobiol., 54 (4) : 533 - 541.

Cummins, K. W., (1973). Trophic relations of aquatic insects. Annual review of entomology, 18 : 183 - 206.

Cushing, C. E., (1964). Plankton and water chemistry in the Montreal river a lake stream system. Saskatchewan. Ecol., 45 (2) : 306 - 313.

*Cushing D. H., (1951). The vertical migration of plankton crustacea. Biol. Rev., 26 : 158 - 192.

*Dall, W., (1968). Food and feeding of some Australian penaeid shrimp F. A. O. Fisheries Reports, 57 (2) : 251 - 258.

Damodaran, R., (1973). Studies on the benthos of the mud banks of the Kerala coast. Bull. Dept. Mar. Sci. Univ. Cochin, 6 : 1 - 126.

Das, K. N., (1935). Developmental stages of Palaemon lamarrei H. M. Edw. Ind. Sci. Congr. 22nd Abstract.

Das, S. M., and Srivastava, V. K., (1956a). Quantitative studies on fresh water plankton of fish tank in Lucknow, India. Proc. Nat. Acad. Sci., India, 26 B (2) : 85 - 92.

_____., and _____., (1956b). Quantitative studies on fresh water plankton II. Correlation between plankton and hydrological factors. Proc. nat. Acad. Sci. India, 26 B (4) : 243 - 254.

_____., and _____., (1959). Studies on fresh water plankton III. Qualitative composition and seasonal fluctuations in plankton composition. Proc. nat. Acad. Sci. India, 29 B : 174 - 189.

_____., and Moitra, S. K., (1955). Studies on the food of some common fishes of U.P, India I. The surface-feeders, the mid-feeders and the bottom-feeders. Proc.nat.Acad.Sci.India, 25B (1 - 2) : 1 - 6.

Das, S. M., and Moitra, S. K., (1956). Studies on the food of some common fishes of U.P., India Part II. On the types of fish food and the variations in the relative length of the alimentary canal, with a description of the latter. Proc. nat. Acad. Sci. India, 26 B : 213 - 223.

*David, A., (1963). Reports on the fishery survey of the River Gandak (North Bihar). Sur. Rep. Cont. Inl. Fish. Res. Inst. Barrackpore, (1) : 24.

Desai, V. R., (1970). Studies on the fishery and biology of the Tor tor (Ham.) from River Narbada. J. Inland Fish Soc. India, 2 : 101 - 112.

Dhar, N. R., (1976). Alkali lands and their reclamation. An world problem. Everyman Sci., 11 (1) : 20 - 32.

Dimitrov, M., and Iosheev, L., (1977). Oxygen regime in the ponds under conditions of intensive polyculture carp rearing . Proc. Fresh water Fisheries Res. Station, Plovdiv, 12 : 67 - 82.

Drantal, E., and Szczensy, B., (1965). Benthic fauna of theDunajec river. Limnol. Invest. in the Tatra Mts., and Dunajec River Basin Komitet Zagosp Ziem Gorskichpan Zeszyt No. 11, Krakow, pp. 161 - 214.

*Dunke, N. A., (1960). Some data on the state of a Bosmina longirostris (O.F. Muller) population in ponds fertilized with varying quantities of nitro-phosphoric salts. Trudy Belorussk Nauchno Issled Ryb. Ichoz., 3 : 71 - 76.

*Eddy, S., (1932). The plankton of Sangaman River in the summer of 1929 state of Illionis Div. Nat. Hist. Surv., 19 : 469 - 486.

Edward, R. W., and Rolley, H. L. J., (1965). Oxygen consumption of river muds. J. Ecol., 53 (1) : 1 - 19.

*Egglishaw, H. J., (1965). Estimating and accounting for the quantity of bottom fauna in Highland streams (Abstract). Rep. Challenger Soc. No. 3 : 36.

_____., and Mackay, D. W., (1967). A survey of the bottom fauna of streams in the Scottish Highlands Part III. Seasonal changes in the fauna of three streams. Hydrobiologia, 30 : 305 - 334.

Einsele, W., (1941). Die Umsetung Von Zuge furton anovganischer Phosphat in eutrophan Sec Und ihre Ruckwirkung auf Seinsen Gesmthaushatt, Z. Fisch., 39 (3) : 407 - 488.

*Ellis, M. M., West Fall, B. A., and Ellis, M. (1946). Determination of water quality. Res. Rep. U. S. Fish Serv., 9 : 1.

*Eyden, D., (1923). Specific gravity as a factor in the vertical distribution of plankton. Proc. Camb, Phil. Soc. Biol. Sci., 1 : 49 - 55.

Fernando, C. H., and Indrasena, H. H. A., (1969). The fresh water fisheries of Ceylon. Bull. Fish Res. Stn., Ceylon, 20 (2) : 101 - 134.

Filipovic, D., (1966). Limnological characteristics of the Lisinski Potok source area on Kopaonik mountain. Arhiv Bioloskih Nauka, 18(3-4):325-337.

*Fisher, E. R., (1963). Influence of oxygen concentration and of its diurnal fluctuations on the growth of juvenile Coho Salmon. M. S. Thesis Oregan state University, Corvallis, : 48.

*Fordyce, C., (1900). The Cladocera of Nebraska, Trans. Am. microsc. Soc., 22 : 119 - 174.

Galtsoff, P. S., (1929). Limnological observations in the upper Mississippi, 1921. Bull. U. S. Bur. Fish. 39 : 347 - 438.

Ganapati, S. V., (1942). The ecology of a temple tank containing a permanent bloom of Microcystis aeruginosa (Kutz.). Henfr. J. Bom. Nat. Hist. Soc., 42 (1 - 2) : 65 - 77.

Ganapati, S. V., (1943). An ecological study of a garden pond containing abundant zooplankton. Proc. Ind. Acad. Sci., 17 B (2) : 41 - 58.

_____., (1949). The hydrology of three summer pools in rocky stream bed at Mettur Dam with special reference to certain abnormal congregation of fishes. J. Zool. Soc. India, 1 : 44 - 48.

_____., (1955). Diurnal variations in dissolved gases, hydrogen ion concentration and some of the important dissolved substances of the biological significance in three temporary rock pools in stream bed at Mettur Dam. Hydrobiologia, 7 : 285 - 303.

Ganning, B., (1971). Studies in chemical, physical, and biological conditions in Swedish rock pools ecosystem. Ophelia, 9 (1) : 51 - 105.

Gasser, J. K. R., (1969). Some process of affecting nitrogen in the soil. Ministry of Agriculture, Fisheries and Food Technical, Bull., 15 :15-29.

George, M. G., (1961). Diurnal variations in two shallow ponds in Delhi, India. Hydrobiologia, 18 : 265 - 273.

_____., (1965). The food of major carps in some fish ponds in Delhi. Ind. J. Fish. 12(1) : 25 - 59.

George, M. R., (1966). Diurnal variations in physico-chemical factors and zooplankton in the surface layers of three fresh water fish ponds. Indian J. Fish. 13 (1 - 2) : 48 - 82.

_____., (1968). Studies on the zooplankton of a tropical fish pond. Hydrobiologia, 32 (1 - 2) : 47 - 68.

*Goldman, C. R., (1968). Aquatic primary production. Am. Zoologist, 8 : 31 - 42.

Goodnight, C. J., and Whitley, L. S., (1961). Oligochaetes as indicators of pollution". Proc. 15th Ind. Wastes Conf., Purdue Univ. Ext. Ser., 106 : 139.

Gopalakrishnan, V., (1952). Food and feeding habits of Penaeus indicus M. Edw. J. Madras Univ., 22 (1) : 69 - 75.

Govind, B. V., (1963). Preliminary studies of plankton of Tungabhadra reservoir. Ind. J. Fish., 10 (1) : 148 - 158.

Green, J., (1954). Size and reproduction in Daphnia magna (crustacea, Cladocera). Proc. Zool. Soc. London, 124 : 535 - 545.

Grover, S. P., (1971). Some biological notes on Barilius bendelisis (Ham.). Indian J. Fish. 18 (1 - 2) : 182 - 183.

Harris, E., (1957). Radiophosphorus metabolism in zooplankton and microorganisms. Can. J. Zool. 35 : 769 - 782.

*Hay, E. R., and Anthony, E. H., (1958). Limnol. Oceanogr. 3 (3) : 293 - 307.

Hazelwood, D. H., and Parker, R. A., (1973). Population dynamics of some fresh water zooplankton II. The effect of lag. Ecology, 44 : 207 - 211.

Heisig, G., (1977). Mass cultivation of Daphnia pulex in ponds: The effect of fertilization, aeration, and removal on the population development. Paper presented at the conference of aquaculture on cultivation of fish and Fry and its live food, Szymbark , Poland.

*Hermann, R. B., Warner, C. E., and Doudoroff, P., (1962). Influence of oxygen concentration on the growth of juveniles Coho Salmon. Trans. Am. Fish Soc., 91 : 155 - 167.

Hora, S. L., (1936). On a collection of fish from the Chitaldrug district, Mysore. Rec. Ind. Mus., 38 : 1 - 8.

*_____., and Mukherji, D. D., (1938). Health Bulletin No. 12, Malaria Bureau : 4.

Howmiller, R. P., and Beeton, A. M., (1971). Biological evalution of environmental quality, Green Bay, lake Michigan. J. W. P. C. F., 43 (1):126 - 133.

Huet, M., (1970). Text book of fish culture, breeding and cultivation of fish. Fishing News (Books) Ltd. 23 Rosemount Avenue, West Byfleet, Survey, England. pp.

Hussainy, S. U., (1965). Limnological studies of the departmental pond at Annamalainagar, Envir. Hlth., 7 (1) : 24 - 31.

_____., (1966). Plankton periodicity in Vihar lake. Envir. Hlth., 8 (164 - 168.

Hutchinson, G. E., (1957). A treatise on limnology Vol. I. John Willey, and Sons, pp. 1015

_____., (1967). A treatise on limnology Vol.II. John Willey and Sons.

Hynes, H. B. M., (1960). The biology of polluted waters. Liverpool University Publication : 202.

Hynes, H. N. N., Kaushik, N. K., Lock, M. A., Lush, D. L., Stocker, Z. S. J., Wallace, R. R., and Williams, D. O., (1974). Benthos and Allochthonous organic matter in streams. J. Fish. Res. Bd., Canada, 31 : 545 - 553.

Indian Standard Methods of Sampling and Test (physical and chemical) for water used in Industry 1968. Indian Standards Institution Manak Bhavan 9, Bahadur Shah Zafar Marg, New Delhi, pp. 122.

Isirimah, N. O., and Keeney, D. R., (1973). Nitrogen transformation in the aerobic and water logged Histosol. Soil. Sci., 115 (2) : 123 - 129.

Itazawa, Y., (1957). The diurnal variation of the oxygen content of fish culture pond water. Bull. Japanese Soc. Sci. Fish. 22 : 685 - 693.

Iyenger, M. O. P., and Venkataraman, G., (1951). The ecology and seasonal succession of the algal flora of the River Cooum at Madras with special reference to the Diatomaceae. J. Madras Univ. 21 : 140 - 192.

*Jarnefelt, H., (1940). Die Wirkung einer Sulfitfabrik auf den Lievestuoreen Jarvi, Verh. Internat. Ver. Limnol., 9 : 180 - 187.

Jensen, L. D., Davies, R. M., Brooks, A. S., and Mayers, C.D., (1968). The effect os alevated temperature upon aquatic invertebrates. A review of literature relating to fresh water and marine invertebrates. Report No. 4. Prepared for Edison Electric Institute Research Project No.49: 1 - 232.

Jhingran, V. G., (1972). Recent advances in Inland Fisheries. Indian Farming, 22 (6) : 115 - 118.

_____., (1975). Fish and fisheries of India. Hindustand Publishing Corporation (India), pp.954.

Jillett, J. B., (1971). Zooplankton and Hydrology of Hauraki Gulf, New Zealand. Oceanographic Institute Memoir No. 53.

*Job, T. J., (1940). "Public health fish farming". Indian Farming, 5 : 10 - 13.

_____., (1940b). An investigation on the nutrition of the perches of the Madras Coast. Rec. Ind. Mus., 42 : 289 - 364.

*_____., (1943). "Mosquito Larvae eating fish". Assam Rev., and Tea News: 111 - 115.

_____., (1944). "Public health fish farming. Indian farming 5 : 10 - 13.

John, M. L., (1957). Bionomics and life history of Macrobrachium rosenbergii (deMan). Bull. Res. Inst. Univ. Kerala, 5 : 93 - 102.

Jones, R., (1975). Comparative studies of plant growth and distribution in relation to water logging IX. The uptake of potassium by Dune and Dune slack plants. J. Ecol., 63 (2) : 859 - 866.

Jyoti, M. K., and Malhotra, Y. R., (1975). Seasonal variations in feeding of Nemacheilus kashmiriensis Hora. Matsya, 1 : 49 - 52.

Kaliyamurthy, M., and Rao, K. J., (1972). Preliminary observations on the food and feeding habits of some fishes of the Pulicat lake. J. Inland Fish Soc. India, 4 : 115 - 121.

Kant, S., and Kachroo, P., (1975). Limnological studies in Kashmir lakes II. Diurnal movements of the phytoplankton. J. Ind. Bot. Soc., 54 : 9 - 12.

Kanwar, J. S., and Chopra, S. L., (1967). Practical Agricultural Chemistry. S. Chand and Co., pp. 235.

Karanth, N., Lokabharathi, G. K., and Nair, S., (1975). Distribution of phenolic acids in soils from two mangrove areas of Goa. Indian J. Marine Sci., 4 (2) : 215 - 217.

Khan, A. A., and Siddiqui, A. Q., (1970). Diurnal variations in the pond Moat at Aligarh. J. Inland Fish Soc., India, 2 : 146 - 154.

_____., and _____., (1974). Seasonal changes in the limnology of a perennial fish pond at Aligarh. Indian J. Fish., 21 (2) : 463 - 478.

*Kofoid, C. A., (1908). The plankton studies V. The plankton of Illinois river, 1894 - 1898 and their seasonal distribution. Bull. III. State Nat. Hist. Surv., 1 - 361.

Kinne, O., (1963). The effects of temperature and salinity on marine and brackish water animals I. Temperature. Oceanogr. Mar. Biol. Ann. Rev., 1 : 301 - 340.

Koshy, M., and Tiwari, K. K., (1975). Clutch size and its relation to female size in two species of fresh water shrimps of the genus Macrobrachium Bate 1968 (crustacea : Caridea : palaemonidae) from Calcutta. J. Inland Fish Soc., 7 : 109 - 111.

Kownacka, M., (1971). The bottom fauna of the stream Sucha Woda (High Tatra mountains) in the annual cycle. Acta Hydrobiol., 13 (4) : 415 - 438.

_____., and Kownacki, A., (1965). The bottom fauna of the river Bialka and of its Tatra Tributaries in the Rybi Potok and Potok Roztoka. Limnol. Invest. in the Tatra Mts. and Dunajec River Basin Komitet Zagosp Ziem Gorskichpan Zeszyt No. 11, Krakow, 130 - 152.

Kramer, J. R., Stephen, E. H., and Herbert, E. A., (1972). Phosphorus analysis of water biomass sediment. In nutrients in natural waters. Edited by Allen, H. E., and Kramer, J. R., 1972 : 51 - 100.

*Krieger, W., (1927). Zur. Biologie des Flussplanktons. Pflanzenforschung, 10 : 66.

Krishnamurthy, K. N., (1966). Preliminary studies on the bottom fauna of the Tungabhadra reservoir. Proc. Indian. Acad. Sci., 68 (2) : 96 - 103.

Kuriyan, G. K., (1949). On the food of Goonch. Bagarius bagarius (Ham.). Curr. Sci., 17 :149

Kurian, C. V., and Sebastian, V. D., (1976). Prawns and prawn fisheries of India. Hindustan Publishing Corporation (India), Delhi. pp. 280.

Kuttayamma, V. T., (1974). Observations on the food and feeding of some Penaeid prawns of Cochin area. J. Mar. Biol. Ass. India, 15 (1) : 189 - 194.

Kuznetov, S. I., (1975). The role of microorganisms in the formation of lake bottom deposits and their digensis. Soil. Sci., 119 (1) : 81 - 88.

Lagler, K. F., (1971). Fresh water fishery biology. W. M. C. Brown Company Publishers, Dubuque, Iowa pp. 421.

*Langford, R. R., (1938). Diurnal and seasonal changes in the distribution of the limnetic crustacea of lake Nipissing, Univ. Tornoto. Stu. Biol., 45 : 1 - 942.

*Loeb, J., (1893). Uber die Kunstliche Umwandlung positiv heliopischer Tiere in negetative heliotropischer and Umgekehrt. Pflugers. Arch. ges. Physiol., 54 : 81 - 107.

*_____., (1904). The control of heliotrophic reactions in fresh water crustacea by chemicals, especially carbon dioxide. Univ. Calif. Publs. Physiol., 2 : 1 - 3.

Macan, T. T., (1963). Fresh water Ecology. Longman Group Ltd., London. pp. 339.

Malhotra, Y. R., (1967). A preliminary account of the relationship between feeding and ovarian cycle in Schizothorax niger (Heckel) and Botia birdi Chaudhry. Indian J. Fish., 14 : 313 - 317.

Mandal, B. K., and Moitra, S. K., (1975). Studies on the bottom fauna of a fresh water fish pond at Burdwan. J. Inland Fish Soc., 7 : 43 - 48.

*Mann, H. H., and Barnes, T. W., (1951). J. Agric. Sci., 41 : 309.

*Margalef, R., (1955). Temperature, dimensions, u evolucion. Proc. Inst. Biol. Apl., Barcelona, 19 : 13 - 94.

Marshall, S., (1949). Chitiruestsya po Mc Laren. 1965. Limnol. Oceanogr., 10 : 525 - 538.

Martin, N. A., (1972). Temperature fluctuations within English low land ponds. Hydrobiologia, 40 (4) : 455 - 469.

Mc Mohan, J. W., (1965). Some physical factors influencing the feeding behaviour of Daphnia magna Straus. Can. J. Zool. 43 : 603 - 611.

Menon, M. K., (1938). Early stages of two species of Palaemon. Proc. Ind. Acad. Sci., 8 : 288 - 294.

_____., (1951). The life history and bionomics of the Indian penaeid prawn Macrobrachium dobsonii (Miers). Proc. Indo. Pacific. Fish. Coun. 3 (2) : 80 - 93.

_____., (1953). Notes on the bionomics and fishery of the prawn Parapenaeopsis stylifera (M.Edw.) on the Malabar coast. J. Zool. Soc. India, 5 (1) : 153 - 162.

Misra, S. B., Bhargava, S. C., and Bohra, O. P., (1975). Diurnal variations in physico-chemical factors at Padamsagar reservoir during premonsoon period of the year, 1974. Geobios, 2 : 32 - 33.

*Miyadi, D., (1931). Studies on the bottom fauna of Japanese lakes II. Lakes of Sinao province. Jap. J. Zool., 3 : 201 - 258.

*_____., and Hazama, N., (1932). Quantitative investigations of the bottom fauna of lake Yogo. Japanese J. Zool., 4 : 151 - 212.

Mizuno, T., Hata, S., and Kono, I., (1960). Seasonal succession of Daphnia pulex and the analysis and ofd its external factors I. The relation between the life cycle of Daphnia pulex and water temperatures. Jap. J. Ecol., 10(1):1-6.

Moitra, S. K., and Mukherji, S. K., (1972). Studies on the fresh water plankton of a fish pond in Kalyani W. Bengal, India. Vest. Spol. Zool., 36(1):23-28.

Mookerjee, H. K., (1947). On the food of Glossogobius giuris (Ham.) Sci. Cult., 13 :162 - 163.

_____., Sen Gupta, S. M., and Roy Choudhury, P.K., (1946). Food and its percentage composition of the common adult food fishes of Bengal. Sci. and Cult., 12 (5) : 247 - 249.

Mortimer, C. H., (1941). The exchange of dissolved substances between mud and water in lakes. Part I. J. Ecol., 29 : 280 - 329.

_____., (1942). The exchanges of dissolved substances between mud and water in lakes. Part II. J. Ecol., 30 : 147 - 201.

Motwani, M. P., and Karamchandani, S. J., (1958). A note on food and feeding habits of Clupisoma garua (Ham.) and Eutropiichthys vacha (Ham.) from Allahabad. Curr. Sci., 27 (2):55-56.

Munshell, Soil Colour Charts, 1954 (edition). Munshell Soil Co., Inc., U. S. A.

Natarajan, A. V., Ramakrishnan, M., and Khan, M. A., (1975). The food spectrum of tras fishes in relation to major carps in Konar and Tilaiya reservoir (Bihar) J. Inland Fisheries Society, India., 7 : 65 - 75.

*Naumann, E., (1927). Zur Kritik des Plankton bergriffes, Arch. F. Botan., 21 A : 1 - 18.

*Newell, B. S., (1957). The nocturnal reduction of oxygen in dams. East. African Agri. J., 23 : 127 - 129.

Nicol, J. A. C., (1967). Biology of marine animals Sir Issac and Sons, Parker Street Kingsway, London : 699.

Nikolsky, G. V., (1963). The ecology of fishes. Academic Press London and New York : 352.

Obreshakove, V., (1930). Oxygen consumption in the developmental stages of cladoceran. Physiol. Zool., 39(3) : 266 - 279.

Odum, E. P., (1971). Fundamentals of Ecology. W. B. Saunders Company. Third edition : 574.

Odum H. T., (1956). Primary production in flowing waters. Limnol. Oceanogr., 1 : 102 - 117.

Oleksynowa, K., and Komornicki, T., (1965). The chemical composition of water in the Polish Tatra mountains and the problems of its variations in time XVI. Limnologorum. Conventus. In Polonia Memlxy : 91 - 127.

Olson, S. R., and Dean, L A., (1967). Phosphorus. In Methods of soil analysis Vol. 2. by C. A. Black - 1965. Amer. Soc. Agronomy. Inc. Publ. U. S. A.

Ordway, R. J., (1974). Earth Science and the Environment. 1974 edition D. Van. Nortrand Co., New York.

*Ortan, J. H., (1920). J. Mar. Biol. Ass. U. K., 12 : 339 - 366.

Pahwa, D. V., and Mahrotra, S. N., (1966). Observations of fluctuations in the abudance of plankton in relation to certain hydrobiological conditions of River Ganga. Proc. nat. Acad. Sci., 36 B : 157 - 189.

Pal, R. N., (1975). Role of fish pathology in aquaiture aquaculture. J. Inland. Fish. Soc, India, 7 : 131 - 136.

Pandian, T. J., (1966). Feeding and reproduction cycles of the fish Mystus gulio in the Cooum back waters, Madras Indian J. Fish, 13(1-2):322-333.

Panikar, N.K., and M.N.(1956).Prawn fisheries of India. Proc.Indo-Pacific Fish Coun.,6(3):328-344.

Parker, R. A.,and Hazelwood,D.H.(1962).Some possible effects of trace elements on fresh water microcrustacean population. Limnol.Oceanogr.,7 : 344 - 347.

Parker, R. A., and Olson, M.I., (1966). The uptake of inorganic phosphate by Daphnia schodleri Sars. Physiol. Zool., 39 (1) : 53 - 65.

Parmeswaran, S., Radhakrishnan, S., and Selvaraj, C., (1971). Some observations on the biology of the carp minnow, Osteobrama cotio (Ham.) J. Inland Fish. Soc., India, 3 : 103 - 113.

Parsad, B., and Hora, S. L., (1936). A general review of the probable larvivorous fishes in India. Rec. Mal. Sur. Ind., 6 : 631 - 645.

Parsad, R. R., (1956). Further studies on the plankton of the inshore waters of Mandapam. Indian J. Fish, 3 (1) : 1 - 41.

*Pearse, A. S., (1915). On the food of the small shore fishes in the waters near Madison, Wiscensin. Bull. Wis. Nat. Hist. Soc., 13.

Pennak, R. W., (1946). The dynamics of fresh water plankton population. Ecol. Mongr., 16 :340-355.

*Philips, A. M., Lovelac, F. E., Podoliak, H. A., Brockway, D. R., and Balzer, G. C., (1955). The nutrition of trout. Fish.Res. Bull., New York, 18 : 52.

*_____., Podoliak, H. A., Brockway, D. R., and Balzer, G. C., (1957). The nutrition of trout. Fish. Res. Bull.New York, 20 : 61.

*Pierce, E. L., (1947). An annual cycle of the plankton and chemistry of four aquatic habitats in Northern Florida. University of Florida Press, Florida.

Porcella, D. S., Rixford, C. E., and Slater, J. V.(1969). Moulting and calcification in Daphnia magna. Physiol. Zool., 42 (2) : 148 - 159.

Pratt, P. F., (1965). Potassium. In Methods of soil analysis Vol.2. by C.A. Black-1865. Amer. Soc. Agronomy. Inc. Publ., U. S. A.

Pruthi, H. S., (1933). Studies on the bionomics of fresh water ponds in India.I. Seasonal changes in the physical and chemical conditions of the waters of a tank in the Indian Museum Compound. Internat. Revue. ges. Hydrobiol., Hydrogr., 28 : 46 - 67.

Radhakrishnan, N., (1957). A contribution to the biology of Indian sand whiting Sillago sihama (Forskal). Indian J. Fish: 254

*Raj, B. S., (1930). The value of fish as natural enemies of mosquitoes. Mad. Fish Dept. Pamphlet.

*_____., and Hussain, S. S., (1956). The determining factor in the distribution of four food fish in the river of U.P. Ann. Zool. Agra., 1 (3) : 79.

Rajan, S., (1963). Ecology of the fishes of the rivers Pykara and Moyar (Niligiris) south India. Proc. Ind. Acad. Sci., 58 B : 291 - 323.

_____., (1965). Environmental studies of the Chilka lake II. Benthic animal communities. Indian J. Fish., 12(2) : 492 - 498.

Rajayalakshmi, T., (1961). Studies on maturation and breeding in some estuarine Palaemonoid prawns. Proc. nat. Inst. Sci., India, 27 B : 179 - 188.

_____., (1964). On age and growth of some estuarine Palaemonoid prawns. Proc. Indo. Pacific. Fish. Coun., 11 : 52 - 84.

_____., (1968). Try prawns in tanks and inland waters. Indian Farming, 18 (8) : 37-43.

Raman, R., (1964). Location of nursery ground of the giant prawn Macrobrachium rosenbergii (deMan). Curr. Sci., 33 : 27 - 28.

Raman, K., Ghose, S. R., and Chatterjee, D. K., (1975). Studies on the ecology of fish ponds with special reference to bottom fauna. J. Inland Fish Soc., India, 7 : 173 - 187.

Rao, R. M., (1965). Breeding behaviour of in Macrobrachium rosenbergii (deMan). Symposium on prawn fisheries. Society of Fisheries Technologists (India). Fish. Technol., 2 : 19 - 25.

_____., (1967). Studies on the biology of the Macrobrachium rosenbergii (deMan), of the Hooghly estuary with notes on its fishery, Proc. nat. Inst. Sci., 33 (5-6) : 252 - 279.

Rao, V. S., (1971). The ecological study of three fresh water ponds of Hyderabad, India I. The environment. Hydrobiologia, 38 (2) : 213 - 223.

*Ravera, Q., and Tonolli, V., (1949). Body size and number of eggs in diaptomids as related to eggs lakes. Limnol. Oceanogr., 6 : 154-164.

Ray, H., (1933). Preliminary observations on Myxosporidia from India. Curr. Sci., 1 : 349 - 350.

Ray, P., Singh, S. B., and Sehgal, K. L., (1966). A study of some aspects of the Rivers Ganga and Jumna at Allahabad (U.P) in 1958 - 1959. Proc. nat. Acad. Sci. India, 36 B (3): 235 - 272.

*Raychaudhuri, S. P., (1964). Land resources of India, Vol. I. Committee on Natural Resources, Planning Commission.

_____., (1966). Land and Soil. National Book Trust, India, New Delhi.

Raymont, J. E. G., (1967). Plankton and productivity in the oceans. Pergamon Press, Oxford. pp. 660.

Reed, E. P., (1962). Limnology and Fisheries of the Saskatchewan river in Saskatchewan. Fisheries report No. 6. Fisheries branch Department of Natural Resources Province of Saskatchewan : 1 - 48.

Reid, G. K., (1961). Ecology of Inland waters and estuaries. Reinhold Pub. Corp., New York. pp. 375.

*Reinhard, E. G., (1931). The plankton ecology of the Upper Mississippi, Minneapolis to Winona. Ecol. Monogr., 1 : 395 - 464.

*Ricker, W. E., (1934). Pub. Ont. Fish. Res. Lab. Toronto, 49 : 1 - 114.

Rickleff, R. E., (1973). Ecology. Nelson and Sons, London, pp. 861.

*Rigler, F. H., (1961). The uptake and release of inorganic phosphorus by Daphnia magna Straus. Limnol. Oceanogr.,6(2) : 165 - 174.

Roe, H. S. T., (1974). The observations on the diurnal vertical migrations of an oceanic animals community. Marine Biology, 28 : 99 - 113.

Royce, F. W., (1972). Introduction to the fishery sciences. Academic Press, New York.pp 351.

Russel, E. J., (1950). Soil conditions and plant growth. Longmans, Green and Co., New York.

*Russell, F. S., (1927). The vertical distribution of plankton in the sea. Biol. Rev. and Biol. Proc. Cambridge. Phil. Soc., 2 : 213 - 262.

Saha, G. N., (1969). Relative efficiency of different nitrogenous fertilizers in fish pond soils. J. Indian Soc. Soil Sci.,17 (1) : 51 - 57.

_____., Sehgal, K. L., Mitra, E., and Nandy, A. C., (1971). Studies on the seasonal and diurnal variations in physico-chemical and biological conditions of a perennial fresh water pond. J. Inland Fish. Sic., India, 3 : 79 - 102.

Saigal, B. N., (1964). Studies on fishery and biology of the commercial catfishes in the Ganga River system II. Maturity, spawning and food of Mystus (Osteobagrius) aor (Ham.). Indian J. Fish., 11 (1) : 1 - 44.

Sankaram, A., (1966). Laboratory manual for agricultural chemistry. Asia Publishing House,New Delhi.pp.340.

Sarkar, H. L., (1946). On a protozoan parasite Myxobolus mrigalae Chakravarty, infecting the fry Cirrhina mrigala (Ham.). Curr.Sci., 15(4) : 111 - 112.

Saunders, H. L., (1956). Oceanography of long island sound 1952 - 1954. Biology of marine bottom communities. Bull. Bingham Oceangr. Coll., 15 : 345 - 414.

Schindler, D. W., (1968). Feeding,assimilation and respiration rates of Daphnia magna under various environmental conditions and their relation to production estimates. J. Anim. Ecol., 37 (2) : 369 - 385.

Schneller, M. V., (1955). Oxygen depletion in salt creek, Indiana, in v4 of investigations of Indiana Lakes and streams. Indiana Univ. Dept. Zoology : 163 - 175.

Schwoerbel, G., (1970). Methods of hydrobiology. (Fresh water biology). Pergamon Press.pp.200.

*Semper, K., (1881). Animal life as affected by the natural conditions of existence, Appleton Co., New York, pp. 472.

Sen, P., (1937). On the food factors of so called mosquito-destroying fishes of Bengal. Panchax panchax, Barbus stigma, Esomus danrica, and Trichogaster fasciatus. Curr. Sci., 5 : 357 - 361.

*Sewell, R. B. S., (1934). Studies on the bionomics of fresh water in India II. On the fauna of the tank in the Indian Museum Compound and seasonal changes observed. Int. Rev. Hydrobiol., 31 : 203 - 208.

*_____., and Chaudhuri, B. L., (1912). Indian fish of proved utility as mosquito destroyers. Calcutta.

Shah, K. L., (1975). Studies on food and feeding habits of brown trout. Salmo trutta in River Beas. J. Inland Fish Soc. India., 7 : 101 - 104.

Shyamsundri, K., and Hanumantha R. K., (1974). Effect of temperature on embryonic and post-embryonic stages of corophium, Triaenonyx stebbing (crustacea, Amphipoda). Broteria Serie de Ciencies Naturais, 43 (3 - 4) : 187 - 194.

*Siebeck, O., (1960). Untersuchungen uber die Vertikalwanderung planktischer crustacean unter besonderer. Berucksichtigung der Stralungsverhaltnisse. Int. Revuges Hydrobiol. Hydrogr., 45 : 381 - 454.

Sinderman, C. J., (1970). Principal diseases of marine fish and shellfish. Academic Press, New York, and London, pp. 369.

Sinha, M., (1972). Observations on the biology of

Puntius sarana (Ham.) of Loni reservoir(M.P) I. Length, weight relationship, food and condition factor. J. Inland Fish Soc., India, 4 :122-131.

Slack, R. V., (1955). A study of the factors affecting stream productivity by the comparative method, in v 4 of investigations of Indiana lakes and streams. Indiana Univ. Dept. Zool: 3 - 47.

_____., (1964). Effect of free leaves on water quality in the Cacapon River, West Virginia. Art., 161 U. S. Geol. Survey Prof. Paper, 475 D : D 181 - 185.

_____., (1967). Physical and chemical description of Birch creek a travertine depositing stream, Inyo. Country. California. Geological Survey Prof. Paper 549 A :A1 - 19.

_____., and Clarke, F. E., (1965). Pattern of dissolved oxygen in a thermally loaded reach of Susquehanna River. Pennsylvania. U. S. Geog. Surv. Prof. Paper 525 C : C 193 - 195.

Slobodkin, L. B., (1954). Population dynamics in Daphnia obtusa . Kurz. Ecol. Monogr., 24 : 69 - 88.

Sorkin, Jr. F., (1975). Sulphide formation and chemical composition of bottom sediments of some Italian lakes. Hydrobiologia, 47 (2) : 231 - 240.

Southwell, T., (1915). Notes from the Bengal fisheries laboratory, Indian Museum 2: On some Indian parasites of fish with a note on Carcinoma in trout. Rec. Ind. Mus., 6 : 311.

_____., and Prasad, B., (1918). XXIII notes from Bengal fisheries laboratory No. 5. Parasites of Indian fishes with a note on carcinoma in the climbing perch. Rec. Ind. Mus., 15 (5) : 341 - 355.

*Southern, R., and Gardiner, R. C., (1926). A preliminary account of some observations on the diurnal migration of the crustacea of the plankton of Lough Derg. Int. Revue. ges. Hydrobiol. Hydrogr., 15 : 323 - 326.

*Southern, R., and Gardiner, A. C., (1932). Reports from the limnological laboratory II. The diurnal migrations of the crustacea of the plankton in Lough Derg. Proc. R. Ir. Acad., 40 : 121 - 159.

Spence, J. A., and Hynes, H. B. N., (1971). Differences in benthos upstream and downstream of an impoundment. J. Fish Res. Board, Canada, 28 : 35 - 43.

Sreenivasan, A., (1964a). "Limnological studies of tropical impoundments II. Hydrobiological features and plankton of Bhavanisagar Reservoir (Madras state) for 1961 - 1962. Proc. Ind. Acad. Sci., 59 B : 53 - 71.

_____., (1964b). "Limnological studies and fish yield in the three upland lakes of Madras state, India". Limnol. Oceanogr., 8 : 564 - 575.

_____., (1967). Application of limnological and primary production studies in fis culture. F. A. O Fish. Rep., 44 (3) : 104 - 113.

_____., (1968). Limnology of tropical impoundments IV. Studies of two hard water reservoirs in Madras state. Arch. Hydrobiol., 65 (2) : 205 - 222.

_____., (1972). Limnology of a seepage tank impoundment Qdathurai tank. J. Inland Fish. Soc., India, 4 : 162 - 168.

Sreenivasan, P. V., (1974). Observations on the food and feeding habits of the Torpedo trevalli, Megalapsis cordyla (Linnaeus) from Vizhinjam Bay. Indian J. Fish, 21 (1) : 76 - 84.

Srivastava, V. K., (1956). Benthic organisms of a fresh water tank. Curr. Sci., 25 : 158 - 159.

_____., (1959a). Studies on fresh water bottom fauna II. Qualitative composition and variation of the available food supply for fishes. Proc. nat. Acad. Sci., India, 29 B : 207 - 216.

Srivastava, V. K., (1959b). Studies on fresh water bottom fauna III. The correlation between bottom fauna and the food fishes. Proc. nat. Acad. Sci., 29 B : 217

Stevenson, F. J., (1965). Origin and distribution of nitrogen in soil. Agronomy, 10 : 1 - 42.

*Stewart, N. E., (1962). The influence of oxygen concentration on the growth of juvenile largemouth bass. M. S. thesis, Oregon state University, Corvallis, pp. 44.

Sumitra - Vijayaraghavan, (1971a). Seasonal variations in primary productivity in three tropical ponds. Hydrobiologia, 38 (3 - 4) : 395 - 408.

_____, (1971b). Studies on the diurnal variations in physico-chemical and biological parameters in Teppakulam tank. Proc. Indian Acad. Sci., 74 (2) : 63 - 73.

_____, (1973). A comparative account of the soil - water relationship in three tropical ponds. Indian J. Fish, 20 (2) : 617 - 623.

Tandon, K. K., and Singh, H., (1972). Effect of physico-chemical factors on the plankton of the Nangal lake. Proc. Ind. Acad. Sci., 76 (1) : 15 - 25.

*Tansley, A. G., (1939). The British Islands and their vegetation. Cambridge University Publication, pp. 930.

Terao, A., (1937). Changes of vitality with age as based on the living unit of organisms I. Oxygen consumption in the Daphnid. Simocephalus exspinosus. Proc. Imperial Acad. (Tokyo), 7 (2) : 136 - 148 .

_____., and Tanaka, A., (1928). Population growth of the water flea Monia macrocopa Straus. Proc. Imperial. Acad. (Tokyo), 4 (9) :550-552.

Thakur, U. C., and Deshpande, W. M., (1976). Problems of industrial wastes disposal in Bihar Vis - a - Vis. The available water resources. Envir. Hlth. 18 (2) : 136 - 148.

*Thorson, G., (1946). Medd. Konom. Danmarks Fiskeri - og. Havandersg., Ser. Plankton, 4 : 523.

Toor, H. S., (1964). Biology and the fisheryo of the pig - face bream, Lethrinus lentjan. Lac. I. Food and feeding habits. Indian. J. Fish, 11 (2) : 559 - 580.

Tripathi, Y. R., (1953). Studies on parasites of Indian fishes I. Protozoa: Myxosporidia together with a checklist of parasitic protozoa described from Indian fishes. Rec. Ind. Mus., 50 (1) : 63 - 68.

Ummerkutty, A. N. P., (1967). Observations on the diurnal vertical movements of planktonic copopods in the gulf of Mannar. J. Bom. Nat. Hist. Soc., 63 (2) : 332.

*Valle, K. J., (1930). Okologisch. Limnologische Uterschungen uber die Boden-und. Tiefenfauna in einigen seen nordlich Vom Ladoga-Sec I - Acta. Zool. Fenn, 2 : 1 - 179.

*Van, Duijn, Jr. (1967). Diseases of fishes. London Iliffe Books Ltd., 309.

*Vannini, E., (1933). Contributo alla conoscenza dei cladoceri dell Italia centrale II Diaphanosoma e la Bosmina. del Laghetto di Poggio ai Pini presso Siena Int. Revue ges. Hydrobiol. Hydrogr., 29 : 360 - 405.

Vasisht, H. S., (1968). Limnological studies on Sukhna lake, Chandigarh (India). Proc. Symp. Recent. Adv. Trop. Ecol.; 316 - 325.

_____., and Dhir, S. C., (1970). Seasonal distribution of fresh water zooplankton of four tanks, Chandigarh. Ichthyologica, 10 (1 - 2) : 44 - 56.

_____., and Sharma, B. K., (1976). Ecology of a typical urban pond in Ambala city of the Haryana state, Indian J. Ecol., 2 (1) :79 - 86.

*Venkateswarlu, V., (1966). Ph.D. thesis submitted to Osmania University, Hyderabad.

_____

*Venkateswarlu, V., (1969). An ecological study of the algae of the River Moosi, Hyderabad(India) with special reference to water pollution III. The algal periodicity. Hydrobiologia, 34 (3 - 4) : 533 - 560.

*Verhoeven, W., (1952). Delft Doct. Thesis.

Verma, M. N., (1964). Hydrobiological survey of the Dalsagar tank, Seoni, M. P, India with special reference to the effects of Microcystis aeruginosa (Kurtz.), bloom on fish production and suggestions for the improvement of the tank fishery. Icthyologica, 3 (1 - 2) : 37 - 46.

Verma, N., (1967). Diurnal variations in a fish pond in Seoni, India. Hydrobiologia, 30 (1) : 129 - 137.

Verma, S. R., and Shukla, G. R., (1967). Limnological studies of Harwaha in relation to fish and fisheries. Envir. Hlth., 9 : 317 - 326.

_____., and _____., (1968). Hydrobiological studies of a temple tank "Devi Kund" in Deoband (U.P), India. Envir. Hlth., 10 : 177 - 188.

_____., and _____., (1970). The physico-chemical conditions of "Kamla Nehru tank", Muzaffarnagar (U.P) in relation to the biological productivity. Envir. Hlth., 12 : 110 - 128.

Wallace, A., and Smith, R. L., (1954). Soil Sci., 78 : 231.

Ward, H. B., and Whipple, G. C., (1959). Fresh water Biology. Edited by Edmondson, W. T., and Published by John Willey and Sons, pp. 1248.

Welch, P. S., (1948). Limnological Methods. McGraw Hill Book Company, New York and London. pp. 538.

_____., (1952). McGraw Hill Book Company, New York and London. pp. 1971.

Widler, J., and Delwiche, C. C., (1954). Plant and soil, 5 : 155.

Wilde, S. A., Voigt, G. K., and Iyer, J. G., (1972). Soil and Plant Analysis for Tree culture. Oxford and IBH Publ. Co., : 172.

*Wilson, H. C., (1917). A note on treatment of Swamps, Stream beds, Ponds, Wells, Pools and other mosquito infected areas. Mad. Fish. Bull., 11 : 161 - 172.

Winberg, G. G., (1971). Methods for the estimation of production of aquatic animals. Academic Press London and New York : 175.

*Wolf, K., Quinby, M. C., (1969). Progress report on in vitro culture of cyclostomes and elasmobranch cells and tissues. In vitro 4 (Abstract 2) : 125.

*Worthington, E. B., (1931). Vertical movements of the fresh water macroplankton. Ind. Rev. d. ges. Hydrobiol. u. Hydrogr., 25 : 394 - 436.

*Yamamoto, G., (1951). Bull. Jap. Soc. Sci. Fish 17 : 53 - 56.

*Yonge, C. M., (1930). A year on the great barrier reef, Putmam, London, :pp 246.

Zafar, A. R., (1964). On the ecology of algae in certain fish ponds of Hyderabad. India I. Physico-chemical complexes. Hydrobiologia. 23 : 179 - 195.

Zelinka, M., (1962). Wztah zoobenthos Morvskych Ych undolnich nadrizi K chemismum Vody-Scient. Papepers from Inst. of Chem. Technol. Progue, 1 (6) : 293 - 312.

Zicker, E. L., Berger, K. C., and Hasler, A. D., (1957). Phosphorus release from Bog Lake Muds. Limnol. Oceanogr., 1 : 296 - 303.

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* References not seen in original.

A N N E X U R E S

(I - VI)

GEOBIOS 2: 158, 1975

REPORT ON A FRESHWATER SPONGE FROM JAMMU

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Reports on the Indian freshwater sponges are those of Annandale (1907, 1908, 1909, 1910. 1911 & 1919). The present report records for the first time the occurence of a sponge, *Spongilla carteri* Carter from the Jammu and Kashmir State.

The sponge was collected from a side pool of Gadigarh stream (Miransahib, Jammu) in August 1973, following a heavy monsoon rain. The Gadigarh stream, situated at longitude of 74°.51′ and latitude of 32°.40′, is a slow running stream with clay and sandy bed, and is fed by natural springs and a tributary of Ranbir canal. Water temperature of the stream varies from 35°C in summer to 14°C in winter, the pH ranges from 7 to 9 but the period when the sponge was collected the pH was between 7 to 7.7. The sponge was found in association with fishes like *Rasbora rasbora, Esomus danrica, Puntius ticto, P. conchonius, Chana punctatus* etc. *Hydrilla sp.* among the aquatic plants was predominant. *Typha*, otherwise dominanting in the stream, was conspicuously absent in the side pool.

The sponge shows the following characters : Sponge massive, soft, with somewhat smooth surface. Colour greyish when fresh, turns greyish-white on preservation. Skeleton fairly compact, with well developed fibres and considerable amount of spongin. Spicules, both skeletal and those on the gemmule, are smooth, pointed, nearly straight but not very stout. Gemmule spicules are smaller than the skeletal spicules.

Gemmules (Fig. 1) are numerous, spherical, arranged singly and each covered with a thick coat comprising of several layers of distinct polygonal air spaces. A single aperture surrounded by a crater-like depression is present in the cellular coat. Foraminal tubule is present but may get datached in some specimens.

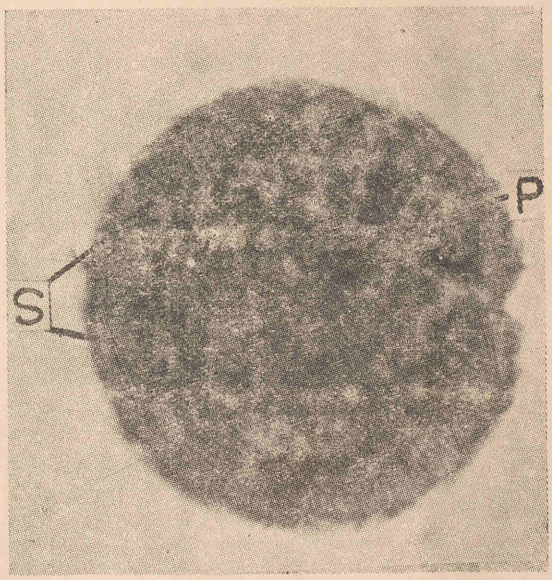

Fig. 1. Gemmule showing polygonal air spaces (P) and spicules (S) ×75.

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REFERENCES

Annandale, N. *Rec. Ind. Mus.*, 1907, 1, 267-273.

Annandale, N. *Rec. Ind. Mus.*, 1908, 2, 25-28,

Annandale, N. *Rec. Ind Mus.*, 1909, 3, 275.

Annandale, N. *Rec. Ind. Mus.*, 1910, 5, 31.

Annandale, N. *Fauna of British India including Ceylon, Burma Freshwater sponges, Hydroids and Polyzoa.* Taylor and Francis, London, 1911.

Annandale, N. *Rec. Ind. Mus.*, 1919, 16, 156-161.

II

OFF-PRINTS FROM

THE UNIVERSITY REVIEW

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An Aid to Indentification of Fishes found in Jammu Division of J&K State

by

Y. R. Malhotra, M. K. Jyoti & S. P. Singh Dutta

An aid to Indentification of Fishes Found in Jammu Division of J & K State

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Abstract

This paper presents a key to the identification of 47 fish species collected from Jammu Division of J & K State.

Introduction

Survey of flora and fauna is an essential prerequisite for any biological research. Although fishes of India have been thoroughly investigated by Chaudhuri 1910, 1912 ; Das 1939 ; Day, 1878, 1889 ; Hora, 1921, 1923, 1937, 1940, 1944 ; Hora and Mukerjee, 1937 ; Menon 1964 ; Misra 1959 ; but no specific collection or survey appears to have been made in Jammu division of J & K State (India). The previous reports pertaining to this division are those of Malhotra and Jyoti (19 1) and Malhotra and Dutta (in press).

The present report is an aid to identification of fishes found in Jammu division of J & K State and is likely to prove useful to students, teachers and investigators, who intend to undertake ichthyological investigations in the area.

This report is the outcome of extensive work that was carried for about 3 years, and is based on original collections made from time to time in the area. The locality of collection has been given against each species so as to facilitate future investigators.

Key to orders.

1a.	Body elongate and eel like.	2
1b.	Body not eel like.	3
2a.	Pre dorsal spines present which vary from 19—39.	Order : Mastocembeliformes.
3a.	Jaws elongated, mouth large.	Order : Beloniformes.
3b.	Jaws not elongated.	4
4a.	Head snake like in appearance, suprabranchial organs present.	Order : Ophiocephaliformes. Family : Ophiocephalidae. Genus : Channa.
4b.	Head not snake like.	5
5a.	Pelvic fins located under the pectoral or anterior to them.	Order : Perciformes.
5b.	Pelvic fins on abdomen, behind the pectoral.	Order : Cypriniformes.

Order : *Cypriniformes.*

Key to sub-orders.

1.	Mouth protrusible, jaws without teeth, and body covered with scales.	Sub-order : Cyprinoidei.
2.	Mouth non protrusible, jaws with teeth and body without scales.	Sub-order : Siluroidei.

Sub-order : *Siluroidei.*

Key to families.

1a.	Dorsal adipose fin present.	2
1b.	Dorsal adipose fin absent.	3
2a.	Head and body ventrally flattened, fins horizontal, eyes reduced and dorsally located.	Family : Sisoridae.

2b.	Body not ventrally flattened, fins not horizontal, eyes laterally located.	Family : Bagridae.
3a.	Barbels four.	Family : Siluridae.
3b.	Barbels eight.	Family : Saccobranchidae.

Family : *Sisoridae.*

Key to genera.

1a.	U or V shaped thoracic adhesive apparatus present, dorsal spine strong.	Genus : *Glyptothorax* Blyth,
1b.	Thoracic adhesive apparatus absent, dorsal spine weak.	Genus : *Glyptosternum* McClelland.

Genus : *Glyptothorax.* Blyth.

Key to species.

1a.	Maxillary barbel reaching below the hind edge of eye. Skin rough with small spinate tube rosities. Adhesive apparatus longer than wide.	*Glyptothorax botium* (Hma. & Buch). Locality Salahar area.
1b.	Maxillary barbel reaching base of pectoral spine, adhesive apparatus wider than long.	*Glyptothorax pectinopterum* (McClelland). Locality Bhadarwah.

Family : *Bagridae.*

Key to genera.

1.	Mouth terminal, upper jaw longer, barbels eight, dorsal fin with one spine and seven rays, pectoral with strong serrated spine.	Genus : *Mystus* Scopoli.

Genus : *mystus* scopoli.

Key to species.

1a.	Origin of dorsal adipose just behind the dorsal fin. Maxillary barbel reaching anal fin.	*Mystus bleekeri* (Day). Locality : Gadigarh and R. S. Pura ponds.
1b.	Origin of adipose fin at a distance from the dorsal fin.	2
2a.	Maxillary barbel reaching middle or just behind rayed dorsal fin, adipose fin with a black spot.	*Mystus seenghala* (Sykes). Locality : Gadigarh, River Tawi.
2b.	Maxillary barbel extends even beyond pelvics, dorsal adipose fin without any black spot, body with 2 or more blue longitudinal bands.	*Mystus vittatus* (Bl.). Locality : Gadigarh & R. S. Pura ponds.

Family : *Siluridae.*

Key to genera.

1a.	Barbels four, cleft of mouth extends beyond the eye orbit.	Genus *Wallago* Blkr.
1b.	Barbels four, cleft of mouth never extends beyond the eye orbit.	Genus : *Ompok* lac.

Genus : *Wallago*. Blkr.

Key to species.

1.	Dorsal 5, pectoral 1/13, Ventral 10, Anal 78.	*Wallago attu* (Schneider). Locality : Gadigarh & R. S. Pura ponds.

Genus : *Ompok* Lac.

Key to species

1.	Dorsal 4, ventral 8, pectoral 1/12, anal 58, mixallary barbels long reaching upto end of pectoral.	*Ompok bimaculatus* (Bloch). Locality : Gadigarh & R. S. Pura ponds.

Family : *Saccobranchidae.*

Key to genera.

1.	Barbels 8, dorsal soft, pectoral with strong spine, anal long.	Genus : *Heteropneustes* Muller.

Genus : *Heteropneustes* Muller.

Key to species.

1.	Pectoral 1/7, ventral 6, dorsal 6, anal 60–79.	*Heteropneustes fassilis* (Bloch). Locality : Gadigarh & R. S. Pura ponds.

Sub-order : *Cyprinoidei.*

Key to families.

1a.	Barbels always more than four, scales small in size.	Family : Cobitidae.
1b.	Barbels may or may not be present, when present not more than four, scales moderate or large	Family : Cyprinidae.

Family : *Cyprinidae.*

Key to genera.

1a.	Abdominal edge cutting.	2
1b.	Abdominal edge normal.	3

2a.	Outer pelvic ray produced, pelic origin nearer to pectoral than to anal base.	Genus : *Chela* Ham.
2b.	Outer pelvic ray not produced pelvic origin nearer to anal base than to pectoral base.	Genus : *Oxygaster*. V. Hass.
3a.	Mouth superior.	4
3b.	Mouth anterior.	7
3c.	Mouth inferior.	10
4a.	Lateral line incomplete.	Genus : *Amblypharyngodon*. Bleeker.
4b.	Lateral line complete.	5
5a.	Barbels absent, lower jaw prominent.	Genus . *Rasbora* Bleeker.
5b.	Barbels present or absent, lower jaw not prominent.	6
6a.	Barbels present, mixallary extend to the base of ventral or even to that of caudal.	Genus : *Esomus* Swainson.
6b.	Barbels may or may not be present when present maxillary reaching end of opercle.	Genus : *Danio* Ham. Buch.
7a.	Dorsal fin without spine, jaws compressed.	Genus : *Barilius* Ham.
7b.	Dorsal fin with a spine, jaws not compressed.	8
8a.	Anal large, rays vary from 21-28.	Genus : *Osteobrama* Heckel.
8b.	Anal short with less than 21 rays.	9
9a.	Mouth with thick lips.	Genus : *Tor* Gray.
9b.	Mouth without thick lips.	Genus : *Puntius* Ham.
10a.	Lower jaw without lip.	Genus : *Aspidoparia* Heckel.

10b.	Lower jaw with a lip.	11
11a.	A definite sucker present on ventral surface.	12
11b.	Sucker absent.	13
12a.	Dorsal fin with a spine, body not ventrally flattened.	Genus : *Oreinus* McClelland.
12b.	Dorsal fin without a spine, body ventrally flattened.	Genus *Garra* Ham.
13a.	Lips thick and continuous at the jaw angles.	Genus *Labeo* Cuvier.
13b.	Lips thin, those of two jaws not continuous.	14
14a.	Lower jaw with a thick horny covering.	Genus : *Crossocheilus* V. Hass.
14b.	Lower jaw with thin lips horny covering absent.	Genus : *Cirrhinus* C.

Genus : *Labeo* Cuvier.

Key to species.

1a.	Barbels present.	2a
1b.	Barbels absent.	2b
2a.	Dorsal 16, lateral line scales 40, lips thick and fringed.	*Labeo rohita* (Ham.). Locality, Tawi.
2b.	Dorsal 13(2/11), lateral line scales 42-43, spurlike scale on ventral fin, lower lip fimbriated.	*Labeo diplostomus* Cuv and Val. Locality : Jammn Tawi.

Genus : *Tor* Gray.

Key to species.

1.	Dorsal 4/9, anal 2/7, barbels longer than eye, lateral line scales 26.	*Tor khudree* (Sykes). Locality : Jammu Tawi.

Genus : *Puntius* Ham.

Key to species.

1a.	Barbels present.	2
1b.	Barbels absent.	3
2a.	Lateral line scales 31-33, pre-dorsal scales 10-11, young with black spot on caudal base, four barbels present.	*Puntius sarana* (Ham.). Locality : Gadigarh.
3a.	Lateral line scales 26, one black spot on caudal peduncle, dorsal spine serrated, anal 2/6.	*Puntius conchonius* (Ham.). Locality : Gadigarh.
3b.	Lateral line scales 25, 2 black spots, one on the sides of the anterior region of thorax and other on caudal peduncle, anal 2/7.	*Puntius ticto* (Ham.) Locality : Gadigarh, & R. S. Pura ponds.
3c.	Lateral line scales 24, two black spots one on caudal peduncle and other on the base of Dorsal fin, anal 2/5 dorsal spine entire.	*Puntius chrysopterus* (McC11) Locality : R. S. Pura ponds.
3d.	Lateral line scales 24-25, two black spots as above, anal 3/5.	*Puntius sophore* Ham. Locality : Gadigarh R. S Pura ponds.

Genus : *Barilius* Han.

Key to species.

1a.	Anal rays 10, each scale with a black spot, those on the lateral line with two spots.	*Barilius bendelisis* (Hamilton) Locality : Gadigarh, River Tawi & Thakarakot Reasi.
1b.	Anal rays 13, each scale without a black spot.	*Barilius vagra* (Hamilton) Locality : River Tawi and Gadigarh.

Genus : *Oreinus* Mcclelland.

Key to species.

1.	Dorsal 9(1/8), ventral 10, anal 7, pectoral 17, lateral line scales 100.	*Oreinus richardsoni* (Gray and Hard). Locality : Neeru Nallah Banihal and Ranbir Canal Jammu.

Genus : *Crossocheilus* V. Hass.

Key to species.

1.	Dorsal 3/8, anal 2/5, barbels 4, lateral line scales 39-40.	*Crossocheilus latius latius* (Ham) Locality : Poonch.

Genus : Cirrhinus C.

Key to species.

1.	Dorsal 10-12, anal 3/5, barbels 2, lateral line scales 36-38.	*Cirrhinus reba* (Ham.). Locality : Gadigarh & Salhar Nallah

Genus : *Osteobrama* Heckel.

Key to species.

1.	Pectoral 13, ventral 11, dorsal 10(1/9),anal 32, lateral line scales 70-72.	*Osteobrama cotio* (Ham.) Locality : Gadigarh & R. S. Pura Ponds.

Genus : *Aspidoparia* Heckel.

Key to species.

1.	Dorsal 9(2/7), ventral 8, pectoral 15, anal 10, lateral line scales 40-42.	*Aspidoparia morar* (Ham.). Locality : River Tawi.

Genus : *Rasbora* Bleeker.

Key to species.

1.	Pectoral 9, ventral 9, dorsal 0, anal 8, lateral line scales 27, pre-dorsal scale 12, a black band passes from eye to the base of caudal fin.	*Rasbora rasbora* (Ham.). Locality : Gadigarh & R. S Pura ponds.

Genus : *Esomus* Swainson.

Key to species.

1.	Pectoral 11, ventral 8, dorsal 8, anal 8, lateral line scales 30, pre-dorsal scale 16-18, lateral line not clear.	*Esomus danrica* (Ham.) : Locality : Gadigarh & R. S. Pura ponds.

Genus : *Chela* Ham.

Key to species.

1a.	Pectoral fins not reaching anal	2
1b.	Pectoral fins reaching anal.	3
2a.	Lateral line scale 75- 0, dorsal 10.	*Chela laubuca* (Ham). Locality : R. S. Pura ponds.
3a.	Lateral line scale 60, dorsal 9.	*Chela atpar* (Ham.). Locality : Gadigarh.

Genus : *Oxygaster* V. Hass

Key to species.

1.	Dorsal 9. anal 15, lateral line scales 98-100.	*Oxygaster bacaila* (Ham.). Locality : Gadigarh.

Genus : *Danio* Ham. Buch.

Key to species.

1a.	Barbels present.	2a.

1b.	Barbels absent.	2b.
2a.	Two pair of barbels, lateral line scales 26-28, dorsal 9, four metalic blue lines along the sides forming three bands on caudal fin, dorsal with blue edging anal with three longitudinal blue lines.	*Danion rerio* (Ham.). Locality : Gadigarh, Mansar lake & R. S. Pura ponds.
2b.	Barbels absent, dorsal 17 lateral line scales 42, no metalic bands.	*Danio devario* (Ham.). Locality : Gadigarh, R. S. Pura Ponds.

Genus : *Amblypharyngodon* Bleeker

Key to species.

1.	Dorsal 9(2/7), pectoral 15, ventral 9, anal 8(3/5), caudal 19, lateral line scales 66-75, lateral line ceases at 11-14 scale.	*Amblypharyngodon gadigarhi* sp nov Locality : Gadigarh.

Genus : *Garra* Himilton.

Key to species.

1a.	Barbels absent.	2
1b.	Barbels present.	3
2.	Adhesive disc weakly developed, without free posterior margin, scales present on back chest and abodmen, origin of anal fin midway between origin of pelvic and base of caudal.	*Garra variabilis* (Heckel). Locality : Ranbir Canal.
3a.	Proboscis absent, 34 lateral line scales, tip of snout marked off by a transverse groove, distance of vent from base of anal fin more than 4 times in that between anterior origin of anal and pelvic fins.	*Garra lamta* Ham. Locality : Thakarakote Reasi.

3b.	Proboscis present, with a well developed lateral tubercular area, depth of body less than 4 times in standard length.	*Garra gotyla gotyla* (Gray) Locality : Poonch river & Tawi river Jammu.

Family : *Cobitidae.*

Key to genera.

1a.	Suborbital spine present.	2
1b.	Suborbital spine absent.	3
2a.	Caudal slightly emarginate, dorsal commencing slightly behind the ventral.	Genus : *Lepidocephalichthys* Bleeker.
2b.	Caudal forked, dorsal commencing before the ventral.	Genus : *Botia* Gray.
3.	Dorsal commencing before the ventral.	Genus : *Noemacheilus* Van. Hasselt.

Genus *: Botia* Gray.

Key to species.

1.	Dorsal 12(3/9) anal 7(2/5), ventral 8, pectoral 14, barbels 8, body with irregular reticulated brown cross bands, which enclose yellowsish spots of different sizes, fins cross banded.	*Botia dayi* (Hora). Locality : Eak Nallah & Jammu Tawi.

Genus : *Lepidocephalichthys* Bleeker.

Key to species.

1.	Dorsal 9(2[7), pectoral 8, ventral 8, anal 7(2/5), barbels 8, body with a band extending from the middle of the snout ending in a black ocellus above the middle base of the caudal fin. Dorsal and caudal with numerous rows of dark spots.	*Lepidocephalichtyvs guntea* (Ham.). Locality : Gadigarh.

Genus *: Noemacheilus* Van Hasselt.

Key to species.

1.	Dorsal 12-13, pectoral 11, ventral 8, anal 7, barbels 6, body with 14 short vertical bars on lateral line and a number of blotches above, a black ocellus on upper part of the base of caudal.	*Noemacheilus botia* (Ham.). Locality : Gadigarh.

Order *: Perciformer.*

Key to sub order.

1a.	Pelvic fins united to form a disc.	Suborder : Gobidoei. Family : Gobidae. Genus : Glossogobius.
1b.	Pelvic fins not united to form a disc.	2
2a.	Suprabranchial organs present.	Suborder : Anabantoidei.
2b.	Suprabranchial organs absent.	Suborder : Percoidei.

Genus *: Glossogobius.*

Key to species.

1.	Two dorsal fins present, eyes on dorsal side, lateral line scales 33, fins wirh dark blotches.	*Glossogobius giuris* (Ham.). Locality : Gadigarh.

Sub-order *: Anabantoidei.*

Key to families.

1.	Outer pelvic rays produced to form a ray.	Family : Osphronemidae.

Family *: Osphronemidae.*

Key to genera.

1.	Pelvic fin with a single ray,	Genus : *Trichogaster.*

single dorsal with spinous and soft portion, anal similar as dorsal, spines more than three.	BL. Schn.

Genus : *Trichogaster*. BL. Schn.

Key to species.

1. Dorsal 16–18, anal 17/16–18, pectoral 10, ventral 10, body with 11–14 oblique bands. lateral line scales 29.	*Trichogaster fasciatus* Bloch & Schn. Locality : Gadigarh.

Sub-order : *Percoidei.*

Key to families.

1. Operculum with a one spine.	Family : Nandidae.

Family : Nandidae.

Key to genera.

1. Single dorsal fin, spinous portion of much greater extent than soft, anal spines 3.	Genus : *Badis*. Bleeker.

Genus : *Badis* Bleeker.

Key to species.

1. Dorsal 16–17/9, anal 3/7, pectoral 12, ventral 1/5, lateral line scale 30–32.	*Badis badis* (Ham. Buch). Locality : Gadigarh.

Order : *Beloniformes.*

Key to suborder.

1. Both jaws enongated, scales small, lateral line located close to the belly.	Suborder : Scomberesocoidei. Family : Belonidae.

Family : *Belonidae.*

Key to genera.

1. Dorsal originates opposite the anal.	Genus : *Xenentodon* Regan.

Genus : *Xenentodon* Regan.

Key to species,

1. Dorsal 18, anal 18, pectoral 11, ventral 6.	*Xenentodon cancila* (Ham.). Locality : Gadigarh.

Family : *Mastocembelidae.*

Key to genera.

1a. Preorbital spine present.	Genus : *Mastocembelus* Scopoli.
1b. Preorbital spine absent.	Genus : *Macrognathus* Lac.

Genus : *Mastocembelus* Scopoli.

Key to species.

1. Caudal fin confluent with anal and dorsal fin, pectoral 23, dorsal 37/75–75, anal 3/80–84.	*Mastocembelus armatus* (Lacepede) Locality : Gadigarh & R. S. Pura ponds.
2. Caudal fin non confulent with anal and dorsal fin, pectoral 19, dorsal 25/36 and 13/37.	*Mastocembelus pancalus* (Ham.). Locality : Gadigarh & R. S. Pura ponds.

Genus : *Macrognathus* Lac.

Key to species.

1. Pectoral 19, dorsal with 3–5 ocelli.	*Macrognathus jammuensis* sp nov. Locality : Selhar area.

Genus : *Channa.*

Key to species.

1a. Dorsal 35–36, anal 21–23, lateral line scales 42–44.	*Channa gachua* (Ham.). Locality : Gadigarh & R. S. Pura ponds.
1b. Dorsal 30, anal 20, lateral line scale 39–40.	*Channa punctatus* (Bloch). Locality : Gadigarh & R. S. Pura ponds.

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1. Chaudhri, B. L.. 1910 : Description of a new species of Nemachilus from Northern India, Rec. Ind. Mus. Vol. II P. 183.

2. Chaudhri. B. L., 1912 : Description of some new species of freshwater fishes from North India. Rec. Ind. Mus. Vol. VII. P. 437.

3. Day, F. 1878 : The fishes of India. Vols. I & II Reprinted 1958. William Dawson & Sons, London.

4. Day, F. 1889 : Fauna of British India. including Ceylon & Burmah Fishes, Vols. I & II Taylor and Francis, London,

5. Horg, S. L., 1921 : Fish and fisheries of Manipur with seme observations on those of the Nanga hills. Rec. Ind. Mus. Vol. XXII P. 165.

6, Hora, S. L., 1923 : Fish of the salt range, Punjab. Rcc. Ind. Mus. Vol. XXV. P. 377.

7. Hora, S. L., 1937 : Notes on the fishes in the Indian Museum. XXVII on three collections of fish from Mysore and Coorg South India Rec. Ind. Mus. Vol. XXXIX P. 5.

8. Hora. S. L., 1940 : On a collection of fish from the headwater of the Muhanadi river, Raipur district, Rec. Ind. Mus. Vol. XIII, P. 365.

9. Hora. S. L., 1944 : Fishes of Mysore state. Rec. Ind. Mus. Vol. XLIV. P. 193.

10. Hora, S. L.,nad Mukerjee D. D. 1937 : Fish of Naga hills, Assam. Rec. Ind. Mus. Vol. XXXVII P. 381.

11. Malhotra, Y. R. and M. K. Jyoti, 1971 : Anidentification of the fishes found in Jammu (Part). J. Assam. Soc. Vol. XIV, No : 2 P. 184.

12. Malhotra, Y. R. and S. P. Singh Dutta : (In press). on a two new fishes from Jammu alongwith a check list of fishes inhabiting Jammu division of J and K state.

13. Mencn, A. G. K., 1964 : Monograph of the cyprinid fishes of the genus Garra Hamilton. Memoris of the Indian Museum. 14 (4) : 173-260.

14. Misra, K. S., 1959 : An aid to the identification of the common commercial fishes of India & Pakistan. Rec. Indian Mus., 57 : 1–320.

Proc. Nat. Acad. Sci., 45 (B), III : 153-162, 1975.

III

ON TWO NEW FISH SPECIES FROM JAMMU ALONGWITH A CHECKLIST OF FISHES INHABITING JAMMU DIVISION OF J & K STATE INDIA

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ABSTRACT

In the present contribution two new species of fishes Amblypharyngodon gadigarhi and Macrognathus jammuensis are being described. Also listed in this contribution are 25 new records and a checklist of 47 fishes reported upto date from Jammu division of J & K State.

INTRODUCTION

Faunistic investigations form a preliminary step in biological research for any region Reports pertaining to ichthyofauna of the Kashmir valley are those of Heckel (1838 and 1844), Valenciennes (1840 and 1842), Day (1876 and 1878), Silas (1961), Das and Subla (1963 and 1964), but the Jammu division of the J&K State has not received much attention in the past, so far as survey of fishes is concerned. Even Day (1878 and 1889) has not referred to investigation of fishes from this part of Jammu and Kashmir State. Misra (1959) dealing with fishes of India and Pakistan has again leftout this part of the country. There is one report by Malhotra and Jyoti (1971) which deals with only twenty species of fishes from this region.

The Jammu division is an extensive hilly area, which is located within the outer and lesser Himalayan zone of Kashmir Himalayas. It is an interesting area from the point of view of ecological distribution of fishes, the rivers from typical ecological division into higher trout section, a comparatively lower barbel section in the foot hills, followed by bream or carp section which starts immediately below the foot hills and extends even into plains of Pakistan.

Jammu region is drained by tributaries of three main rivers namely Jhelum, Chenab and Ravi. Jhelum drains only the Poonch district, Ravi drains only the eastern peripheries of this division. The main drainage of this division is due to Chenab drainage system which besides its ownself has important tributaries like Tawi of Jammu and Tawi of Rajouri, the latter moves through Nowwhera and is called as Manawer Tawi in its lower reaches.

Most of fishes inhabiting this part of the state belong geographically either to plains of Punjab or have distributional affinities with those of Kashmir, yet a comprehensive list of fish species inhabiting Jammu region in particular is desirable for reference by future investigators and fish culturists for whom it offers ample opportunities of development.

The present contribution deals with description of two new species, collected from Jammu division of the J&K State for which the names Amblypharyngodon gadigarhi and Macrognathus jammuensis have been proposed. An up-to-date checklist of fishes (47 species) inhabiting this region has also been prepared. Out of which 25 species (besides the 2 new species) have been recorded for the first time from this region of J & K State.

MATERIAL AND METHODS

The collection of fishes was done from the localities mentioned against each species and collection devices used were the Haul net, Cast net, Basket trap, Pot trap, Rod with hook and long line. The fishes after collection were preserved in 8% formaldehyde and brought to the laboratory, where they were identified. For counting the lateral line scales and fin rays in case of smaller sized fishes, Binocular stereoscopic microscope was used. All the

measurements were made with the use of calipers.

Attempt has been made to determine the age of new species from scales and operculum. But due to absence of well marked growth rings, age has remained beyond exact determination. Grossly the collected specimens are placed in one year old category. Howev-er, study of gonads has revealed that Macrognathus jammuensi's sp. nov. are mature adults. Specimens of Amblypharyngodon gadigarhi sp. nov. are sexually immature, but are far advanced over fingerling stages, suggesting to be well developed in their Ist year of age.

The system of classification followed is mainly of Berg (1940) although later work of Nikolskii (1961) has also been consulted.

Amblypharyngodon gadigarhi sp. nov. (Fig. 1).

The relationship of the present species with those of the existing ones is represented in table I.

A comparison of characters of Amblypharyngodon gadigarhi sp. nov. with other existing species suggests the creation of a new species as is clear from table I. It differs from Amblyphryngodon saranensis Chaudhuri in having 9 in place of 8 ventrals and lateral line ceases at 11-14 scales in place of 16-18. It differs from Amblypharyngodon melettinus (Cug. and Val.) also in that lateral line in latter ceases at more than 15 scales. In having 14 pectoral rays Amblypharyngodon microlepis Bleeker also differs from the present species.

Amblypharyngodon mola (Ham.) in most of the characters and in its distribution in areas adjoining to the site of collection agrees with the present species, but differs from it in having 7 rays to anal and that its lateral line ceases at 15 scales, but never short of 15,

Table I

Work consulted for	A.mola (Ham.Buch) Day(1878)	A.Atkinsonii (Blyth) Day(1878)	A.microlepis (Bleeker) Day(1878)	A.melettinus (Cuv & Val) Day(1878)	A.saranensis Chaudhuri (1912)	A.gadigarhi sp.nov.
Characters						
Dorsal	9(2/7)	9-10(2-3/7)	9(2/7)	9-10(2-3/7)	9(2/7)	9(2/7)
Pectoral	15	15	14	15	14-15	15
Ventral	9	9	9	9	8	9
Anal	7(2/5)	8(2/6)	7(2/5)	7-8(2-3/5)	-	8(3/5)
Caudal	19	19	19	19	-	19
Lateral line cease at	65	19	-	15-20	16-18	11-14
Lateral line scales	65-75	55-65	55-60	50-57	81-92	66-75
Length of head in total body length	5	4-4 2/3	4 3/4-5	5-5 1/2	4-4 1/5	3 1/2-4 2/3
Body height in total body length	4-4 1/4	3 1/3	4 3/4-5	5-5 1/2	3	4-4 1/2
Eye diameter in head length	3 1/2-4	4-4 1/4	3 2/3-4	4	3 1/2	3 1/5-4 1/4
Colour	Silvery lateral band and dots on dorsal caudal and anal fins.	Silvery golden about head	with gloss and	Silvery lateral band.	Greenish along back, silvery on sides and beneath.	Golden yellow with a broad dark band from above the gill cleft to the caudal pedunncle.	Greamy, silvery lateral band, minutely spotted longitudinal bands one above the silvery line extending on sides, black spot on upper labial fold and lower lip.
Distribution:	Sind Burma throughout India except Malabar coasts Assam and Burma	Hooghly through Orissa, Coromandal coast to Madras.		Bombay Malabar coast, and Southern India	Thari river, Saran North' India	Gadigarh, Jammu.

while in the present species anals possess 8 rays and that lateral line also ceases short of 15 scales (i.e.11-14).

Amblypharyngodon atkinsonii (Blyth) has 55-65 lateral line scales and its lateral line ceases at 19 scales; while in the species under description lateral lines scales vary from 66-75 and lateral line ceases from 11-14 scales as already mentioned.

Thus from the above discussion it is clear that the specimens of Amblypharyngodon being presently described are different from previously described species in one character or the other. These differences suggests that these specimens belong to a new species, which also possess the following supporting features.

(i) Head length to total body length ratio may vary from $3\frac{1}{2}$ to $4\frac{2}{3}$ while in all the other species it is never recorded to be less than four.

(ii) It possesses longitudinal coloured bands, one above the silvery lateral band and other in middorsal position, the latter extending in dots for some distance on the lateral sides.

(iii) There are black spots on upper labial folds and lower lip.

Thus their differences from previously described species (listed above) and the possession of these distinct supporgint features demand the creation of new species for which the name Amblypharyngodon gadigarhi is proposed.

Holotype and paratype. Eight specimens ranging in size from 4.1-7.5 cm from Gadigarh Nallaha Jammu. Dated 15-7-1974. Placed in Department of Bio-Sciences, University of Jammu.

Macrognathus jammuensis sp. nov. (Fig. 2)

Discussion. Misra (1959) has synonimized genus Rhynchobdella (Bloch and Schneider) with Macrognathus Lac. Thus to our knowledge only two species from this genus have been described and are (i) Macrognathus dhanashorii (Hora) and (ii) Macrognathus aculeatum (Bloch).

Compnative statement of distinguishing features of two previously described species and present species is represented in table 2.

Hora (1921) created the new species of Macrognathus dhanashorii on the following basis:

(i) 17 pectoral rays against 23 in Macrognathus aculeatum (Bloch).

(ii) Head length to body length ratio being 7 against 5-6 of Macrognathus aculeatum (Bloch).

The present species differs from Macrognathus aculeatum (Bloch) and Macrognathus dhanashorii (Hora) in having:

(i) 19 pectoral fin rays.

(ii) Head length/total body length ration 4-5 (but less than 5). In both the previously described species this ratio always exceeds 5 (see table 2).

(iii) Ratio of eye diameter in head length in Macrognathus dhanashorii is 5 times, but in present species is $9\frac{2}{3}$ to $10\frac{1}{3}$.

The characters thus stand in sharp contrast to those of both of the previosuly described species and justify the creation of a new species for which the name Macrognathus jammuensis sp. nov. is proposed.

Table 2

Work consulted for determining characters of species.	Macrognathus aculeatum (Bloch) Day (1878)	Macrognathus dhanaskhrii (Hora) 1921	Macrognathus jammuensis sp. nov.
Characters			
Dorsal	16-20/44-54	19/45	19/48-52
Pectoral	23	17	19
Anal	2-3/44-52	3/47	3/45-50
Caudal	15	16	16
Length head in total body length	5-6	7	4-5(but less than 5)
Body depth in total body length	8-10	$9\frac{1}{3}$	$8\frac{1}{3}$-$9\frac{1}{4}$
Diameter of eye in head length		5	$9\frac{2}{3}$ to $10\frac{1}{3}$
Colour	Brownish or greenish marbled superiorly, becoming yellowish along the abdomen a light band along the body just above the lateral line. A series of from three to nine large black ocelli, having a white or puff edge, along the base of the soft dorsal fin. Caudal with from six to eight vertical brown bars, fins otherwise greyish. Pectoral sometimes yellow. The body has several longitudinal bands in Sind.	Dull olivaceous speckled with numerous very characteristic pale lines extending downwards and forwards from the base of the dorsal fin and becoming obscure in the belly region. Behind the vent these lines are joined together in an irregular manner to form a reticulation. A pale longitudinal band extends backwards from behind the eye and becomes obscure in the post anal region. The lower surface is pale, speckled with black on the lower surface of the head. The fins are dark, minutely banded or speckled with dull white.	Body light yellow with light dots, dark above on dorsal surface, a brown reticular band running from the snout to the base of the caudal fin just below the lateral line. A pale band above the lateral line. Dorsal caudal and anal finds with dark striations. Three to five black ocelli with white margin on the base of the dorsal fin.

The creation of new species is also supported by the fact that previously described species are reported either from the brackish waters (Macrognathus aculeatum) of frewhwater of Assam and Nagaland (Macrognathus dhanashorii), while the present species is collected from the freshwaters of Jammu and as such is quite isolated from the areas stated above.

Holotype and paratype Four specimens ranging in size from 11.5 - 14.3 cml collected from small Nallaha near Salhar on 2-6-1974. Placed in the Department of Bio-Sciences, University of Jammu.

List of fishes including new records from Jammu.

Order: Cyprinformes
Sub-order: Cyprinoidei. Name of fish Place of catch
Family: Cyprinidae.

1.	Gara gotyla gotyla (Gray).	Poonch river Tawi River, Jammu.
2.	Garra lamta Ham.	Rud Nallah Thakrakot Reasi
3.	*Garra variabilis (Heckel).	Ranbir Canal Jammu
4.	Amblypharynagodon gadigarhi sp.nov.	Gadigarh.
5.	Chela atpar(Ham.)	Gadigarh.
6.	*Chela laubuca(Ham.)	R.S.Pura ponds.
7.	Oxygaster bacaita (Ham.)	Gadigarh.
8.	Puntiussarana(Ham.)	Gadigarh.
9.	Puntius sophore (Ham.)	Gadigarh.
10.	*Puntius chrysopterus (McClelland).	R.S.Pura Ponds
11.	*Puntius ticto(Ham.)	Gadigarh, R.S. Pura ponds.
12.	*Puntius conchonius (Ham.)	Gadigarh, R.S. Puraponds.

32.	*Mystus vittatus (Bloch)	Gadigarh and R.S.Pura ponds.

Family: Siluridae.

33.	*Wallago attu (Schneider)	Gadigarh and R.S.Pura ponds.
34.	Ompok bimaculatus (Bloch).	Gadigarh and R.S.Pura ponds.

Family: Sisoridae.

35.	Glyptothorax pectinopterum (McClelland).	Bhadarwah and River Tawi Jammu.
36.	Glyptothorax botium (Ham.)	Eak Nallah(Sheru chak).
37.	Glyptosternum sp.	Bhadarwah.

Family: Saccobranchidae.

38.	*Heteropneustes fossilis (Bloch)	Gadigarh and R.S.Pura ponds.

Order: Beloniformes.

Sub-order: Scomberesocoidei.

Family: Belonidae

39.	Xenentodon cancita (Bloch).	Gadigarh.

Order: Ophiocephaliformes.

Family: Ophiocephalidae.

40.	Channa gachua(Ham).	Gadigarh and R.S.Pura ponds.
41.	*Channa punctatus (Bloch).	Gadigarh and R.S.Pura ponds.

Order: Perciformes.

Sub-order: Percoidei.

Family: Nandidae.

42.	Badis badis (Ham. Buch).	Gadigarh.
43.	Glossgobius giuris (Ham.).	Gagidarh.

13.	Tor sp.	River Tawi Jammu.
14.	Aspidoparia morar (Ham.)	River Tawi Jammu and Gadigarh
15.	Barilius bendelisis (Ham.)	River Tawi Jammu and Thakrakot(Reasi)
16.	*Barilius vagra((Ham.)	Tawi of Jammu and Gadigarh.
17.	Cirrhinus reba(Ham.)	Gadigarh and Eak Nallah.
18.	Crossocheilus latius latius (Ham.)	Poonch river.
19.	Danio rerio(Ham.)	Mansar Lake, Surinsar Lake and Gadigarh.
20.	*Danio devario (Ham.)	Gadigarh and R.S.Pura ponds.
21.	*Esomus danrica (Ham.)	Gadigarh and R.S.Pura ponds.
22.	*Rasbora rasbora (Ham.)	Gadigarh and R.S.Pura ponds.
23.	*Creinus richardsoni (Gray and Hard).	Banihal Neeru Nallah
24.	*Labeo rohita(Ham.)	River Tawi Jammu.
25.	*Labeo diplostomus Cuv and Val.	River Tawi Jammu.
26.	*Osteobrama cotio (Ham.)	Gadigarh and R.S.Pura ponds.

Family: Cobitidae.

27.	Botia dayi (Hora).	River Tawi Jammu and Eak Nallah (Sheru Chak).
28.	Lepidocephalichthys guntea(Ham).	Gadigarh.
29.	Noemacheilus botia (Ham).	Gadigarh.

Sub-order: Siluroidei.

Family: Bagridae.

30.	Mystus bleekeri (Day).	Gadigarh
31.	Mystus seenghala (Sykes)	Gadigarh and River Tawi Jammu.

Sub-order: Anabantoidei.

Family: Osphronemidae.

44.	Trichogaster fasciatus (Bloch Schen.).	Gadigarh, Eak Nallah and Salahir ponds.

Order: Mastocembeliformes.

Family: Mastocembelidae.

45.	*Mastocembelus armatus (Lacepede).	Surinsar, Mansar Lake Gadigarh and R.S.Pura ponds.
46.	*Mastocembelus pancalus (Ham.).	Gadigarh, R.S.Pura ponds and Sruinsar lake.
47.	Macroganthus jammuensis sp.nov.	Small stream near Salahar.

Note: (1) Names of fishes marked with asterisk are old records by Malhotra and Jyoti 1971. All other fishes are recorded for the first time from Jammu.

Note: (2) Regarding 25 species recorded for the first time, the following sources of identification have been used: Menon (1959) has been followed for species of Genus: Garra; Misra (1959 for species of Genus: Chela, Oxygaster, Puntius, Tor, Aspidoaria, Barilius, Cirrhinus, Crossocheilus, Botia, Noemacheilus, Mystus, Xenentodon, Channa, and Glossogobius; Day (1878 and 1889) for species of Genus: Danio, Lepido-cephalichthys and Trichogaster; Day (1878 and 1889) and Hora (1921) for species of Genus: Badis and Day (1878 and 1889) and Hora (1923) for species of Genus: Glyptothorax and Glyptosternum.

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REFERENCES

*BERG, L.S. (1940). Trav. Inst. Zool. Acad. Sci., U.S.S.R., 5:87-517.

CHAUDHURI, B.L.(1912). Rec. Ind. Mus., 7: 437.

DAS, S.M. AND SUBLA, B.A. (1968). Ichthyologica,2(1-2): 87-106.

_____(1964). Ichthyologica, 3(1-2): 57-62.

*DAY, F. (1876). Proc. Zool. Soc., London, 781-807.

*_____(1878a). Ichthyology, Calcutta, 1-25.

_____(1878). The fishes of India. Vols. I and II Reprinted, 1958. William Dawson & Sons, London.

_____(1889). Fauna of British India, including Ceylon and Burma fishes. Vols. I and II Taylor and Francis, London.

*HECKEL,J.J.(1838). Fischeaus Cashmir, Sttutgart.

*_____.(1844). Kashmir und das Reich der Seik Bd. 4 abth., 2: 351-384.

HORA, S.L. (1921). Record Ind. Mus., 22: 165.

_____. (1923). Red. Ind. Mus., 25: 8.

MALHOTRA, Y.R. AND JYOTI, M.K. (1971). J.Assam Sci. Soc. 14(2): 184.

MENON, A.G.K.(1964). Memoirs of the Indian Museum, 14(4): 173-260.

MISRA, K.S. (1959). Rec. Indian Mus., 57: 1-320.

NIKOLSKII, G.V. (1961). Special Ichthyology.Published for National Science Foundation,Washington,D.C. and Smithsonian institution,by the Israel Program for Scientific Translation,Jerusaleum, 1961.

SILALS?B.G.(1961).Journ. Bombay Nat.Hist.Soc.,57:66-77.

*VALENCIENNES,A.(1841-1842).Histoire Naturelle des Poissens, 15-16.

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ON SOME FRESH WATER RHIZOPODA FROM JAMMU

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ABSTRACT

During the limnological investigations of Gadigarh stream, (Miran Sahib, Jammu) eleven species of Rhizopod Protozoa belonging to two families and four genera were collected. In the present communication these eleven species of protozoa viz. Lesquersia spiralis (Ehrenberg), Difflugia pyriformis Perty, D. tuberculata (Wallich), D. acuminata Ehrenberg, D. corana Wallich, Centropyxis ecornis (Ehrenberg), C. aculeata (Ehrenberg), C. spinosa (Cash and Hopkinson), Arcella dentata Ehrenberg, A. discoides Ehrenberg, and A. vulgaris Ehrenberg are described in detail. The species described are the first records of any fresh water protozoan from Jammu.

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SOME TORTOISES FROM JAMMU

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(Reveived March 8, 1975; Revised May 18, 1971).

During July/September 1975 and March, 1976, the junior authors collected a number of herpetiles from various sites in the Gadigarh stream, Jammu (74°.51' long and 32°. 40' lat.). The stream is relatively shallow and slow running and is essentially spring fed. It varies in depth from 0.5 ml - 1.25 ml along its course and differs in the nature of its bedn and trophic level of its vegetation. The collections were generally made in the early hours of the day along half a mile of the R. D. of the stream. From amongst the collection, only the tortoise specimens are recorded herewith as of special interest.

In all 20 specimens of tortoises, 19 live and 1 dead, were collected, besides a tortoise shell picked from a nearby field. These specimens represent 4 species, pertaining to two families, none of which has been reported previously from Jammu. In reviewing these tortoises, we have survyed as much as possible of the literature pertaining to Indian tortoises (Boulenger, 1890; Smith, 1931).

Kachuga tectum tectum (Gray) (Fig.). Family Emydidae (Cat. Nos. JUBR 15 - 19). 3 specimens were obtained in July and 2 in August 1975 which agree with previous descriptions. The maximum measurements for the carapace were 210 × 179 mm.

Kachuga smithi (Gray) (Fig. 2). Family Emydidae (Cat. Nos. JUBR 20 - 21). 2 specimens were collected in August, 1975. Both the specimens agree in all respects with Smith's (1931) description of the species. The maximum measurements for the carapace recorded were 126 x 109 mm. Tjis is the first report of the species from north west India.

Lissemys punctata punctata (Bonn.). (Fig. 3). Family Trionychidae (Cat. Nos. JUBR 22 - 30). 9 specimens of all sizes were collected. This species seemed to prefer such spots along the stream where water was restricted to disconnected pit holes, and were available in August - September, 1975 and in March, 1976. In all features but the markings on the head and the size variation in the plastral callosities, these specimens agree with previous description of the species. The maximum measurements of the carapace recorded was 232 x 208 mm.

Trionyx gangeticus (Cuvier). (Fig. 4). Family Trionychidae (Cat. Nos. JUBR 31 - 34). While 1 dead specimen and a shell were collected in August, 1975; 3 live specimens were caught in March, 1976. In their external morphology, these specimens agree to a large extent with the features of the species but the skeleton shows some very interesting and significant taxonomic features which warrant a separate specific status to these forms. For the present till many more specimens are collected and screened, these specimens are tentatively placed as members of the species T. gangeticus. The maximum measurements of carapace recorded were 462 x 343 mm.

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References

Boulenger, G. A. Fauna of the British India, including Ceylon and Burma, (Reptilia and Amphibia), 1890.

Smith, M. A. Fauna British India, Rept. Amphi. Vol. 1. Loricate Testudines. 1931.

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ON SOME DECAPOD CRUSTACEA FROM JAMMU

Y. R. Malhotra, and S. P. Singh Dutta, Jammu.

ABSTRACT - 15

A detailed survey of both lotic and lentic water bodies of Jammu regions has revealed the occurrence of five species of decapod crustacea belonging to three families and four genera. The species recorded are Macrobrachium dayanum (Henderson), M. lamarrei (H. Milne Edward), Caridina sp., Paratelphusa (Barytelphusa) masoniana Henderson and Potamon sp., All these species form a first record of any decapod crustacea known from this part of J & K state.