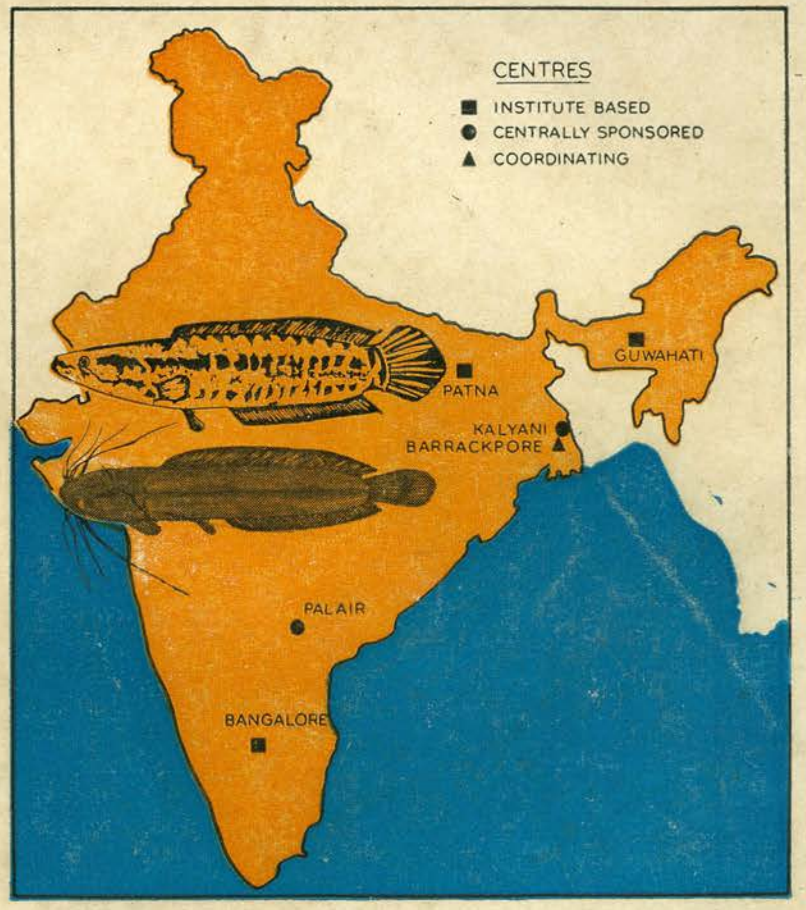
ALL INDIA COORDINATED RESEARCH PROJECT ON AIR BREATHING FISH CULTURE

FINAL REPORT (1971-85)



ICAR

Central Inland Fisheries Research Institute
BARRACKPORE 743 101
WEST BENGAL

FISHERIES RESEARCH INFORMATION SERIES No. 5
1987

ALL INDIA COORDINATED RESEARCH PROJECT ON AIR BREATHING FISH CULTURE

FINAL REPORT (1971 - 85)

CENTRES — KARNATAKA, BIHAR, ASSAM, ANDHRA PRADESH, WEST BENGAL

COORDINATING CENTRE — BARRACKPORE, WEST BENGAL

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1987

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FOREWORD

Eastern India, bracing the States of Assam, Tripura, Manipur, West Bengal, North Bihar and parts of Orissa, is characterized by vast flood plains and high precipitation and water table. It abounds in extensive stretches of shallow water bodies choked with diverse aquatic weeds, spawning across over 0.6 million ha in area. These ecosystems offer ideal ecological niches for a variety of fishes, mostly predatory, of which air breathing fishes like murrels, magur, singhi and koi constitute a major component because of their adaptation to thrive in such oxygen-starved waters which tend to recede and partly dry up during summer months. It is difficult to convert the vast expanse of water-logged habitats into productive fish ponds due to the high capital outlay involved, seepage problems and risk of inundation during the monsoon months. Apart from Eastern India, States like Karnataka, Kerala, Andhra Pradesh and Tamil Nadu also abound in shallow, low-lying areas, contributing to a significant fishery of air breathing fishes.

The All India Coordinated Research Project on the Culture of Air Breathing Fishes was launched in May 1971 with the clear objective of developing appropriate technology for the culture of air breathing fishes in swamps, ponds, tanks, cages and pens for harnessing the natural resources, which otherwise remain fallow. These fishes are in high demand because of their flavour, keeping quality, high protein and minerals,low fat content and recuperative and medicinal qualities, fetching high price all over the country. Being minor or major predators, they have been methodically eliminated from aquaculture ponds. Although extensive data on the respiratory physiology of these fishes have been gathered, very little information on their age and growth, food and feeding habits, fecundity, breeding cycle and reproductive physiology, seed resources, nursery management, supplemental feeding and growout were available. Thus, compared to the other Coordinated Projects undertaken by the Institute, fundamental studies were also propagated in the case of the present project.

Suitable, three Centres of the Project were started by the Institute, one each in Assam, Bihar and Karnataka. Two more Centrally sponsored Centres, one each in West Bengal and Andhra Pradesh, came into existence in 1975 and 1976. The work was concluded in March 1985. Limitations of laboratory and field facilities notwithstanding, the Centres could generate valuable information on the bioecology of swamps and other derelict waters, biology of various air breathing fishes, their hypophysation, natural seed resources and nursery management and captive culture in ponds and cages. The spawn and fry of air breathing fishes being very delicate, highly cannibalistic and selective in their feeding habits, the nursery management practices of carps are not applicable to them. In contrast to carp culture, where some amount of empirical knowledge was readily available, the programme of air breathing fish culture had to begin from rudiments and there are still areas such as seed production and rearing, and growout of table fish, where considerable amount of field studies are warranted, to develop technology packages for transferring to the fishculturists.

A brief account of the work done by the various Centres of the All India Coordinated Research Project on

Air Breathing Fish Culture is presented in this report. I express my appreciation and thanks to the Scientists whose sincere efforts have resulted in the generation of so much data. I should make a special mention of the dynamic leadership and thrust given to the Project by Dr. P.V. Dehadrai, the first Project Coordinator, in planning, coordinating and actively participating in the work programmes. I take this opportunity to acknowledge and thank the Directors of Fisheries of Bihar, Assam, West Bengal, Karnataka and Andhra Pradesh and their Officers for their active involvement and for providing various facilities.

Dr. S. Parameswaran, Scientist S-3, carefully scrutinized and evaluated the reports prepared by the various Centres and edited them in the present form. I wish to place on record my appreciation of the efforts put in by him. I should also appreciate Mr. P. Kumaraiah, Scientist S-2, who ably assisted Dr. Parameswaran in the editorial work with deep involvement.

27-4-87

(ARUN G. JHINGRAN)

DIRECTOR

PROJECT PROFILE

Air breathing fishes remain a biological enigma ever since their discovery. They are characterized by their capacity to utilize atmospheric oxygen for respiration by certain morphological adaptations, in addition to availing the dissolved oxygen in water through branchial respiration as in other fishes. The structural adaptations for air breathing appears to have been developed by these fishes belonging to diverse genera to insure against adverse water conditions when aquatic respiration becomes inadequate. Majority of the air breathing fishes are native to tropics, mainly found in freshwater swamps and pools, which often develop anoxic conditions and nearly dry up during summer months. A few air breathing fishes occur in temperate regions and also in brackish and marine environments. Air breathing fishes surface at intervals to breathe atmospheric air.

The synaptic or bifarious respiration in air breathing fishes has been studied extensively because of its possible role in the evolution of amphibious and terrestrial vertebrates. However, air breathing fishes remained a neglected group from the fisheries concern and very little baseline information on their biology, seed resources and production amplitude had been available, compared to cultivated carps. There are over 20 species of air breathing fishes in India belonging to different families, of which species such as the giant murrel Channa marulius (Hamilton), striped murrel Channa striatus (Bloch), common murrel Channa punctatus (Bloch), magur Clarias batrachus (Linnaeus), singhi Heteropneustis fossilis (Bloch), kawai Anabas testudineus (Bloch) and chital Notopterus chitala (Hamilton) are important food fishes. They are accepted all over the country for their flavour and medicinal and recuperative attributes, high mineral and low lipid content and keeping quality. The high demand for air breathing fishes is only partly met from the capture fishery resources. Considerable scope exists for augmenting their supply by culture. Being minor or major predators, they have been considered as unwelcome in fish ponds from where they are systematically removed.

In an endeavour to achieve a quantum advance in the knowledge on the biological complexities, seed resources and aquaculture management of air breathing fishes on a national level, the Indian Council of Agricultural Research sponsored the All India Coordinated Research Project on Air Breathing Fish Culture, with a view to develop appropriate technology for their culture and put to effective immediate use the extensive derelict water resources in the country estimated to be over 0.6 million ha. in area, with minimum outlay. The project was initiated in June 1971 with Centres in Karnataka, Assam and Bihar with the Coordinating Station at Darbhanga (Bihar), later shifted to Barrackpore in 1974. Two centrally sponsored Centres were established in West Bengal and Andhra Pradesh in 1975 and 1976.

Swamps indicate a high carrying capacity. The air breathing fishes, by virtue of their adaptability to adverse water conditions are the resilent material for stocking such water bodies. Detailed studies undertaken in the laboratory and in the field on various aspects of the biology of these fishes such as reproductive processes, induced breeding, natural seed resources and nursery management have yielded considerable information to embark on production oriented programmes. Stocking of swamps, derelict waters and ponds, offers scope for high production of fish unit^{-1} water space. Culture of air breathing fishes in cages installed in swampy waters also can give high yields from such waters.

The immense potential of air breathing fishes as promotional species for developing new fish culture systems to harness fallow, energy-rich natural resources and thus opening up new prospects for improving the national economy by increased fish production and employment generation has been justifiably envisaged.

PROJECT PROTOCOL.

The broad technical programme of the Project was as follows :

i) Studies on the fishery status of air breathing fishes.

ii) Investigations on the ecology of derelict waters (swamps, tanks, etc.), including nutrient balance of soil and waters.

iii) Studies on the biology of air breathing fishes (murrels, magur, singhi and kawai).

iv) Induced breeding of air breathing fishes and standardization of the techniques.

v) Seed prospecting of air breathing fishes from natural sources, refinement of methods of location and collection and drawing up of seed calendar and index through time and space.

vi) Studies on incubation of eggs and rearing of spawn, fry and fingerlings of air breathing fishes.

vii) Developing suitable supplemental feeds for nursery phase of air breathing fishes.

viii) Short and long distance transportation of fry and fingerlings of air breathing fishes.

ix) Culture of air breathing fishes in swampy ponds, paddy fields, cisterns and cages with varying stocking density and inputs.

x) Formulation of supplemental feeds for the growout phase of air breathing fishes and studies in feed conversion.

xi) Demonstration of the culture of air breathing fishes in farmer's ponds, under 'lab to land' programme, for dissemination of the technology.

xii) Economics of air breathing fish culture.

xiii) Diseases and parasites in air breathing fishes.

xiv) Digestive physiology of air breathing fishes.

xv) Nutritional and biochemical studies of magur in relation to its culture in paddy fields.

xvi) Toxicity, metabolism and detoxification of organophosphorus pesticides in magur.

xvii) Toxicity and metabolism of malathion and carbofuran in magur in relation to its culture in paddy fields.

xviii) Nonprotein nitrogen utilization by magur and singhi.

PROJECT APPRAISALS

Altogether seven Workshops were held at Cuttack (September 1971), Patna (December 1972), Bangalore (September 1976), Barrackpore (December 1978), Hyderabad (October 1980), Barrackpore (December 1982) and Patna (July 1984) for the critical evaluation of the work done and to decide the guidelines for future work.

PROJECT OVERVIEW

1 KARNATAKA CENTRE

1.1 INTRODUCTION

In view of the high demand for murrels and scope for their culture in peninsular India, the Centre in Karnataka concentrated on these fishes. From 1977 onwards investigations on singhi and magur were also undertaken. The broad work programme of the Centre included the estimation of the swamp and tank resources of Karnataka, investigations on the ecology and fisheries of these water bodies, studies on the biology of murrels, singhi and magur and their seed mobilization including induced breeding, nursery management and development of growout practices.

The Centre was initially located at the Karnataka Government Fish Farm at Bhadra Reservoir Project (latitude : 13° 48' N; longitude : 75° 39' E) in Shimoga district. During the Centre's existance there till September 1975, baseline information on swamp ecology and the biology and fisheries of air breathing fishes assigned to the Centre, viz., *C. marulius*, *C. striatus* and *C. punctatus* and on aspects such as their induced breeding, incubation of eggs, rearing of larvae, nursery management and growout in ponds and swamps was collected. Since the field being practically virgin, such information was not available hitherto.

The Centre was shifted to Bangalore (latitude : 12° 58' N; longitude : 77° 38' E) in October 1975 at the instance of the Director of Fisheries in Karnataka for better coordination to carry out further research directed at propagation and culture of the commercially important air breathing fishes in tanks.

1.2 FRESHWATER RESOURCES AND THEIR FISHERIES

Surveys were conducted to take stock of the freshwater rerources and status of fisheries of air breathing fishes in Karnataka.

1.2.1 Water resources

The State has 2,700 major and 30,000 minor tanks with a water-spread area of 0.45 million ha which could be used for fish culture. In addition, there are 25 reservoirs with a water-spread of 0.11 million ha, where capture fisheries can be developed. The state also has 21 important rivers with a total length of 6,000 km and connected channels of 3,000 km. A network of irrigation canals running to several thousand km also contribute to the fisheries to some extent.

1.2.2 Management of water sheets

The fishery rights of the major tanks and reservoirs rest with the Fisheries Department and those of minor tanks, with the respective Panchayats in which they are situated. At present about 20 % of the major tanks and reservoirs are being stocked with fingerlings of major carps and common carp. Only a few Panchayats have shown interest in undertaking fish culture in tanks. As such, more than 80 % of the water sheets available for fish culture are lying fallow for want of seed, transportation facilities and interest. As there is no agency for supplying seed of air breathing fishes, none of these water sheets are stocked with these fishes excepting some occasional stocking of irrigation wells by their owners with murrel seed collected from nearby tanks.

The major tanks are annually auctioned for exploitation wherever bidders come forward. Otherwise fishing licences are issued for exploitation of individual water sheets (tank, reservoir and river stretch). A licence fee of Rs.10.00 is charged for operating a unit of 200 m gill net by two fishermen for a month. The annual licence fees for operating rod and line and long line of 100 hooks are Rs.5.00 and Rs.10.00 respectively.

12.2.3 Exploitation

People belonging to the castes, Gangamatha and Bestha do fishing in tanks and rivers. The State has attracted fishermen from neighbouring States. Fishermen from Tamil Nadu belonging to Guha Vellala Gowdar and Sembadavar communities have migrated to Karnataka. Most of them fish in reservoirs and large tanks. The Marathi speaking nomads, Killekatha or Burdebestha move from place to place in groups and exploit large tanks. A few economically backward people also engage themselves in fishing in the absence of alternate employment.

Surface gill nets (rangoonvalai) of 30 to 120 mm mesh bar and 1.5 to 2.2 m depth are extensively used in reservoirs and large tanks for catching major carps and larger freshwater catfishes. Large specimens of C. marulius and C. striatus are also caught in the net. The bottom-set gill net (bidubalai) of 45 to 65 mm mesh bar and 0.5 to 0.7 m depth are operated by Guha Vellala Gowdar and Killekathas in tanks for catching carps and air breathing fishes.

For exploitation of tanks devoid of weeds, drag nets (maribalai) of 15 to 30 mm mesh bar are operated, especially during the summer season when the water level in them recedes considerably. Major, medium and minor carps, catfishes and air breathing fishes are obtained in the net. Although carps dominate (60 to 85 %) the catches, considerable quantity (10 to 30 %) of air breathing fishes are also caught in the net.

Chuthubalai, a locally fabricated encircling net of 23 to 20 mm mesh bar, 30 m length and 1.5 m depth is operated during summer in weed infested tanks having air breathing fishes. After paying the net in a circle, the enclosed area is disturbed by the fishermen for driving the fishes towards the net. They get entangled in the pockets of the net and are collected by frequent examination.

Cast net (beesubalai) is a common gear operated in all types of waters. Generally more of trash fishes and minor carps are caught in this net when operated in tanks and rivers. The gear is also specifically used to catch murrels moving with their brood of young in weed free areas of water bodies.

Traps such as filter trap (kodme) and plunge basket (kule) are also operated in Karnataka. The filter trap is set against the current in irrigation canals and paddy fields. The catches are dominated by trash fishes, followed by loaches and small species of murrels, C. orientalis and C. punctatus. The plunge basket is operated in the shallow areas of tanks for trapping air breathing fishes.

Rod and line (kaddigana) and long line (dhavnigana) are operated in all types of waters for catching fishes such as murrels, magur, singhi. Wallago attu and eels. An angler operates 4 to 6 rod and lines at a time. The catches are dominated (over 70 %) by murrels in Malnad and around Bangalore regions, followed by Mastacembelus armatus, Ompok bimaculatus and air breathing catfishes.

Shooting C. marulius and C. striatus with a gun is common practice when they move with the brood, near the margin of the tank.

A dip net with a mouth diameter of about 15 cm is used in shallow marginal areas of tanks around Bangalore infested with Eichhornia sp. for catching H. fossilis.

Coracle (ukkada, argolu) is extensively used in slow flowing rivers, reservoirs and tanks for operating gill nets and long lines. Occasionally, rafts made of elephant grass, Typha elephentina are also used as craft. Killekatha use dry shells of bottle gourd (sorakai) Lagalaria vulgaris or empty sealed tins to swim in water for paying gill nets.

1.2.4 Distribution of air breathing fishes

Only 4 species of murrels viz., C. marulius C. striatus and C. punctatus and C. orientalis are encountered in Karnataka waters. While the last three species have a wide distribution, occurring in almost all types of freshwater ecosystems, C. marulius is generally encountered only in rivers, reservoirs and larger tanks.

Among the two air breathing catfishes, C. batrachus is come across in almost all the tanks, rivers and reservoirs, being more abundant around Mangalore, Shimoga and Bangalore, whereas H. fossilis occurs in large numbers in weed infested tanks around Bangalore.

The featherback, N. notopterus is found in tanks and rivers. But the giant featherback, i.e. N. chitala has not been recorded in any of the water sheets.

1.2.5 Size attained by air breathing fishes

The maximum size attained by the different species of air breathing fishes in various ecosystems, recorded in the course of the investigations, has been given in Table 1.

1.2.6 Demand for air breathing fishes

Because of the high demand, most of the air breathing fishes caught are disposed off at the landing site itself and only a part is brought to the market for sale in live or dead condition. Larger specimens of *C. marulius* and *C. striatus* fetch the highest price among the freshwater fishes. The market price for air breathing fishes is about 80 % more than that of carps and 90 % more than that of catfishes, other than air breathing catfishes.

1.3 LIMNOLOGY OF TANKS

Lack of information on the physico-chemical and biological conditions of water and soil in derelict tanks and swamps has been a constraint in the formulation of proper management measures for increasing fish production from such ecosystems. To bridge the information gap, investigations on the limnology of 3 representative tanks, in the Malnad region of the State (Fig. 1), *viz.*, Belasokere (area : 19.2 ha) in Bhadravathi taluk (Shimoga district), which is highly polluted by the effluents brought in by the city drainage, Doddakere (area : 44.4 ha), a large tank in Shimoga taluk (Shimoga district) and Rangenahallikere (area : 22.2 ha) in Tarikere taluk (Chickmagalur district) which is a typical medium sized tank, were undertaken. In Malnad region the annual rainfall is fairly high ($\bar{x}$: 1,016 mm).

The range in physico-chemical conditions of water in the tanks were as given in Table 2. While the range in different parameters were ideal for organisms therein in Rangenahallikere and Doddakere the parameters such as dissolved oxygen (DO) and free carbon dioxide (CO_2) showed wide fluctuations and at times reached levels lethal to fish and fish food organisms in the sewage fed Balasokere. The nutrient status in all the three tanks was generally poor. The ammoniacal nitrogen (NH_4-N) content in water in Balasokere was relatively high.

The range in quality of soil in the three tanks was as in Table 3.

The density of both phyto- and zooplankton in the water was poor in Rangenahallikere and Doddakere, while Balasokere had a larger population of both. Among the phytoplankton, *Melosira* sp. and *Microcystis* sp. were present throughout the year in Rangenahallikere and Doddakere. Forms such as *Staurastrum* sp., *Pediastrum* sp., *Ankistrodesmus* sp., *Euglena* spp., *Navicula* spp., *Pinnularia* spp., *Synendra* sp. and *Dinobryon* sp. occurred occasionally. *Polyarthra* sp. dominated the zooplankton, followed by *Filinia* sp., *Moina* sp., *Cyclops* spp. and nauplii in both the tanks. *Microcystis* sp. and *Melosira* sp. were present throughout the year in Belasokere. *Desmedium* sp., *Synendra* sp., *Ceratium*, *Pinnularia* spp. and *Euglena* spp. appeared in different months. *eratella* sp. dominated the zooplankton in the tank followed by nauplii, *Cyclops* spp., *Cypris* sp. *Bosmina* sp. and *Trichocerca* sp.

The bottom macrofauna was poor in Rangenahallikere and Doddakere where a few *Tubifex* sp. and *Chaoborus* spp. were present, whereas in the sewage fed Belasokere, fairly rich bottom fauna were encountered. These included annelids, chironomid larvae (*Tendipes* spp. and *Chaoborus* spp.), bivalves (*Corbicula* spp., *Unio* spp.) and gastropods (*Amnicola* sp., *Lymnaea* spp., *Gyraulus* sp. and *Melanoides* sp.).

The gross primary production in the surface layer of water ranged from 31.2 to 212.5, 12.5 to 62.5 and 831.4 to 2,556.3 mg C m^{-3} h^{-1} in Rangenahallikere, Doddakere and Belasokere respectively.

The study indicated that the natural productivity of the tanks in general in Malnad is very low. The higher productivity of Belasokere is due to the discharge of city drainage effluents

1.3.1 Experimental fishing in tanks

The exploitation of most of the derelict tanks is rendered difficult because of the rank growth of macrophytes in them. Various types of gears like gill nets, cast nets, long lines and traps were operated in the three tanks to study their efficiency and economics with a view to develop techniques for the effective exploitation of such tanks.

Nylon gill nets of mesh bar 15, 20, 25, 30, 35, 40, 45, 50, 60, 70 and 80 mm with a width of 2 m were operated in the three tanks during the summer and monsoon for 12 h from 18-00 h . The data on catch effort^{-1} (100 m^2 net 12 h^{-1}) are given in Table 4.

Cirrhinus reba constituted the major catch in Doddakere and Rangenahallikere whilst in Belasokere, small *Puntius* spp. dominated. Murrels in general seem to avoid gill nets, as long lines operated simultaneously took more murrels than the gill nets.

Based on fishing data and measurements of girths of fish, the size ranges of *C. marulius*, *C. striatus* and *C. punctatus* which could be caught in gill nets of particular mesh sizes were computed (Table 5).

Long lines were found to be the most efficient gear for the collection of murrels from the tanks with live minnows, frogs and crabs as baits. Hooks of code numbers 7, 8 and 9 were found to take larger size murrels. The catch unit effort^{-1} of long lines in the three tanks in different seasons are given in Table 6.

Cast nets were found to be nOt efficient for fishing in the tanks, because of the difficulty in their operation due to the aquatic vegetation present. The catch per effort of cast net in the tanks are furnished in Table 7.

1.4 BIOLOGY OF MURRELS

Biological aspects such as maturity cycle, sex ratio, fecundity, spawning, age and growth and food and feeding habits of murrels and air breathing catfishes had not been studied in detail earlier. Practically no information on the bionomics of murrels inhabiting swampy tanks in Karnataka was available. Samples obtained from fish landing centres as well as fish markets in Shimoga and Bhadravati were utilized for the study of the biology of murrels. Samples were obtained from fish markets in Shimoga, Bhadravati, Mangalore and Bangalore and fish culture ponds in Bangalore [illegible].

1.4.1 Speciation in murrels

In the course of the biological investigations on murrels, it was observed that the ocellus in the caudal fin of C. marulius disappears by slow dispersal of pigments with increase in size of fish, suggesting that C. marulius and C. leucopunctatus are one and the same species. An analysis of the salient meristic and morphometric characters of C. marulius and C. leucopunctatus indicated that there is not even a single character showing significant variation, justifying separate species status for the latter. Student's 't' test of the meristic characters and analysis of covariance of the morphometric characters also supported this view. Several broods of C. marulius with distinct ocellus in the caudal fin were collected along with the parents in which the ocellus was wanting. On fingerlings reared in experimental ponds the ocellus began disappearing by slow dispersal of pigment when they attained a size of about 300 mm and completely disappeared when they were over 500 mm in length. The speciation of the Indian murrels was reviewed and a key based on morphomeristic characters for the identification of the various species worked out. The study revealed that of the 10 species of murrels described by Day (1889), only the following 7 are valied.

Channa marulius (Hamilton, 1822)
Channa striatus (Bloch, 1793)
Channa punctatus (Bloch, 1793)
Channa orientalis (Bl. and Sehn., 1801)
Channa stewartii (Playfair, 1867)
Channa micropeltes (Kuhl. and Val., 1831)
Channa barca (Hamilton, 1822)

1.4.2 Age and growth of murrels

Age and growth of *C. marulius*, *C. striatus* and *C. punctatus* were studied from length frequency data, growth checks on scales and opercular bones and by fitting of von Bertalanffy's theoretical growth model to the age data derived by the study of growth checks on scales. Length frequency data of the three species of murrels were analysed by probability paper plot method for dissecting out the length frequency distribution and to delineate the various age groups (Tables 8, 9 and 10).

The length weight relationship of the three murrels derived are given in Table 11.

The relative condition factor (Kn) of the three murrels through months was found to be related to maturity cycle and feeding intensity.

1.4.3 Maturity cycle of murrels

The maturity cycle of murrels was investigated by examining the stages of maturity of gonads through months, computation of gonado-somatic index and by studying the progression in the $\bar{x}$ size of the ova through months towards maturity and their final depletion. All the three species were found to be fractional spawners. Their breeding season extends from March to October/ November, the peak being June to July in Karnataka. The characters by which their sexes can be identified have been given in Table 12. The ratio between males and females, in C. marulius, C. punctatus and C. striatus was found to be as in Table 13. Their age and size at first maturity are given in Table 14. The data on fecundity of the three species are subscribed in Table 15.

1.4.4 Food and feeding habits of murrels

The feeding intensity of murrels through different size ranges and months and diet constituents were studied. The fry (4 to 30 mm) were found to subsist mainly on zooplankton while fingerlings of C. marulius (31 to 150 mm), C. striatus (31 to 120 mm) and C. punctatus (31 to 100 mm) fed mainly on aquatic insects, small fishes and shrimps. Still larger specimens of all the three species fed on trash fishes, insects and shrimps. The food of C. striatus and C. marulius over 300 mm in size consisted of insects, crabs, trash fishes, tadpoles and frogs.

1.5 BIOLOGY OF MAGUR AND SINGHI

Some aspects of biology of C. batrachus and H. fossilis were also investigated. The studies revealed that C. batrachus matures in South Kanara district during April to May, in Shimoga district during May to July and in Bangalore district during June to August. The sex ratio of the two species in these regions was found to be as follows :

District	C. batrachus males : females	H. fossilis males : females
Bangalore	1 : 1.10	1 : 1.28
Shimoga	1 : 1.24	1 : 1.70
South Kanara	1 : 1.39	1 : 1.25

Both species breed in Karnataka during June to August, coinciding with the south west monsoon, the peak spawning being in July.

H. fossilis (165 to 300 mm in length) subsisted on insects, organic matter, crustaceans and small fishes. In addition to the above, gastropods were also come across in the guts of C. batrachus (125 to 378 mm in length).

1.6 INDUCED BREEDING OF AIR BREATHING FISHES

As culture of air breathing fishes is yet to become popular in India, there is at present only very limited demand for their seed for stocking, which is met from natural sources. With progress in air breathing fish culture it will not be possible to meet the demand for seed from nature and seed production will have to be augmented by hypophysation.

Experimental induced breeding of the spotted murrel, magur and singhi has been reported. The Centre succeeded in the hypophysation of the giant murrel, striped murrel, the mud murrel, spotted murrel, magur and singhi, the former three for the first time, and has standardized the induced breeding technology of murrels to a great extent by conducting a large number of experiments.

1.6.1 Induced breeding of murrels

Carp pituitary hormones were administered to 10, 41, 52 and 17 sets of C. marulius, C. striatus, C. punctatus and C. orientalis of which 4 (40 %), 28 (68.2 %), 32 (61.5 %) and 14 (82.3 %) respectively yielded positive results. The experiments were conducted in circular plastic pools (diameter: 120 cm), holding water to a height of 35 cm with one female and one or two males. Aquatic weeds such as Hydrilla were introduced in the pools in the first few experiments to simulate natural environment.

1.6.1.1 Doses administered

An initial dose varying from 2 to 20 mg kg^{-1} weight of fish was administered to the females and nil to 20 mg kg^{-1} to the males. Four to six h afterwards, a higher dose varying from 5 to 380 mg kg^{-1} was given to the females and 5 to 250 mg, to the males.

1.6.1.2 Response

Unlike in carps, where the spawning occurs 4 to 6 h after second injection, in murrels the breeding occurred 10-30 to 22-00 h after, at a temperature range of 23 to 33° Celsius, although the doses administered were 2 to 54 times more than that given to carps.

The experiments indicated that a dose range of 45 to 60 mg kg^{-1} females in C. striatus and C. marulius and 15 to 40 mg in C. orientalis and C. punctatus is adequate for successful spawning.

1.6.1.3 Spawning behaviour

The female was found to pair with a single male 1 to 4 h after the second injection. Spawning was preceded by active, excited movement of the paired breeders. Spawning movement commenced about 8 to 10 h after the second injection. The male was found to hit the female near the vent region frequently and at times nibble its snout. This activity continued till spawning was completed, which took about 15 to 45 minutes.

1.6.1.4 Artificial fecundation

In instances where no spawning occurred within 21 to 24 h of second injection, the breeders were examined and if the female was found to be oozing eggs freely, artificial fecundation was resorted to, with success.

1.6.1.5 Water conditions

The average water conditions at the time of introduction of the breeders and spawning in the pools (with and without weeds) are given in Table 16. In pools having weeds, DO and pH were high and free CO_2 and alkalinity low and vice versa in those devoid of weeds at the time of spawning, which took place mostly between 10 to 14 h. NH_4-N showed an increase at the time of spawning in the pools without weeds compared to those with weeds.

1.6.1.6 Spawning by uninjected females

Uninjected, mature females of *C. striatus* introduced in the pool along with hypophysed breeders also spawned in four instances. Similarly, two uninjected *C. punctatus* held along with injected set of the same species also spawned. It appears that spawning of the injected breeders in the vicinity acted as a stimulus to the uninjected female to breed, indicating the possible occurrence of pheromones in regulating piscine reproduction.

1.6.1.7 Second spawning during the same season

To study whether murrels spawn more than once during the same season, the female breeders after spawning were held in a separate pond after fin clipping. Five such females each of *C. striatus* and *C. punctatus* could be successfully bred a second time during the same season. The second spawning took place between 63 to 142 days after in *C. striatus* and 55 to 87 days after in *C. punctatus*. This confirms the inference based on the examination of gonads that murrels are fractional spawners and can spawn more than once during the season. Apparently, the breeder stock could be used two or three times for induced breeding during the same season.

Observations seem to indicate that provision of weeds is not essential for spawning of murrels, which is primarily in response to administration of hormones. When aquatic weeds are introduced in the pools, collection of developing eggs is rendered difficult and hence it is not recommended.

It appears from the data that the number of eggs laid by a female murrel when hypophysed is more than in natural spawning. The identifying characters of developing eggs of murrels are given in Table 17.

1.6.1.8 Mass breeding of murrels

With a view to develop a simple method of breeding of murrels for obtaining seed on large scale, a total of 5 experiments, 3 with C. punctatus and 2 with C. orientalis were conducted in ponds during May and June 1977. 2 breeders each out of 8 females and 10 males in the experiment 1, 2 each of 7 females and 10 males in experiment 2, 1 each of 6 females and 8 males in experiment 3 of C. punctatus and 2 each of 6 females and 8 males in experiment 4 and 1 each of 6 females and 5 males and experiment 5 of C. orientalis were injected with carp pituitary gland, the dose administered being 20 mg kg^{-1} to the females and 5 to 10 mg kg^{-1} to the males. The second and third dorsal fin rays of the injected females were clipped prior to releasing them in the breeding ponds on rainy days. The catchment rain water was directed to the ponds, through polythene pipes jetting into the ponds.

The physico-chemical conditions of water in the ponds on the day of release of the breeders and the day after are given in Table 18.

Pairing and sexual activity were noticed 10 to 16 h after relasing the injected breeders in the ponds. Broods of eggs were observed 48 to 60 h later. A total of 14 broods (5,116 fry from 5 broods, 5,686 fry from 5 broods and 3,055 fry from 4 broods) of C. punctatus and 8 broods (3,486 fry from 5 broods and 1,995 from 3 broods) of C. orientalis, were examined. It was observed that all the hypophysed females and out of the uninjected females, 3 each of C. punctatus (50, 60 and 60 %) and 3 and 2 of C. orientalis (75 and 40 %) had spawned.

The observations suggest that spawning in the case of injected sets may have been due to the cumulative effect of pituitary hormones as well as the stimulus created by the flow of rain water into the breeding environment and that spawning of the uninjected females may have been activated by the spawning of injected breeders in the vicinity as also by the inflow of the rain water. Seed production of murrels on a large scale in tanks with less effort can be undertaken by this method.

In another experiment, 3 females of C. striatus were injected with a single dose of carp pituitary hormones at the rate of 40 mg kg^{-1} and together with 3 males injected uniformly at the rate of 20 mg kg^{-1} and released in a nursery pond at Kodigehalli fish farm. Two females spawned within one week, yielding 4,178 fry after a month.

1.6.2 Induced breeding of magur and singhi

Experiments were conducted during July 1983 on the hypophysation of C. batrachus, at the Government Fish Farm, Hagaribommanahalli in Bellary district. Five sets (1 set = 1 female and 2 males) of breeders were injected with carp pituitary hormones. The female breeders were 70 to 135 g in weight. A single dose of pituitary gland, varying from 20 to 30 mg kg^{-1}, was administered to the females and 15 to 20 mg kg^{-1}

to males. The breeders were held in hapas fixed in a pond. All the sets responded to the hormone injection. The percentage of fertilization of the eggs (in all the cases) was low (2.3 to 6.5). The fertilized eggs were sorted out after embryo formation and kept in a plastic tub for hatching. However, all the embryos died before hatching due probably to the high temperature of the ambient medium (37 to 39° Celsius).

Though the maturity condition of the breeders was not very satisfactory during 1984 breeding season, probably due to scarcity of monsoon rains, altogether 13 sets of C. batrachus and 5 sets of H. fossilis from the brood stock maintained in ponds at Hessaraghatta/ Kodigehalli fish farms, were hypophysed, of which 2 sets of C. batrachus and 4 of H. fossilis responded. The pituitary hormone, doses administered and breeding results are given in Table 19.

To trigger the maturity and spawning, 6 specimens each of either sexes of C. batrachus breeders were released in a small earthern nursery pond at Kodigehalli fish farm having 20 cm water, after administering both the males and females a pituitary dose of 10 mg kg^{-1} body weight of fish. The breeding pond was also provided with six horizontal holes (dia: 15 cm; depth: 30 cm) on the dyke and an outlet and inlet across the pond dykes, in order to give a natural spawning environment. Altogether 645 fingerlings ($\bar{x}$ size: 62.3 mm) were collected from the pond by draining, 4 months after.

1.6.3 Breeding of magur in ponds

Magur, which breeds in nature in inundated paddy fields during monsoon months, was induced to breed in a pond provided with about a dozen horizontal holes (20 cm in diameter and 30 cm long) made on pond dykes and inundating the pond with rain water. 3 female and 6 male breeders were introduced in the pond. Two months later when the water level receded in the pond, 152 fingerlings of magur in the size range 45.8 to 53.1 mm ($\bar{x}$ size: 51.5 mm) were collected. Though the fingerlings obtained were very few, the study certainly indicates successful breeding of the species in such simulated conditions.

1.7 COLLECTION OF SEED FROM NATURAL SOURCES

1.7.1 Murrel seed potential of tanks in Malnad

Intensive surveys were made to assess the murrel seed potential of six selected swampy tanks viz., Lakkavallikere (16.0ha)Rangenahallikere (22.0 ha), in Chickmagalur district, Doddakere (44.4 ha), Belasokere (19.2 ha), Milkatte (33.4 ha) and Nidige (12.2 ha) in Shimoga district.

Floating eggs guarded by the parents located in the weed infested marginal areas of the tanks were scooped with the help of a clean mug. Fry of C. striatus, C. punctatus and C. orientalis were found to move in shoals close to the water margin. The small fry were collected by a quick haul with a fine meshed cloth hapa and larger ones, with a velon netting hapa. Shoals of fry and fingerlings of C. marulius generally moved at a distance from the water margin. The fry were collected with a velon netting hapa and fingerlings, by operating a small meshed (7 mm mesh bar) cast net. More or less the entire brood could be collected by allowing the escaped fry, if any, to congregate and by repeated seining.

The fry and fingerlings of the various species were distinguished mainly by their general body colouration (Table 20). The eggs/ fry in each brood were enumerated. From the stage of development of embryos/ size of fry, their age was fixed and the breeding season of the different species determined.

The number of broods of the various species of murrels collected through months in the swamps are given in Table 21. The first collections of broods of C. marulius and C. striatus were made on March 1, 1973, the size of fry in the former ranging from 44 to 56 mm and in the latter, 22 to 25 mm, suggesting that spawning in both instances would have taken place during early February. Broods of C. marulius were obtained till October (size of fry: 23 to 26 mm) and those of C. striatus, till early December (size of fry: 16 to 18 mm). Broods of C. punctatus were available from May (size of fry: 9 to 11 mm) to September (size of fry: 12 to 14 mm) and of C. orientalis, during June (size of fry: 8 to 10 mm) to August (size of fry: 6 to 7 mm). A total of 48, 230, 30 and 9 broods of seed of C. marulius, C. striatus, C. punctatus and C. orientalis were collected from all the 6 swamps together. Maximum number of broods of all the four species were obtained during June and July, coinciding with the peak monsoon rains.

The number of fry brood^{-1} in the various swamps ranged from 357 to 3,649 in C. marulius, 538 to 5,290 in C. striatus, 477 to 1,864 in C. punctatus and 458 to 1,255 in C. orientalis (Table 22). The number of seed brood^{-1} during the later months of the spawning season, however, showed a progressive reduction in number.

The total quantity of seed of the different species collected from all the tanks together during the two years was as follows:

Species	Seed collected during 1973	1974
C. marulius	7,307	38,339
C. striatus	182,274	164,542
C. punctatus	12,750	15,575
C. orientalis	3,804	5,463

The 'seed index' computed through the various months for the different species indicated that Lakkavallikere and Rangenahallikere are richer in seed than Doddakere, Milkatte, Nidige and Belasokere. Among the four species of murrels, the 'seed index' through months of C. striatus was maximum in all the swamps investigated, followed by C. marulius in Lakkavallikere, Rangenahallikere, Doddakere and Milkatte and by C. punctatus in Belasokere and Nidige. The minimum 'seed index' was recorded in C. orientalis.

1.7.2 General seed surveys

Surveys were conducted to locate the breeding ground of air breathing fishes in the districts of Mandya, Mysore, Tumkur, Kolar, Bellary, Raichur and South Kanara. While seed of C. striatus and C. punctatus were collected from rivers and tanks of both seasonal and perennial nature in all the districts surveyed, that of C. marulius was generally encountered only from rivers and perennial tanks connected with river systems in the districts of Bangalore, Shimoga, Chickmagalur, Mandya and Mysore. Though H. fossilis and C. batrachus are distributed in most of the districts surveyed, the young ones of the former could be located in large numbers only in some seasonal tanks which are connected with the perennial Bellandur, Varthur and Doddaballapur tanks and Byramangala reservoir in Bangalore district and the latter, from the paddy fields in South Kanara district. Magur take shelter in the deep ditches in paddy fields during summer and with the onset of south-west monsoon and flooding due to heavy rains, migrate to the adjacent paddy fields for breeding. The paddy fields serve as nurseries for magur seed as they have a rich population of natural feed.

Since C. marulius grows fast and has high potential for culture; concerted efforts were made for mapping the seed resources of this species in river systems and tanks. Surveys indicated that seed of C. marulius is available in the river Tunga during March to June with peak during May. Seed availability became less and collections difficult once heavy rains set in and the river flow increased. New breeding grounds of the species were located in the river Hagari near Hagaribommanahalli during 1983 and the river Cauvery near Srirangapatnam during 1984. Their potential need to be assessed by further studies.

Survey for the giant murrel seed was taken up from April 1984 in five tanks (Yelahanka, Hebbal, Sankey, Lalbagh, Varthur and Bellandur tanks) around Bangalore, where the species was stocked by the Centre and is represented in the commercial catches. The leftover stock of C. marulius in the second culture experiment from Fish Farmer's pond at Hebbal was observed to have attained maturity and started breeding during March/April. The broods of C. marulius fry were located in this pond in April.

The details of the seed of different species of air breathing fishes collected incidental to the surveys undertaken are given in Table 23.

1.8 INCUBATION OF EGGS AND REARING OF FRY OF MURRELS

1.8.1 Incubation of eggs

In induced breeding experiments, where the eggs were left in the breeding containers for hatching, heavy mortality of developing eggs was observed. The dead eggs developed fungal moulds which spread to developing embryos and caused further mortality. Considerable mortality was observed in the process of larval devedpment also. Unlike in nature, the parents were found not to take care of the eggs and hatchlings when they were induced to breed.

In the subsequent experiments, the eggs were transferred to plastic basins having clear water after 1 to 2 hr of spawning. This helped in reducing the mortality to some extent.

Due to disintegration of dead eggs and larvae, a thin film of oil was found to cover the water surface which probably prevented atmospheric oxygen from coming in contact with water and mixing, thereby leading to reduction of oxygen in the water medium and causing mortality of embryos and larvae. Dripping of water arranged into the hatching basin helped in breaking the oil film, movement of the embryos as well as better oxygenation of the water medium, Aeration of the water using aquarium aerators also helped in reducing the mortality.

Experiments were conducted to evolve a simpler method of hatching of eggs. By holding the developing eggs (after removal of the dead ones) under oxygen packing till hatching and hatchlings till yolk absorption, mortality could be reduced to less than 5 to 10 %.

1.8.2 Rearing of early fry in plastic pools

The hatchlings after complete yolk absorption were reared in plastic pools having about 25 cm water column and feeding with seived zooplankton such as rotifers and cladocerans. In 8 to 10 days they attained a length of 10.5 to 12.0 mm, when they were transferred to cement cisterns for further rearing.

1.8.3 Supplemental feeding and nursery rearing

1.8.3.1 Supplemental feeding

Experiments were conducted with 3 replicates in earthen gamlas (vats), each holding 20 l chlorine-free tap water and 20 fry of *C. striatus* of the same percentage, obtained from nature by hypophysation. The feeds tested in addition to zooplankton were goat's blood, egg yolk, notonectids (*Anisops* spp.), fish meal, shrimps (*Penaeus* spp.), defatted silkworm (*Bombax mori*) pupae, groundnut cake, rice bran, wheat flour, bloated rice and cooked potato. The parameters considered for relative evaluation of the feeds were $\bar{x}$ survival of fry and production in the experimental units. Feeds which showed promise were experimented in combination (1 : 1) and also with micronutrients yeast or vitamin B complex. The micronutrients were supplied at the rate of 1 mg day^{-1}.

All the staple feeds excepting zooplankton were sundried and made into powder. They were broadcost over the surface of water in the experimental containers. Plankton alone was given in fresh condition.

The experiment (Table 24, experiment 1) showed that the fry fed with zooplankton registered maximum growth and survival followed by goat's blood, notonectids, egg yolk, fishmeal, shrimps and silkworm pupae among feeds of animal origin. Feeds of plant origin generally gave poor results, their rankings being lower than those of all the feeds of animal origin tested, excepting silkworm pupae. The poor survival and growth of fry fed with silkworm pupae were rather surprising.

The experiment was repeated deleting potato, rice and wheat flour (Table 24, experiment 2). Although both growth and survival of fry were poor with silkworm pupae, peanut cake and ricebran, these items were once again tested, since they are the commonly used carp feeds. The trend generally concurred with that of the earlier experiments. The two sets of experiments suggested that goat's blood, notonectids and egg yolk (in that order) are the promising feeds for murrel fry.

1.8.5.2 Nursery rearing

Experiments aimed at standardizing the nursery rearing techniques were carried out in duplicate, in cement cisterns (area: 11 m^2) having a water column of 50 cm. The number of fry stocked in the cisterns ranged from 220 to 1,650 (density of stocking: 0.2 to 1.5 million ha^{-1}). The management measues adopted were fertilization (with raw cow-manure at the rate of 20,000 kg ha^{-1}) along, fertilization and supplemental feeding with goat's blood or notonectids or a mixture of both (1:1) as well as addition of yeast or vitamin B complex to the feed. In experiments conducted with spawn (post-larvae, just after yolk absorption) the quality of feed supplied was computed as 2, 4 and 6 times the initial weight of spawn respectively till 10th, 20th and 30th day. In experiments with fry, the feed given daily was at a uniform rate of 50 % of their initial weight. Yeast or vitamin B complex when added to the feed was at the rate of 1 mg fry^{-1}. In experiments where spawn was stocked in nurseries, the aquatic insects therein were eradicated beforehand.

Of the 12 sets of nursery rearing experiments conducted (Table 25), in two (experiments 1 and 2), spawn just after absorption of yolk was stocked in the manured nurseries. In experiment 2 alone goat's blood was given as supplemental feed. The percentage of survival of fry ranged from 1.76 to 24.55 in experiment 1 and 2.49 to 26.36 in 2. The growth of spawn in both instances was poor. Fry over 8.48 mm in length were used in the later experiments. In addition to manuring, supplementary feeding was done in all these experiments excepting 3 with feeds evolved <u>vide</u> the laboratory experiments. In experiment 3, where there was no supplemental feeding, the survival of fry was low, ranging from 8.52 to 40.91 % and growth poor, whereas in experiments 4 to 12 (where there was supplemental feeding), the survival and growth of fry were better.

1.8.4 Seed rearing in paddy fields

An experiment was conducted in collaboration with the University of Agricultural Sciences, Bangalore with a view to find out the possibilities of using the paddy plots as nurseries for rearing murrel seed to fingerling size (about 100 mm). 3 plots, each having an area of 0.04 ha with 6 rescue pits (1 m^2 area and

0.5 m depth) made in the plots were stocked with advance fry (size: 44.5 mm/ 0.5 g) of C. striatus, at a density of 25,000 ha^{-1}. On conclusion of the experiment after 30 days it was found that the survival was poor (4.2, 5.5 and 7.4 %). It appears that most of the stock escaped through crab holes. The seed, however, attained a $\bar{x}$ size of 105 mm/ 1.8 g.

1.8.5 Seed rearing in cages

Seed of C. marulius collected from Tunga river and those of C. batrachus obtained from Mangalore were reared in cages made of nylon webbing (size: 2 x 1 m; mesh bar 6 mm). The rate of ~~stocking~~ feeding, growth and survival of the seed in cages were as in Table 25. Although the survival was not very high, the experiment indicates that cages can be utilized for the seed rearing of murrels and magur.

1.8.6 Seed rearing in nursery ponds

Seed of C. marulius collected from river Tunga during 1982 were reared in 2 nursery ponds (area: 0.04 ha each) at the State Government Fish Farm, Thippuganahalli in Kolar district. The details of the experiment are given in Table 26.

1.8.7 Rearing of murrel fingerlings in aquaria

To assess the acceptance of fresh silkworm pupae as feed, experiments were conducted for a period of 10 days with fingerlings of C. marulius (size: 72.6 to 115.9 mm) and C. striatus (size 54.3 to 107.1 mm) in aquaria (size : 60 x 30 x 30 cm) having 25 l water, feeding with fresh trash fish and silkworm pupae. The details of the experiment are presented in Table 27.

Fingerlings of C. marulius and C. striatus consumed fresh silkworm pupae, but not as readily as they took fresh trash fish in which case the growth was invariably better than that with fresh silkworm pupae.

1.9 SUPPLEMENTAL FEEDING OF MAGUR AND SINGHI

Experiments were initiated for evolving suitable formulated supplemental feeds for air breathing catfishes, using readily available ingredients.

1.9.1 Formulation of feeds

Six different feeds were formulated for magur and singhi, using components such as ricebran (RB), groundnut cake (GC), fishmeal(FM), drid animal blood (AB), dried cowmanure (CW) and commercial agrofeed (AF). The compounded feeds were made into water stable pellets using white flour as binder (5 %) with the help of a hand mincer, sun dried and stored air tight in plastic bags. The ingredients of the feeds and their ratios are given below :

Feed type	Ingredients	Ratio
F1	RB and GC	3 : 1
F2	RB and AB	3 : 1
F3	RB and FM	3 : 1
F4	CM, RB and FM	3 : 1 : 1
F5	CM, RB and FM	3 : 1 : 1
F6	AF	

The proximate composition of the different feeds is given in Table 2C.

1.9.2 Screening of feeds

A preliminary experiment was conducted to evaluate the feeds using fingerlings of singhi as test fishes in specially designed basket cages (area : 0.3 m^2) in Sankey tank, Bangalore. The stocking density was 15 fish $cage^{-1}$. The experiment was run for a period of 111 days. The different feed pellets were given daily, at the rate of 5 % weight of the stock. The $\bar{x}$ growth of fish ranged from 30 to 60 mg day^{-1}. The details of the experiment are given in Table 29. The study indicated that the feeds may be ranked as follows based on their performance:

F5, F4, F6, F1, F2 and F3.

1.9.3 Growth of magur and singhi under supplemental feeding

A preliminary experiment conducted to compare the growth and conversion efficiency of *C. batrachus* and *H. fossilis* when fed with blood obtained from abattoir (boiled and minced) showed that the growth of the former species is better than that of the latter, under similar experimental conditions (Table 30). The weight gain of magur was more than double that of singhi.

1.10 ENEMIES OF FRY AND MANAGEMENT MEASURES

The yolked larvae of murrels and air breathing catfishes with their heavy yolksac, being not able to move fast, were found to be attacked and killed by copepods, especially *Cyclops* spp. To ward off the attack, only sieved, plankton (preferably rotifers and cladocerans) should be given in the early rearing phase of murrel fry.

Notonectids (7 to 8 mm long) were found to attack and kill *C. striatus* fry measuring up to 16 mm. To overcome this problem, the same precautionary measures adopted for controlling aquatic insects in carp nurseries may be followed with advantage in the nursery rearing phase of murrel till the fry grow to a size of 22 to 24 mm. They begin feeding on notonectids at this stage.

Dragonfly and mayfly larvae were found to prey upon the fry and fingerlings of murrels. Mayfly larvae were observed to stick to the body [illegible] and prey upon the flesh of murrel fingerlings (48 to 73 mm long).

Among fishes, Oxygaster spp., Puntius spp., Mystus spp., Mystus tengara, Ompok bimaculatus, Ambassis spp. and N. notopterus in addition to murrels, were observed to predate on murrel fry.

1.11 CANNIBALISM AND MANAGEMENT MEASURES

Cannibalism was found to be very pronounced in murrels, magur and singhi, especially in the fry and fingerling stages, the larger and stronger ones preying upon the weaker and smaller ones. In the normal course, if the fry are released in a nursery without adopting any management measure, only a few survive and attain fingerling size because of cannibalism. Due to this, the fry rearing phase in these fishes, unlike in carps, is complex.

By rearing uniform sized fry/ fingerlings in plastic pools with adequate feed, 100 % survival of fry was achieved. It was also observed that by providing feed in abundance, the cannibalistic tendency in fry and fingerlings can be minimised.

1.12 SEED TRANSPORT

1.12.1 Seed transport under oxygen packing

Experiments were conducted holding spawn and fry of C. striatus in various densities and for different time durations in 8 l water and a column of oxygen is air tight polythene bags kept inside tin containers, with the objective of studying the physico-chemical changes taking place in the water medium and standardising the transportation techniques of murrel seed.

In experiments on transport of eggs, only fertilized eggs were used. The density of packing (number of seed l^{-1}) ranged from 400 to 2,000 in the first two sets of experiments which were run for 24 and 48 h, and from 400 to 1,500 in the third, run for 72 h (Table 32). The $\bar{x}$ survival of seed in the experiments ranged from 77.3 to 100.0 %, 69.4 to 94.7 % and 71.5 to 97.1 %. The seed, in experiment 1, on conclusion were still in embryonic stage whereas in 2, part of them had hatched out while in 3, hatching was complete. The few dead ones had developed fungal mycelia and clustered as floating white masses.

The initial and final temperature of water in the experimental units varied only by $\pm$ 0.2° Celsius. The water in the experimental units was rich in dissolved oxygen, the values being generally higher than the initial, especially in those where the density of packing was low and duration of observation short. The values of free carbon dioxide, alkalinity and ammoniacal nitrogen (NH_4-N) showed an increase with increase in the density of packing and duration of the experiments. The pH was more or less steady, coinciding with the increase in DO.

When yolked hatchlings (3.0 to 3.5 mm long) were held under oxygen packing, the density ranged from 400 to 1,500 in experiments 1 and 2, and 400 to 1,000 in 3 which were run for 24, 48 and 72 h respectively (Table 32). The $\bar{x}$ survival of spawn was very high, ranging from 75.4 to 99.9 %, 71.4 to 96.3 % and 71.3 to 93.8 % in the experiments. The fluctuation in water temperature was limited to $\pm$ 0.1 to 0.3° Celsius. The concentration of DO on conclusion was higher than the initial in all the experimental containers excepting in one set (experiment 3) where it was less (6.4 g l^{-1}) and the density of packing, 1,000. In general, higher values of DO were obtained in experiments where density of packing was less and duration of observations short. The dissolved free CO_2, alkalinity and NH_4-N content showed the same trend as in the earlier experiments. However, although the densities of packing in these experiments were comparatively less than those with developing embryos (Table 34), the increase in the concentrations of free CO_2, alkalinity and NH_4-N was significantly higher. The pH showed a decline with increase in density of packing and duration of experiments.

Fry, measuring 9 mm were packed in experiments 1 to 5 (Table 33). The packing density ranged from 400 to 750 in experiments 1 and 2 which were run for 24 h. The experimental units of the former were transported covered and the latter, exposed to sunlight. The $\bar{x}$ survival in the first ranged from 72.5 to 94.8 % and in the other 63.3 to 85.3 %. Water temperature in experiment 2 at conclusion had increased by 5.1 to 5.5° Celsius from the initial value whereas in 1, the increase was only $\pm$ 0.1 to 0.2° Celsius. Significant decrease in DO and pH and increase in free CO_2, alkalinity and NH_4-N were recorded in experiment 2 in comparison to 1. In experiments 3, 4 and 5 which were run for 36, 48 and 72 h, the density of packing ranged from 300 to 600, 250 to 500 and 125 to 300 and the survival of fry varied from 71.7 to 92.1 %, 68.2 to 84.3 % and 58.4 to 79.2 % respectively. Although the density of packing in the experiments was considerably less than those in Tables 31 to 33, the values of free CO_2, alkalinity and NH_4-N were higher and DO and pH lower at close, apparently as a result of the higher oxygen demand and excretion of larger amounts of metabolites by bigger fry. The values of DO and pH in experiment 2 which was exposed to sunlight and run for 24 h were less, and free CO_2, alkalinity and NH_4-N more, at conclusion than those of experiment 2, which was run for 36 h.

17 more experiments were conducted with fry of different sizes. The density of packing, duration of observation and the $\bar{x}$ percentage of survival were as in Table 34. With larger fry, even when the density of packing was less, the DO content and pH of water decreased while free CO_2, alkalinity and NH_4-N increased considerably at conclusion of the experiments.

In experiments 13 and 17, where the fry were repacked, the survival at 72 h ranged from 51.8 to 84.6 %

in the former and 69.4 to 96.7 % in the latter. The values of DO and pH of water at conclusion of these experiments were higher, and free CO_2, alkalinity and NH_4-N lower than those of 12 and 16 h durations.

It was observed that when various factors individually or collectively reached lethal levels in the experimental units, the colour of fry slowly changed from light brown to dark. The fry showed signs of distress, congregating and gasping near the surface of water later went passively down, moved erratically and died.

When fry on conclusion of the experiments were directly released in rearing ponds or containers having a large water column, considerable mortality occurred as a result of their failure to come up to the water surface for breathing atmospheric air. Hence the contents of the experimental units were transferred to a basin and the water was gradually replaced with that of rearing pond. The fry were allowed to acclimatize and feed on the plankton available in the water and were then stocked in the rearing ponds in which case the mortality was observed to be negligible.

1.12.2 Transportation of seed in open containers

The fry (6 to 30 mm) of *C. striatus* and *C. punctatus* could be transported with negligible mortality in *hundis* (capacity : 100 l) at 300 to 100 l^{-1} for 4 to 10 h without renewal of water. Fingerlings (31 to 60 mm) of the two species also could be transported at a density of 80 to 50 l^{-1} in *hundis* without mortality for periods extending from 4 to 8 h. The tendency for jumping in the fingerlings could be controlled by the introduction of some aquatic weeds in the containers.

The seed of *C. marulius* was transported with and without oxygen. When seed carriers (capacity : 20 l;

volume of water : 10 l) are used without oxygen, up to 750 fry (size : 43 to 95 mm) could be transported safely for a road journey of 10 h duration without change of water enroute. However, under oxygen packing, up to 250 fry of the same size only could be transported without motality for the same 10 h journey duration, probably due to the smaller volume of water available in this type of container.

Seed of magur was transported from Mangalore to Bangalore by road in small mouthed plastic containers (10 l capacity) holding 5 l of water, covered with a perforated lid, in 20 h. The size range of fry and numbers held in each containers are given below :

Length range (mm)	$\bar{x}$ weight (g)	No.of seed container^{-1}
15 - 62	0.480	500
25 - 55	0.405	730
56 - 82	1.125	500

Water was replaced enroute at Hassan after about 6 h journey. The fry withstood the journey of 10 h without showing stress. However, in each carrier, 3 to 5 specimens with just head and vertebral column were seen. Apparently, the flesh of these probably weak specimens was completely eaten by the other fry.

There is perhaps no need to transport magur seed under oxygen packing as there is a possibility of their puncturing the polythene bag with the strong pectoral spines.

1.13 PROPAGATION OF THE GIANT MURREL

With a view to propagate the less common C. marulius in tanks devoid of this species in Bangalore, 575 fingerlings, weighing 4.5 g ($\bar{x}$) and 20 brood fish, were released in Hebbal tank, during 1979. They made use of the hitherto underutilized abundant forage fishes, grew fast and established in the tank. The species formed 5 and 30 % in the commercial catches from this tank in 1981 and 1982 respectively.

1.14 CULTURE EXPERIMENTS

Because of the rich accumulation of organic matter, swamps can be highly productive under proper management. The oxygen depletion occurring in such water bodies will not kill air breathing fishes if cultured in them and high yields can be expected. In view of the efficiency of feed conversion and the capacity to thrive in over-crowded situations and their high demand, culture of air breathing fishes such as the giant murrel, striped murrel, magur and singhi was attempted in derelict tanks and fish culture ponds with supplemental feeding. Practically very little work in these lines has been done.

Due to the constraints with regard to field facilities, only a few experiments of a preliminary nature could be conducted on the culture of air breathing fishes. However, the data gathered have given sufficient indications regarding their potential for culture.

1.14.1 Culture of murrels

1.14.1.1 Culture of *C. striatus* in swampy pond

Six simulated swampy ponds in the fish farm at B.R. Project were stocked with minnows such as *Puntius stigma*, *Puntius ticto*, *Rasbora daniconius* and *Amblypharyngodon mola* to multiply and serve as forage for the murrel, *C. striatus* which was stocked after 2 months. Care was taken to stock uniform sized murel seed of the same brood in each pond. Because of limited field facilities, the experiments could not be replicated. Ponds 1 and 2 were kept without any treatment (control) whereas fertilization with cow manure and lime was done in the rest. The layout of the experiment is given in Table 35.

Manuring helped in production of food organisms to trash fishes which multiplied rapidly and formed sustained forage for murrels. The ponds were harvested after 6 to 12 months. The computed production ha^{-1} yr^{-1} was 128.7 and 143.6 kg in the control ponds and 713.1 to 894.8 kg in the ponds where manuring and other management measures were undertaken (Table 36).

1.14.1.2 Culture of C. marulius in swampy pond

In another experiment a swampy pond (area: 0.0285 ha) was stocked with trash fishes at the rate of 20,000 ha^{-1} ($\underline{c}$ weight : 46 kg ha^{-1}), two months prior to releasing of murrels, so that they could multiply and form sustained forage for murrels. Fingerlings of C. marulius (61 to 67 mm long) were stocked in the pond at the rate of 10,000 ha^{-1}. Manuring was dispensed with and the stock fed with dried trash fish at 3 to 5 % body weight. The experiment was concluded after 9 months of observation. By then the fish had attained a $\bar{x}$ weight of 290 g. With 83.5 % of recovery, the total weight of fish harvested from the pond was 68.4 kg. The $\underline{c}$ production worked out to 2,401.5 kg ha^{-1} 9 $months^{-1}$.

1.14.1.3 Culture of C. marulius in earthen pond

An earthen pond (area: 0.06 ha) at the State Fish Farm, Hessaraghatta, Bangalore was stocked with 900 fingerlings of C. marulius in the size range 91 to 165 mm ($\bar{x}$ size: 119.5 mm/ 3.25 g). The stock was fed with tadpoles and trash fishes collected from nearby ponds. For some time they were also fed on minced marine trash fish. There was Lernaea sp. infection in about 8.57 % of the stock when examined on the 30th day of stocking (1 to 2 Lernaea sp. in each fish). As a result of frequent change of water, the infection declined and by the 60th day there were practically no fish afflicted with the parasite in the pond. The water supply condition to the fish farm was severely affected by November due to the prevailing drought condition in the area. Since the water column in the pond was very low, the fish were found getting embodded in the mud and becoming weak and dying. The fish were drag netted and the details of recovery (41.6 %) and production are given in Table 37. The net increment was 0.49 g day^{-1}.

1.14.1.4 Culture of C. marulius in cages

An experiment was conducted on the table fish rearing of the giant murrel, C. marulius in captivity in a circular floating net cage of size 5 m^2 (underwater volume: 5 m^3) from December 1984, for a period of 160 days. The stocking density was 40 fingerlings m^{-2} (200 fingerlings in 5 m^2 cage) in the range 145 to 245 mm in total length ($\bar{x}$ size: 155 mm/ 25.8 g). Feeding was done as far as possible daily with freshly collected trash fish at the rate of 10 to 12 % of the weight of the stock on wet weight basis. The $\bar{x}$ size attained by the fish on final sampling (after 160 days) was 177.1 g (size range: 198 to 362 mm/ 65 to 270 g) and the gross and net production obtained were 6.9 and 5.9 kg m^{-2} 160 $days^{-1}$ respectively, with a survival of 98 %, which incidentally is a record production so far in cage culture of C. marulius. The food quotient was 2.5, based on the dry weight of the feed and wet biomass gain by the stock.

The experiment indicated that the giant murrel can be efficiently utilized for the conversion of trash fish into quality table fish.

1.14.2 Culture of magur

1.14.2.1 Culture in earthen pond

An experiment on the culture of C. batrachus was carried out for a period of 220 days from January 1983 in three earthen ponds (area : 0.05 ha each) at State Government Fish Farm, Hagaribommanahalli (350 km from Bangalore, latitude : 15° 20' N; longitude: 76° 13' E) having granite stone revetted dykes holding a water column of 50 $\pm$ 25 cm The ponds were uniformly fertilized with cowmanure at the rate of 12 t ha^{-1}.

The fingerlings of magur (19,000 collected from nature) procured from West Bengal were transported by rail in 10 round galvanised iron drums, each of 100 l capacity, from Howrah to Hagaribommanahalli, covering a distance of 1,922 km in 51 h. Water was partially replaced in the containers enroute once at Vijayawada railway junction (34 h after commencement of journey). On arrival of the consignment at the fish farm, about 33 % of the seed were observed to have died and a large number of the surviving ones were weak due to stress, strain and injuries sustained during transit. The live ones were sorted out and given a bath in 10 mg l^{-1}, Furanace (Furanace granules 10 % : chemically nifurpirinol manufactured by Dainippon Pharmaccutical Co., Ltd., 25 Doshomachi 3-Chome, Higashiku, Osaka, 541 Japan) solution for about 10 min. After sample measurements, the fingerlings were enumerated and released in the experimental ponds. Since some more mortality of the badly injured seed was expected, two concrete cisterns (with soil bottom) were stocked with 100 fingerlings each and, based on their survival 15 days after, the final stocking figures in the ponds were adjusted. The details of the stocking of the ponds are given in Table 38.

Chickmash (locally available commercial poultry feed) was given as feed to the fish stock after binding with white flour (7% w/w). The flour was mixed with water and boiled to make a thin paste to which chickmash was added, made into balls and kept in earthen vats in the four corners of the experimental ponds. The daily ration provided was 1.5 to 3.0 % body weight of the stock. During the last 120 days of the experiment, because of the poor growth of the stock, the chickmash was fortified with 13.0 % fishmeal. Feeding was done once a day between 09.00 and 15.00 hour for the first 57 days and thereafter, twice a day at 08.00 and 15.00 hour. The experiment was run for a period of 220 days. The quantity of feed supplied in the three ponds during the experiment is given in Table 39 and its proximate composition, in Table 40. While most of the feed was consumed by the fish stock, part of it may have got dispersed in the pond water and acted as fertilizer.

The water quality (range) in the ponds was as in Table 42. The water which was fairly clear in the beginning turned brown after fertilizing with cowmanure. Zooplankton dominated the plankton population up to March in all the ponds. However, from April onwards the population of phytoplankton was more than that of zooplankton, except in August in pond 1 where the reverse was the case. Blooms of Rivularia sp., Spirulina sp., Ceratium sp., and Microcystis sp. appeared in the three ponds in different months. Among the zooplankters, rotifers (Keratella spp., Brachionus sp., and Filinia sp.) and copepods (Diaptomus sp., Cyclops spp. and their nauplii) were the dominant forms in the ponds.

Harvesting was done by operating a drag net thrice in each pond, followed by partial draining and picking up the fish from the bottom mud, using dip nets. The data on the $\bar{x}$ size of the stock in the ponds at the time of completion of the experiment, the percentage recovery, gross and net production and food quotients are given in Table 42. It is estimated that about 5 to 18 % of the fish could not be recovered from the ponds because of their escaping into the numerous crevices in the dykes, below the water surface.

The gross production from the ponds ranged from 1.5 to 2.8 t ha^{-1}. The increment in weight of the fish was 28 g in the two ponds with higher stocking density and 44 g in the pond with lower stocking density, i.e. 3.9 to 6.0 g $month^{-1}$; in contrast to the high growth of magur in the experiment in spite of ideal water temperature (25.8 to 31.5° Celsius) is rather surprising. Although no mortality was observed, the DO and high free CO_2 appears to have adversely affected the feed consumption and conversion and growth of the fish. Further, the poor growth rate of the fish and the low production may probably be due to the cumulative effect of the inferior quality of the feed, commencement of maturation of the stock resulting in the reduction of somatic growth and accumulation of matabolites in the water medium.

1 .14.2.2 Culture in nursery pond

With a view to utilize carp nursery ponds during off-season, the fry (340) of C. batrachus (Length range : 28 to 77 mm ; $\bar{x}$ length: 48.9 mm; $\bar{x}$ weight: 0.94 g) procured at Mangalore were stocked in a small earthen nursery pond (area: 0.002 ha) of the private fish farmer at Kodigehalli village, Bangalore for rearing to table size. The fish were fed with left-over feed from the fish farmer's poultry farm. Since the water level in the pond was shrinking rapidly and the fish were being preyed upon by birds, the pond was dewatered and 217 fish were retrieved (length range: 160 to 205 mm). It was noticed that there were underwater crab holes in the common dyke, separating the nursery from the adjoining large pond and it is possible that some fish may have entered the large pond through the holes. The growth, survival and production obtained during the rearing period of 250 days is reported in Table 44. The c gross and net production obtained were respectively 5,050 and 4,840 kg ha^{-1} in 250 days.

1 .14.2.3 Culture in cages

An experiment on the culture of magur was undertaken in 3 cages made of knotless nylon webbing of mesh size 12 mm (area: 2 m^2 each) stocking with 200 fingerlings ($\bar{x}$ initial size: 111 mm/ 7.4 g) at the rate of 1 million ha^{-1} in each cage. The fish were fed with a mixture of rice bran, dry fish (cooked) and groundnut cake in the ratio 4:2:1. The experiment was run for a period of 3 months. Growth, survival of the stock and production were as in Table 45.

1 .14.3 <u>Culture of singhi</u>

An earthen pond belonging to an agriculturist of Jalahalli village, Bangalore was stocked with 2,250 fingerlings (80 to 102 mm in length and 6.3 g in $\bar{x}$ weight) of singhi at a density of 0.15 million ha^{-1} during 1980. The fish were fed with a mixture of rice bran and groundnut cake (2:1 ratio). They attained a size ranging from 152 to 185 mm with a $\bar{x}$ weight of 28.5 g in 4 months. A total of 594 stock (26.4 %) weighing 16.9 kg (1,126 kg ha) was harvested from the pond. All the fish could not be retrieved as the pond was deep in the middle and was heavily silted and it could not be drained.

A newly built side revetted soil bottom pond (area : 30 m^2) of another agriculturist at Doddagubby, Bangalore was stocked with 1,800 fingerlings of singhi (initial $\bar{x}$ weight: 18.3 g) at the rate of 0.6 million ha^{-1}. The fish were initially fed with a mixture of rice bran, groundnut cake, ragi (Eleustine coracapa)flour, fishmeal and silkworm pupae in the ratio 3:2:1:1:1 and later with a mixture of rice bran, and biogas slurry in 1:1 ratio (dry weight) at 10 % body weight. Once in a month the pond was dewatered, cleared of the bottom accumulations and filled with fresh water. About 10 % of the stock, when they attained a $\bar{x}$ weight of 32.5 g, developed abscess on their body. With treatment the infection could be controlled and the stock recovered within 10 days time. 7 months later, 1,465 fish weighing 72.0 kg was harvested from the pond. The $\bar{x}$ weight of fish was 49.2 g, survival 81.4 % gross production, 24 t ha^{-1} in 7 months.

12.14.4 Mixed culture of murrels, magur and singhi

12.14.4.1 Culture in swampy ponds

With a view to demonstrate the production potential in mixed culture of air breathing fishes, a swampy pond (area : 0.1 ha) in Lalbagh, Bangalore was stocked with them. The layout of the experiment was as given in Table 46.

Murrels were trained to accept supplemental feed by providing fresh fishes in the beginning, which was progressively substituted by dried marine trash fish (soaked and chopped) and fresh silkworm pupae. The quantity of feed given day^{-1} was adjusted according to demand. The feed was broadcast twice a day in the feeding area cleared of weeds.

Among murrels, C. marulius responded well to the supplemental feeding. The growth of the species was remarkable during the first 3 months, rather slow during 4th and 5th month and again picked up in the 6th month (Table 47). After the 3rd month the fish stock could not be fed adequately. The experiment was concluded after 7 months and a total of 235.75 kg fish was harvested from the pond. The c production was 2,358 kg ha^{-1} 7 $months^{-1}$ (4,041 kg ha^{-1} yr^{-1}).

The fishes were sold at the rate of Rs.8 kg^{-1}. The details of recovery percentage, production, expenditure and returns (on current price rates) are presented in Tables 48 and 49.

The poor survival obtained in *C. punctatus* and *C. striatus* may be due to predation by *C. marulius*, suggesting that it may not be desirable to co-stock the former two species with the latter.

The second experiment on the culture of air breathing fishes in the same pond was initiated by stocking 810 fingerlings of *C. marulius*, 110 *C. striatus* and 1,000 *C. batrachus*. The fishes were fed with trash fishes and a mixture of groundnut cake and ricebran. *C. marulius*, *C. striatus* and *C. batrachus* attained 900 to 1,850, 350 to 680 and 210 to 375 g in weight, respectively within a culture period of 12 months. Unfortunately, the fishes could not be harvested in time as dewatering the pond for collecting the stock or clearing the thickly infested aquatic weeds (*Nymphaea* sp. and *Salvinia* sp.) for operating nets could not be done due to certain administrative problems from the Lalbagh authorities. However, after a lapse of 10 months, a total of 38.5 kg of murrels and magur could be collected from the pond.

12.12.4.2 Culture in cisterns

To assess the feasibility of culturing air breathing fishes in cisterns, experiments were conducted with fingerlings of *C. marulius*, *C. striatus* and *C. batrachus*. The stocking rates were 150, 200, 250 fingerlings m^{-2}.

Trash fishes collected from nearby ponds were given as feed for murrels and a mixture of trash fish, groundnut cake and ricebran, for singhi. Although the growth of C. marulius and C. batrachus was encouraging, that of C. striatus was disappointing. Gross production ranging from 16.325 to 22.150 kg m^{-2} 6 $month^{-1}$ in C. marulius, 4.050 to 5.220 kg m^{2} 6 $months^{-1}$ in C. striatus and 12.800 to 18.475 kg^{-2} 6 $months^{-1}$ in C. batrachus was obtained.

A cistern (area : 40 m^2) available with an agriculturist at Doddagubby near Bangalore was stocked with murrels, singhi and magur at a density of 0.1 million ha^{-1}. The number of fingerlings stocked and their $\bar{x}$ size were as given below :

Species	No.stocked	Size of fingerlings ($\bar{x}$) length (mm)	weight(g)
C. marulius	110	115.0	11.25
C. striatus	75	72.4	3.00
H. fossilis	105	96.4	8.75
C. batrachus	110	125.3	18.70

The culturist was advised to feed the murrels with trash fishes and the catfishes with a formulated pellet feed consisting of abattoir waste, fishmeal, poultry droppings and silkworm pupae in 3:1:1:1. Due to non-availability of trash fish on regular basis, discontinued the feeding of murrels. However, the feeding schedule for catfishes was adhered to C. batrachus attained (100 to 120 g ($\bar{x}$: 105.4 g) and singhi, 35 to 55 g ($\bar{x}$: 40.5 g) in 6 months. The survival was 100 % in the former and 74.2 % in the latter. The total production from the cistern was 14.75 kg (c production : 3,688 kg ha^{-1} in 6 months).

1 .14.5 Harvesting of wild stock from a derelict pond

A small circular swampy pond (area: 0.009 ha; depth: 1.5 m at the time of harvesting) situated near Hebbal tank, belonging to an agriculturist, was harvested in May 1984. During the earlier years it was observed that the impoundment was harbouring magur, singhi and murrels. In monsoon months (July to September) the pond becomes connected with Hebbal tank. It is infested with Typha sp. (in the periphery) and Hydrilla sp. Air breathing fishes migrate to the pond from Hebbal tank, and other water bodies in the catchment area. Both Hebbal tank and the derelict pond studied completely dried up during May 1984. The fishes caught from the pond were mostly one year old. The harvesting of the pond was done by dewatering (using a pumpset) and picking up the fish with the help of dip-nets from the bottom and after initial netting. The soil at bottom was loose up to 50 cm depth and it was very difficult to recover the fishes, especially singhi and magur, which got embedded in the mud. The details of the harvest are given in Table 50. The gross yield obtained from the derelict pond was 37.51 kg (4,168 kg ha^{-1}).

Four specimens of C. marulius (size range: 600 mm/ 1,500 g to 705 mm/ 1,800 g) were also caught from the pond. From the study of their scales, the fish were found to be of 2 + years old. They seem to have migrated from the Fish Farmer's pond (left out stock from second culture experiment) during rainy season. None of the murrels (both C. marulius and C. striatus) collected from the pond were in gravid condition. A few magur and singhi however, were found to be mature.

1 .15 PARASITES AND DISEASES

1 .15.1 Parasites

The parasites most commonly encountered in murrels were Lernaea sp. and Argulus sp. Murrels having attack of these two crustacean parasites were come across both in swamps and ponds, the incidence being more during summer and winter months. From the higher frequency of occurrence of Lernaea sp. in C. striatus, it appears that this species is more suceptible to attack by the parasite which makes the fish weak and emaciated.

Among fish diseases, dropsy and fin-rot were observed mostly in the nursery reared fry and fingerlings of C. striatus. Handling was found to be the main reason for fin-rot and the disease was controlled by giving a bath in 1 % acriflavin or 0.3 % formalin solution for about 10 minutes for a week.

1 .15.2 Eye disease in C. marulius

In the culture experiment pond at Lalbagh, a few specimens of C. marulius having eye disease, as evidenced by the milky white appearance of the eyes, were come across. The disease causing bacterium was isolated, cultured and identified as Staphylococcus sureus. This is the first record of disease due to S. aureus in fishes.

1 .15.3 Furunculosis in H. fossilis

In a culture experiment, where fingerlings of H. fossilis were stocked in a pond (area 30 m^2), about 10 % of the fish ($\bar{x}$ size: 175.4 mm/ 32.5 g) developed abscess on their body. A sample of severely affected specimens was brought to the laboratory for investigations. Abscess material drawn from the infected fish was streaked on to blood agar and incubated. The colonies which appeared were subjected to bacteriological tests to identify, the bacterium. The disease was diagonised as furunculosis, caused by Alkaligenes faecalis. Tests carried out revealed that the bacteria are sensitive to Kanamycin and chlortetracycline. Administration of intramuscular injection of Kanamycin (brand: Kanein: manufactured by Alembic Chemical Works Co., Ltd., Baroda, vials containing Kanamycin acid sulphate B.P., equivalent to 0.5 g of Kanamycin base) at the rate of 1 mg fish^{-1} day^{-1} resulted in disappearance of the abscess within 6 days. However, when the drug was mixed with feed and given, it took about 10 days for the disappearance of the vesicles in the fish.

1.15.4 Emaciation in C. punctatus

Post mortem examination of an emaciated C. punctatus found in the margin of a tank in Bangalore during routine surveys revealed that the fish was a male with a normal right testis and an abnormally large left testis, that the musceles were pale and atrophic and that liver had become atrophied with yellowish colouration. The abnormal testis measured 4 x 2 cm in size. It was whitish in colour and soft in consistency with translucent fluid inside and had four opaque round nodules measuring 4 to 8 mm in diameter. The growth consisted of a mass of neoplastic cells arising from tubular epithelium of the seminiferous structures. The studies led to the conclusion that the fish suffered from toxic hepatitis and primary testicular neoplasis and that it had been starving, leading to extreme emaciation.

1.16 GROWTH OF TAGGED GIANT MURREL

Studies were undertaken on the growth of the giant murrel by releasing tagged fish during 1977 and 1984. Pond reared C. marulius of length range 143 to 289 mm were tagged during 1977 and of 80 to 185 mm, during 1984 (Table 49), with cuff-type external tag sutured to the body by a hypodermic syringe in the distal caudal region, above the lateral line. The plastic fish tags were hand-crafted, using embossing plastic tape and a letter embossing gun. Monofilament thread (1 mm dia) was used for making the 15 mm long tag-cuff.

In 1984 the tagged specimens (No: 555; 45 days old) were reared in a cistern (area: 3 x 2 m) after labelling, for a period of 45 days and were examined for infection and mortality due to suturing, shedding of tags, etc. There was some mortality (14.05 %) in the initial stages up to 12 days. Of the surviving tagged fish, only 6 (1.15 %) had dropped their tags. All the fish were found to be healthy with the scar of the post-operation injury of tagging.

The data on recovery of the fish made from the different habitats are given in Table 50. The tagged specimens examined after recapture exhibited no sign of muscle dystrophy and the monofilament thread fused well in the back muscle. The highest increment in growth was 3.7 g day^{-1}, observed in Sankey tank where the recovery was after 327 days, probably due to availability of trash fish in abundance (<u>Puntius</u> spp., <u>Ambassis</u> spp., <u>Oreochromis</u> sp., etc) in the tank. The growth was minimum in Hessaraghatta tank where the availability of trash fish was poor.

1.17 SALINITY TOLERANCE OF FRY OF <u>C. STRIATUS</u> AND <u>C. PUNCTATUS</u>

Laboratory experiments were conducted on the salinity tolerance of advanced fry ($\bar{x}$ size 49.97 mm/ 1.054 g) of <u>C. striatus</u> and fry ($\bar{x}$ size 21.3 mm/ 0.080 g) of <u>C. punctatus</u> holding uniform sized fry of the same brood in various concentrations of salinity from 3 to 16 $mg\ l^{-1}$ with 3 replicates. The fry of both the species, when directly transferred to water of different salinities, tolerated levels up to 5 $mg\ l^{-1}$ without mortality and up to 7 $mg\ l^{-1}$ with 30 % mortality. Gradual acclimatization of fry was found to be advantageous over direct transfer and the fry of the above sizes acclimatised to salinities up to 12 mg. l^{-1} in C. striatus and 8 mg l^{-1} in C. punctatus. The results indicate that these fishes can be used for culture in slightly saline waters available in coastal areas.

1.18 IMPLEMENTS DEVELOPED

1.18.1 Inexpensive coracle

The craft commonly used in peninsular India, especially Karnataka, Tamil Nadu and Andhra Pradesh for fishing air breathing fishes and other fishes in rivers, reservoirs and tanks is the coracle. It is a saucer shaped craft made with cattle hide, reinforced with a split bamboo wicker work. Two to three fishermen with their gear move about in the water body in the craft. Vegetable oil (about 2 kg) is applied to the coracle hide every alternate month to preserve its texture and strength. With the increase in the price of cattle hide and vegetable oil several fold during recent years, the price of a medium size (1.5 m dia.) coracle which used to be about Rs.180 to 250 in 1971 is now over Rs.1200 and its maintenance has become expensive, due to the high cost of vegetable oil, making it difficult for the fishermen to own the craft with his limited income.

An inexpensive coracle was fabricated by substituting the cattle hide of the conventional coracle with high density polyethylene (HDPE) or high density polypropelene (HDPP) woven sack material of 16 x 16 count (available in running length) and coating it with bitumen. The bitumen is heated and on melting, a thin coating is applied on the outside of the HDPE/ HDPP material to make it water proof. When any leakages develop on the material due to usage, another coating of bitumen may be given. In the event of localised damage to the material, it is repaired by applying a little melted bitumen around the hole and sticking a piece of synthetic sack material and giving another coating of bitumen on the top of the piece. Comparative studies on the durability of the two types of coracles indicated that with proper care, both will serve for 2 years of regular use.

The cost of fabrication and maintenance of HDPE/HDPP coracle is about one fifth of that of a leather coracle. The advantages of the synthetic back coracle over the conventional one are :

i) The investment is less

ii) Maintenance expenditure is almost negligible and there is no need for periodic application of vegetable oil as in the case of leather coracle.

iii) Expenditure towards repair work is low and the fishermen themselves can attend to the same even in the field, unlike in the case of leather coracle where the services of an experienced cobbler are required

iv) Being light, carrying the coracle in the field is easy

v) Chances of theft are least, as the material is cheap (Rs. 7 m^{-1}) and it does not find alternate uses, in contrast to leather.

Thus, the financial burden of the fishermen in owning and maintaining a craft is substantially reduced with the HDPE/HDPP woven sack coracle. This coracle is becoming popular with the fishermen in Malnad region of Karnataka.

1.18.2 A new Measuring board

Recording the length measurements of murrels (with cylindrical body), magur and singhi (with dorso-ventrally flat head) is found to be difficult, using the conventional measuring board, especially when the samples handled are live. The thick layer of slime on the body in general and sharp pectoral spines (of catfishes) in particular render their handling and measuring difficult. To overcome these, a simple measuring board for conveniently measuring air breathing fishes has been designed. It consists of a split half of hollow bamboo, a head piece, a scale mounted on a wooden plank and a supporting base (Figs 2 and 3). The following are the suggested inner diameters of bamboo pieces for scales of different lengths, taking into account the girth of the fish and/ or the spread of pectoral fin spines as the case may be.

Length of scale (mm)	Inner diameter of the bamboo piece (mm)
300	45 ± 05
400	55 ± 05
500	65 ± 05

Magur, singhi and murrels are measured keeping the fish straight on their ventral side. The person taking measurements has to hold the fish with left hand, placing its snout touching the head piece on the board and use the right hand to straighten the body and the tail fin and note the length. Because of the curvature of the measuring board, the live catfish kept on the board will fit exactly with the pectoral fins in between the walls, thus preventing it from struggling and slipping off. Similarly, when the murrel is placed, it almost fits in the corvature of the board and does not slip off. The time taken for measuring 100 specimens each of murrel, magur and singhi in the conventional and the modified measuring boards and the time saved (%) with the latter are given in Table 51.

1.18.3 Basket cage

A floating somewhat conical basket shaped net cage for rearing magur and singhi has been designed, keeping in view the physiological needs of these fishes to surface for breathing air. The cage, has a large surfacing area, reducing the chances of the fish hitting each other while making frequent upward or downward movement.

The cage consists of a frame made of galvanised iron (GI rod of 10 mm thickness with a lower ring (dia: 50 cm) and a larger upper ring (dia: 75 cm) connected by six supporting GI rods (each of 60 cm) and a bottom plastic basin with perforations (dia: 50 cm; depth: 10 cm) fastened to the lower ring/ Fig.4. The curved outer surface is covered with well stretched nylon net cloth of 8 mm mesh, the upper and lower edges stitched to the circular rings with nylon twins. The top of the cage is also covered with net cloth, hand stitched to the upper ring all along, with a flap which can be closed or opened. Rexin floats (dia: 15 cm), fixed to each radiating supporting rod, 25 cm below the upper ring, help to float the cage, providing enough open space above water level. A number of such cages can be floated and held in an anchored rectangular floating bamboo frame. The cages are light in weight, easy to handle, durable and cheap.

These cages are ideal for the culture of magur and singhi in any type of protected freshwater body, with supplemental feeding. They come handy for conducting replicated experiments on screening feeds, studying the influence of stocking density in fish growth, etc. They can be used for seed rearing of air breathing fishes, holding of fish stock and for conditioning. The cage can also be used for bioassay studies of water bodies using fish as indicator. The dimensions of the cage can be varied according to the specific requirements.

1.18.9 <u>Circular net cage</u>

Culture of freshwater and marine fishes

in net cages and pens is being practiced extensively in recent years, in both developed and developing countries. In India attempts made on the culture of fishes in net cages have been less successful, due to a variety of reasons, including lack of suitable cage design to suit the tropical fishes. The need therefore was felt to develop convenient net cage designs for the purpose. A successful design of a circular net cage for culture of air breathing fishes, keeping in view the unique respiratory needs of these fishes has been developed. The cage can be used for the culture of carps also.

The basic model of the circular net cage (surface area : 5 m^2); total volume : 7.5 m^3; underwater volume : 5 m^3) has three components, the cage frame, the net material and the floats.

The cage frame as shown in Fig. 5 consists of three arc pieces, each unit 1.32 m in length, with nut and bolt arrangement for assembling to form the frame of a cylindrical cage. The frame is made of iron conduit pipes (20 mm dia, 16 gauge) used for electric wiring which are light in weight. Each are unit has uniformly arced top and bottom pieces which are joined by welding three 1.5 m long vertical pipes. Each vertical pipe has a float ring welded at a height of 1 m from the bottom. The size of the cage can be enlarged both area- and depth-wise, the former by increasing the number of area and adjusting the curvature, and the latter by increasing the length of the vertical rods.

The cage can be made of nylon net material of suitable mesh size, depending on the size of fish to be stocked. Nylon webbing is stitched like a cylindrical bag closed on the top, with a slit for handling the fish, which can be closed with a zip fastner. The net is fastened securely to the cage frame.

The cage can be floated in the water using 3 sealed drums or polythene jerry cans of suitable size (buoyancy : 25 kg each) tied to the float rings on alternate vertical rods in order to keep the cage floating.

The system will be free floating and can be positioned in open water by anchoring. A number of such cages can be left floating in the water body in which cage culture of fishes is undertaken. The free floating installations can only be reached by a boat and thus have protection from **tresspassers.**

For sampling the stock, the cage can be brought to a jetty made with bamboo, after detaching from the anchor. The cage can be lifted out of water manually and the fish stock emptied into a hapa or plastic pool for sampling. Once the sampling is over, the cage is taken out and the next one brought in.

The advantages of the cage are :

i) wave action is minimum, the cage being circular in shape

ii) can be moved with least resistance from place to place

iii) being circular, rearing space available is maximum for the material used

iv) aeration/ water circulation in the cage is better and

v) fishes can move about in the cage with least obstruction unlike in rectangular cages.

1.18.5 A simple gadget for scaling fishes

Scaling of fishes, prior to preparing for table, is both time consuming and cumbersome. When the fish to be scaled are too small or too large, considerable time is needed for the removal of their scales. Generally the fish is rubbed against a rough surface and/ or a blunt knife is used to remove the scales. No special gadget or techniques are in vogue for this purpose in our country. A simple gadget has been designed for scaling fish quickly and with ease.

The scaler is made by modifying the ordinary 'tyre buffer' employed to buff (roughen) the smooth surface of used automobile tyres prior to vulcanizing, commonly sold in hardware shops. It consists of a small piece of wood of silver oak (Grevillea robusta A. Cunn.) of size 15 to 18 x 5 cm and a thickness of 1 cm, fitted with 15 to 17 width-wise straight rows of pointed steel teeth of about 2 mm diameter and 18 mm length, of which about 8 mm will be projecting out. Rows with 6 and 5 teeth alternate. Length-wise in successive rows the teeth are placed in between (i.e., the teeth in alternate rows are in a straight line) to increase the efficiency of the gadget. The sharp teeth are slightly blunted by rubbing against a rough surface. A slightly larger wooden piece of about 1 cm thickness is fixed to the toothed piece (tyre buffer) with screws, on top of which a handle is fitted for holding the gadget (Fig 6).

For scaling, the fish is held by the head with the left hand, inserting the thumb and pointer finger in the gill openings and the scales on one side are scraped off from the posterior end of the body to the anterior, with swift movements of the scaler held in the right hand. The other side and the dorsal and ventral parts of the fish are similarly scaled. The arrangement of the teeth on the scaler is such that all the scales on the fish are removed with one or two strokes, without any damage to the flesh. If large fish are to be scaled, they may be kept on a platform instead of holding in hand. The scaler costs about Rs.7-00 and is very useful in both households and fish retail shops.

1.19 FISHERIES EXTENSION AND TRAINING

1.19.1 Fisheries extension

1.19.1.1 'Lab to land' programme of ICAR

The inauguration of the 'lab to land' programme was conducted on November 21, 1975. The Secretary, Social Welfare and Labour Department, Government of Karnataka presided over the function. The Hon'ble Minister of State for Fisheries, Government of Karnataka, inaugurated the programme and released a brochure on 'lab to land programme' of air breathing fish culture, specially prepared for the occasion.

An agriculturist who had a shallow derelict pond of 0.15 ha was adopted under the 'lab-to-land' programme of the ICAR during 1979 its Golden Jubilee year for demonstrating the aquaculture technology of air breathing fishes developed by the Project.

The pond was stocked with C. striatus, H. fossilis and C. batrachus at 42,000 fry ha^{-1}. A net production of 120 kg fish was obtained after 12 months, which gave the farmer a revenue of Rs.1,200. The layout of the experiment and harvesting particulars are presented in Table 52.

The farmer initiated the second experiment in the same pond on 1.10.1982 under the guidance of the Centre and the details of stocking, growth and production of fish during 20 months are given in Table 53.

1.19.1.2 Supply of seed

7,000 fry of C. striatus were supplied to the Department of Horticulture and 210 fingerlings of C. marulius to the Department of Fisheries in Karnataka for stocking purpose. 110 fingerlings of C. marulius were supplied to a private fish culturist in Goa. A consignment of 200 fingerlings each of giant murrel and striped murrel was sent to Palair Fish Farm in Andhra Pradesh.

1.19.2 Fisheries training

Training in air breathing fish culture was imparted to officials of the Karnataka Fisheries Department and interested fish farmers. The activities of the Centre were explained to the trainees from the Central Fisheries Extension Training Centre, Central Institute of Fisheries Education (CIFE), Hyderabad and the Central Inland Fisheries Training Centre, CIFE, Barrackpore. Field visits were also arranged for them.

Mr Abdul Rahman, Assistant Chief, Planning Cell, Government of Bangladesh, FAO was appraised of the state of art of the culture of murrels, magur and singhi in India and provided with the Institute's handouts on air breathing fish culture. Field visits were also arranged.

1.20 SIGNIFICANT ACHIEVEMENTS

The significant achievements of the Centre towards fulfilling the objectives of the Project are listed below :

1.20.1 Limnology and fisheries of tanks

1) Collected baseline information on freshwater resources and status of air breathing fishes in Karnataka.

ii) Investigated the limnology and fisheries of three derelict tanks.

1.20.2 Biology of air breathing fishes

i) Biology of all the economically important air breathing fishes in Karnataka was studied.

1.20.3 Induced breeding

i) Successfully hypophysed *C. marulius* *C. striatus*, *C. orientalis*, *C. punctatus*, *H. fossilis* and *C. batrachus* [illegible], the former 3 species for the first time.

ii) Standardised the hormone doses for induced spawning of different species of murrels.

iii) Demonstrated successful hypophysation of *C. striatus* and *C. punctatus* twice during the same breeding season, facilitating higher seed yield from same brood stock.

iv) Developed a simple technique for mass breeding of murrels with minimum use of pituitary glands and less labour on hatching of eggs and rearing of the resultant spawn.

v) Successfully bred *C. batrachus* by providing horizontal underwater holes in pond dykes.

1.20.4 Seed sources in nature

i) Delineated the seed resources in time and space of air breathing fishes in tanks.

1.20.5 Incubation of eggs and rearing of fry

i) Standardised the techniques of incubating eggs and rearing of fry of murrels.

ii) Evaluated the prospects of murrel seed rearing in paddy fields

iii) Evolved suitable supplemental feeds for murrels in the nursery phase.

1.20.6 Seed transportation

i) Standardised transportation technique of air breathing fishes in open containers and under oxygen packing

1.20.7 Propagation

i) Propagated C. marulius in tanks around Bangalore

1.20.8 Package of practices for air breathing fish culture

i) Evolved package of practices for culture of air breathing fishes in ponds, cisterns and cages.

ii) Formulated and screened supplemental feeds for magur and singhi.

iii) Diagonised the cause of extreme emaciation in a specimen of C. punctatus through post-mortem examination and histopathological studies.

iv) Isolated the eye disease causing bacterium S. aureus in giant murrel.

v) Successfully isolated, cultured and identified the bacterium causing furunculosis in H. fossilis. Methods of treatment of the disease were evolved after studying the sensitivity of the bacterium to various drugs.

1.20.9 Other investigations

i) The growth of C. marulius in tanks was studied by tagging experiments.

ii) Determined the salinity tolerance of fry of C. striatus and C. punctatus.

1.20.10 Extension/ Training activities

i) Demonstrated the economic viability of air-breathing fish culture in privately owned ponds under 'lab to land' programme of I C A R.

ii) Trained the officials of the Department of Fisheries in Karnataka and fish farmers in the culture of air breathing fishes.

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1.22 PUBLICATIONS AND IMPLEMENTS DEVELOPED

1.22.1 Publications

1.22.1.1 Research papers

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ii) Dehadrai, P.V., S. Parameswaran and V.K. Murugesan, 1975. Trends in murrel fishery in Malnad region of Karnataka State. Third All India Congr. of Zoology: 12.

iii) Parameswaran, S and V.K. Murugesan, 1975. Supplementary feeding and nursery rearing of murrel fry. Proc. Nat.Acad.Sci.India, 45 (B): 133-42.

iv) Parameswaran, S. and V.K. Murugesan, 1976 a. Observations on the hypophysation of murrels (Ophicephalidae). Hydrobiologia, 50 (1) : 81-87.

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vi) Murugesan, V.K. and P.V. Dehadrai, 1976. Murrel culture in derelict waters. Sixty third Indian Sci. Congr. Ass., Waltair.

vii) Murugesan, V.K. and S. Parameswaran, 1977. Observations on the transportation of murrel seed under oxygen packing. Mysore J.Agric. Sci., 11 (2): 199-211.

viii) P. Kumaraiah, V.K. Murugesan and P.V. Dehadrai, 1977. A new record of a bacterium causing eye disease and mortality in Channa marulius (Ham.). J.Inland Fish.Soc. India, 9 : 214-15.

ix) V.K. Murugesan and P. Kumaraiah, 1977. Observations on the biology of Channa marulius (Hamilton) based on the recovery of tagged specimens. Ibid. 9 : 216-17.

x) Murugesan, V.K. and P. Kumaraiah, 1977. The behavioural patterns of the snake headed fishes Ophicelidae. Abstract of paper presented in VI Annl.Con. of the Ethological Soc.India, P. 40.

xi) Murugesan, V.K. 1978. The growth potential of the murrels, Channa marulius (Ham.) and Channa striatus (Bloch). J. Inland Fish. Soc. India. 10 : 169-70.

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xiii) Murugesan, V.K., P. Kumaraiah and P.V. Dehadrai, 1978. Observations on the culture of some air breathing fishes in swamp. Ibid., 88-94.

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xvi) Dehadrai, P.V., V.K. Murugesan and S.C. Pathak, 1979. Semi-intensive and intensive culture of air-breathing fishes. Ibid., Part I, 86-89.

xvii) Murugesan, V.K., P.V. Dehadrai and P.Kumaraiah, 1979. Culture of murrels (Ophicephalus spp.) in a swamp. In : Proc. Symposium on Inland Aquaculture., Cent.Inland Fish.Res.Inst.

xviii) Murugesan, V.K. and P. Kumaraiah, 1979, A simple technique for mass breeding of murrels. Ibid., 125 P.

xix) Murugesan, V.K., P. Kumaraiah and P.V.Dehadrai, 1979. Salinity tolerance of fry of Channa striatus (Bloch) and Channa punctatus (Bloch). Sixty sixth session of the Indian Congr. Asso., Hyderabad.

xx) Murugesan, V.K and P. Kumaraiah, 1980. Experiments on air-breathing fish culture in Karnataka. Proc. Sem. Aspects of Inland Aquaculture in Karnataka, July 14-15, 1980, Bangalore, 107-11.

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xxiii) Murugesan, V.K. and S. Parameswaran, 1983. Culture of air breathing fishes in cages and pens. In : Proc. National Sem. on Cage and Pen Culture. Fisheries College, Tamil Nadu Agricultural University, Tuticorin, March 18-19.

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xxvi) Kumaraiah, P and S. Parameswaran, 1986. A modified measuring board for air breathing fishes. J. Inland Fish. Soc. India. 11 (1) : 77 - 79.

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xxix) Parameswaran, S. Synopsis of biological data on the giant murrel, Channa marulius (Hamilton, 1822), striped murrel, Channa striatus (Bloch, 1793) and the spotted murrel, Channa punctatus (Bloch, 1793).

xxx) Parameswaran, S., P. Kumaraiah and V.K. Murugesan (in press). A note on the culture of magur, Clarias batrachus (Linnaeus) in ponds in Karnataka. J. Inland Fish. Soc. India.

xxxi) Parameswaran, S and V.K. Murugesan, (MS). Preliminary investigations on the culture of murrels in swamps.

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xxxiii) Kumaraiah, P. and S. Parameswaran, (in Press). Design of a circular floating net cage for fish culture. J. Inland Fish. Soc. India.

xxxiv) Kumaraiah, P. and S. Parameswaran, 1987. A simple gadget for scaling fishes. Curr. Res., 16 : 60 - 61.

xxxv) Parameswaran, S. and P. Kumaraiah (MS). A note on the cage culture of the giant murrel, Channa marulius (Hamilton).

1.22.1.2 Popular articles

i) Anon, 1979. Lab-to-land programme on air breathing fish culture, Central Inland Fish. Res. Inst., Barrackpore.

ii) P-hadrai, P.V. and V.K. Murugesan, 1980. Murrel culture in ponds. Central Inland Fish. Res. Inst., Barrackpore, 5 p.

iii) Kumaraiah, P and G. Gananeela, 1981. An air-breathing fish-a-day keeps the doctor away. Fishing Chimes. 1 (8) : 25-27.

iv) Anon., 1984. A new design for the floating net cages for air-breathing fishes. CIFRI Newsletter, 7 (3 & 4): 6 - 7.

v) Anon., 1984. A new measuring board for air breathing fishes. Ibid., 7 (3 & 4) : 7.

vi) Anon., 1984. CIFRI develops a new low-cost coracle for fishermen. Ibid., 7 (1 & 2) : 3 - 4.

vii) Anon., 1985. New circular net cage ... designed. Ibid., 8 (3 & 4) : 2.

viii) ... Scaling of fishes made easy. Ibid. (in Press).

ix) Introducing a progressive fish farmer from Karnataka. Ibid., (in Press).

1.22.1.3 Ph.D. Thesis

Parameswaran, S., 1975. Investigations on the biology of some fishes of the genus Channa Gronovius, 1763. Ph.D. thesis, Magadh Univ. 299 p.

1.22.2 Implements developed

i) An inexpensive coracle for fishing in Peninsular India.

ii) Length measuring board for air breathing fishes.

iii) Basket cage for air breathing fishes

iv) Circular cage for air breathing fish culture.

v) A gadget for scaling of fishes.

1.23 FUTURE LINE OF WORK

The Project Centre had to work under severe constraints with regard to the availability of field facilities by way of cisterns, nurseries, ponds and derelict water bodies. Consequently, only a limited number of experiments on induced breeding of air breathing fishes, nursery management and growth could be undertaken. Neverthless, the data gathered have been extremely valuable, especially when there has been very little information available on these aspects.

India has made considerable headway in carp culture in recent years. However, it should be mentioned that we already had considerable empirical knowledge on the subject and during the forty years or so, large number of ponds and other facilities and manpower have been made available by the Central and State Governments for research on carp culture, whereas for a crash programme for developing the technology of the aquaculture of air breathing fishes, about which practically nothing was known, the facilities available to the Centre were extremely meagre. In spite of the limitations, significant achievements could be made in such a short period.

Future work in Karnataka should probably be directed towards the following :

i) Conducting large number of experiments on seed production of air breathing fishes by methods such as hypophysation and manipulation of the environment, to standardise the technology. Since most of the air breathing fishes do not grow to a large size, the seed requirements will be high in culture operations, to attain high targets of production. These fishes generally have low fecundity. Consequently, large number of them will have to be bred to meet the seed requirements. Seed of air breathing fishes cannot be collected from nature on a large scale, unlike in the case of carps, as they are less abundant.

ii) Very little work on nursery management of most of the air breathing fishes has been carried out due to facilities limitations. Unlike carps, the early stages of these fishes are very delicate, have highly specialised feeding habits and are cannibalistic, making the nursery rearing phase highly complicated. Large number of statistically designed yard and field experiments will have to be carried out to evolve suitable nursery feeds and standardise the nursery rearing technique of these fishes ensuring high survival.

iii) The growout on the air breathing fishes, especially murrels, is very complex because of their predatory nature and specialized food habits. Murrels do not accept any of the conventional inert supplemental fish feeds such as oil cakes, rice and wheat bran and fishmeal and take only fresh (trash) fish and, with some training, dry fish (soaked) and silkworm pupae. Replicated field experiments need to be carried out to determine and quantity the feed requirements and the conversion efficiency by different species of murrels, of such feed supplied. Magur and singhi accept most of the conventional supplemental fish feeds. There is, however, need to formulate efficient 'complete feeds' for these fishes in the lines of the American catfish feeds, based on their specific needs. Floating, soft, pelleted feeds may be ideal for these two fishes.

iv) Retrieval of murrels and the two air breathing catfishes is a problem as they have a tendency to avoid getting caught in drag nets and gill nets. Murrels are generally taken in long lines using live fish, frogs, etc. as bait, whereas magur and singhi are mostly caught either by draining water bodies or by scooping in the water margins. It is rather difficult to catch those fishes from large water bodies with conventional gears. Specialised gears such as traps, etc. need to be developed for their effective exploitation.

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2 BIHAR CENTRE

2.1 INTRODUCTION

The Bihar Centre locatdd at Lahariasarai (Darbhanga) commenced functioning in June 1971 together with the Coordinating (Project Coordinator's) Centre. The latter was shifted to Barrackpore in 1974 for administrative reasons. For availing better facilities and for coordination with the State Fisheries Department, the Lahariasarai Centre was shifted to Patna in July 1977 and was accomodated in one of the Laboratories of the Bihar State Fisheries Research Station. One pond of 0.03 ha size was kept at the disposal of the Centre for maintaining the stock of experimental fishes. Investigations mainly on three air breathing fishes namely, singhi (H. fossilis), magur (C. batrachus) and kawai (A. testudineus) were carried out at this Centre. Ecological conditions of swamps were also studied.

2.2 ECOLOGICAL STUDIES OF SWAMPS

A detailed study of Balabhadrapur, Bahadurpur and Janomano swamps at Darbhanga was undertaken. Seasonal and diel fluctuations in physico-chemical factors, primary and plankton production of water and nutrient status of bottom soil of the three swamps are given in Tables 54, 55, 56, 57, 58 and 59.

Balabhadrapur swamp is a perennial lagoon (area : 0.48 ha) formed by the dialation of the town sewage drain with yearly flushing during the monsoon and has heavily silted bottom, periodic blooms of *Microcystis* and floating aquatic vegetation with a depth of about 0.9 to 2 m, fluctuating with the seasons. The water in the swamp was turbid due to plankton, heavy suspended silt and inflow of the town drainage, had high alkalinity and showed extreme fluctuations in oxygen content. The swamp is utilized for the culture of *makhana*, *Euryale ferox*. The increased demands on the nutrients by the *makhana* plants from February to November probably left little scope for primary and secondary production. The low oxygen content and the shading effect of the *makhana* leaves made the water unsuitable for most of the fishes. After harvesting the *makhana* by October, the water became highly turbid for about a month and only for November-December to March, it was amenable for carp culture.

Bahadurpur swamp (area : 0.6 ha) in Balabhadrapur village is a heavily silted, shallow water body (depth : 0.6 to 1.2 m) with profuse growth of *makhana*. The physico-chemical and biological conditions of water are given in Tables 54, 56 and 57, primary production in Table 58 and nutrient content of bottom soil in Table 59.

Janomano is a shallow swamp (area : 8.8 ha) having high embankment, with floating mat of decayed aquatic vegetation, over which aquatic grasses such as Cyperaceae grew in abundance. The vegetation was interspersed with profuse growth of water-hyacinth. The swamp is situated about 56 km from Darbhanga near Tamuria Railway Station. Monsoon rains are the only source of water supply. The swamp is heavily silted and the bottom soil is alluvial. The water level varied from 0.6 to 1.8 m through various seasons. The physical and chemical factors influencing the ecology of water area were highly adverse. The swamp had very low oxygen and meagre primary and secondary productivity (Table 58). The bottom fauna tended to be more in number in winter and belonged to Naididae, Viviparidae, Ostracoda, Chironomidae, Stylaria, Branchiura, Corydalus, Sialis, Lumbriculidae, Anisoptera, Glossiphonia, Lymnaea, Bulimidae, Ephippium and Belostoma.

The water in the swamps studied lacked movement, was pocketed and had extreme diurnal pulses of dissolved oxygen values influenced by seasonal changes. Abundance of vegetation elevated the free carbon dioxide content of water sometime to lethal levels for the fish and other aquatic fauna. Decaying organic matter was a source of rich nutrients to the water for primary and secondary production. The undisturbed ecosystem precluded the transfer of nutrients from the bottom sediment layers.

The swamps were characterised by the absence or poor development of bottom fauna, partial decomposition of plant remains and overall low biological productivity. Biota was restricted qualitatively and quantitative production was usually low for the component species. Also, the food relations were restricted and growth rates often slow. The swamps abanddoned in aquatic insects representing several orders. The conditions of the water bodies were such that only air breathing fishes could thrive in them.

2.3 BIOLOGICAL INVESTIGATIONS

2.3.1 Biology of singhi

2.3.1.1 Length-weight relationship

367 H. fossilis comprising 51 juveniles (50 to 100 mm), 147 females (122 to 361 mm) and 169 males (107 to 270 mm) were studied. Samples were obtained during the years 1972 to 1974, from ponds. The regression equations were found to be :

Juveniles : $\text{Log } W = -5.6460 + 3.1646 \log L;\ r^2 = 0.9405$ (Fig.7)

female : $\text{Log } W = -50817 + 2.9418 \log L;\ r^2 = 0.9502$

Males : $\text{Log } W = -42147 + 2.5271 \text{ Log } L;\ r^2 = 0.8292$

2.3.1.2 Sexual dimorphism

During the breeding season mature females have rounded abdomen, extending posteriorly past the pelvics to the urinogenital papilla. The males are relatively lean. The genital papilla in both sexes is conspicuous even during non-breeding season. In the mature female the clefted papilla is suffused with blood and in male the pointed papilla is prominent and reddish in colour.

2.3.1.3 Fecundity

The fecundity of singhi varied from 14,733 to 36,706 in the size range 222 mm/ 67 g to 285 mm/ 112 g (Table 60).

2.3.1.4 Spawning behaviour

The spawning activity in the species was found to be prolonged with intermittent mating, releasing a small number of eggs at each mating.

2.3.1.5 Embryonic and larval development

Eggs of singhi are brownish. They become translucent as the development proceeds. They measure as follows :

	Range (mm)	$\bar{x}$ (mm)
Diameter of the egg	1.4 to 1.6	1.38
Diameter of the yolk sphere	1.2 to 1.4	1.29

The blastodisc is brick red in colour. Early segmentation is completed within 1 - 30 h after fertilization. The embryonic rudimet appears in 3 h. In the successive stages of development, the embryo spreads gradually over the yolk sphere. In 4 h the head and tail ends of embryo are distinguishable. Somites begin appearing between 5 to 6 h of development. 12 somites are distinct in 8 h old embryo and optic cups appear at this stage. In about 10 to 12 h the number of somites increases to 22 and the Kaupffer's vesicle and the fore-runner of heart are distinguishable. After an hour the Kaupffer's vesicle disappears and the lens appears in the optic cup. At this stage the caudal portion of embryo begins to get free from the yolk mass. The tip of the tail is round.

The incubation period is 18 to 20 h at an ambient temperature range of 26 to 29° Celsius. The larval development is as follows :

1 day old larva	Upper and lower jaws formed; tiny protruberances of barbels; pigmented eyes; circulating system stabilised.
2 days old larva	Eyes pigmented; 41 to 42 myomeres formed
3 days old larva	Barbels long; pectoral fin buds have appeared.
4 days old larva	Larva started feeding; dorsal and caudal fins sppeared; pectorals more conspicuous; melanophores arranged in rows.
5 days old post-larva	Rudimentary rays appearing on caudal fin; yolk completely absorbed.
10 days old post-larva	Dorsal fin with 6 branched rays, spine and rays developed in pectoral fin; of the 53 myomeres, 14 are preanal.
15 days old post-larva	Dorsal fin with 6 to 7 branched rays as in adult; ventral fin with 6 indistinct branched rays. 47 to 48 anal fin rays; caudal fin rays 13; of the 55 myomeres, 15 are preanal; pigmentation pronounced.

Body measurements of larvae and post-larvae in the various stages of development are given in table 61.

2.3.2 Biology of magur

2.3.2.1 Length-weight relationship and relative condition (Kn).

The length-weight relationship of C. batrachus was studied by the examination of 750 specimens in the size range 40 to 360 mm (Fig. 8) collected from nature. There was no significant variation in the length-weight relationship of males and females. The equations computed were as follows:

Adults : Log W = −5.3838 + 3.1195 log L; r^2 = 0.9811
Juveniles : Log W = −3.8262 + 2.3619 log L; r2 = 0.9446

Fluctuations in Kn in relation to length (Fig.9) were more or less identical in both the sexes. Kn through months (Fig. 10) revealed that females maintain higher value in most of the months.

2.3.2.2 Food and feeding habits

Guts collected from 503 specimens (size 9 to 357 mm) were studied. The data were grouped into 4 size groups and the 'Index of preponderance' was computed for evaluating the importance of food items (Table 62). The monthly fluctuations in gastrosomatic index, mean food index, gonadosomatic index and relative condition are given in Table 63.

2.3.2.3 Sexual dimorphism

Sexual dimorphism in magur is similar to that of singhi. The females are dark grey during the breeding season and the males brownish in colour. The females have a large rounded abdomen. The males are slender. The urinogenital papilla in females is short with a broad base, whereas in males the papilla is large and elongated. The papilla in female protrudes or retracts if the fish is gently pressed of the abdominal region, but not in male.

2.3.2.4 Fecundity

The fecundity varied from 1,000 to over 20,000 in magur measuring150 to 350 mm in length and increased at a rate slightly higher than the cube of length. The calculated values of body weight, ovary weight and fecundity are presented in Table 64.

2.3.2.5 Maturity and spawning

Maturity and spawning of C. batrachus were studied by examining the stage of maturity of gonads, gonadsomatic index and ova diameter measurements (Figs. 11, 12 & 13). The species has a short and distinct spawning period during July and August. Single peak of mature ova in ovaries indicate that the fish spawns only once during the breeding season. The fish attains maturity in a year.

2.3.2.6 Spawning behaviour

The spawning in the species is completed in about 6 to 8 h. Intermittent mating acts take place and a small number of eggs are released at each mating.

2.3.2.7 Embryonic and larval development

The embryonic and larval development of magur were studied from fertilized eggs of the fish obtained by induced breeding.

Fertilized eggs are demersal, spherical and highly adhesive, measuring 1.7 to 1.9 mm in diameter. Yolk is pale or greenish yellow in colour. The incubation period varied from 21 to 24 h at 25 to 29° Celsius. Hatchlings have a pigmentless, laterally compressed body, measuring 4.6 mm in length, bearing a large ovoid yolk-sac (2.1 x 1.6 mm). Yolk is absorbed on 5th day. The larvae commence feeding on minute plankton even before the completion of yolk absorption. Compared to the corresponding stages of singhi, the larvae and postlarvae of magur grow fast, are swift in movement and are active enough to ward off attack by Cyclops. Aerial respiration commences on 10th or 11th day. The adult characters are attained by the 20th day.

2.3.3 Biology of kawai :

2.3.3.1 Length-weight relationship and relative condition

The length-weight relationship of A.testudineus was computed based on the data of 75 juveniles and 169 adults (Fig.14). The regression equations were found to be :

Juveniles : $\text{Log } W = -6.0211 + 3.7107 \log L \ (r^2=0.0701)$

Males : $\text{Log } W = -5.2297 + 3.2178 \log L \ (r^2=0.9791)$

Females : $\text{Log } W = -5.1715 + 3.1899 \log L \ (r^r=0.9750)$

As the values of experiment in males and females were not significantly different, a common length-weight equation was computed as follows :

$$\text{Log } W = -5.2039 + 3.2053 \log L \ (r^2=0.9779)$$

The 'Peaks' and 'valleys' in the relative codition curve (Fig.15) may be attributable to repeated development of gonads and spawning.

2.3.3.2 Sexual dimorphism

A. testudineus is sexually dimorphic only during the breeding season when the males acquire a reddish hue on the body, particularly on the pectoral and ventral fins. The females exhibit such colouration only on the fins. The black spot on the caudal peduncle in males is diamond shaped, with sharp boundary, whereas in females it is oblong and somewhat diffused.

2.3.3.3 Spawning behaviour

Observations on the spawning behaviour of hypophysed kawai were made. Different sets of spawners took 6 to 28 h after the injection for commencement of spawning, releasing the eggs in batches of 20 to 30. The interval between successive spawning acts ranged from 2 to 10 minutes and there were 20 to 30 spawning, spread over 3 to 4 h.

2.4 INDUCED BREEDING

Experiments were carried out to produce seed of C. batrachus, H. fossilis and A. testudineus on a mass scale, through hypophysation. The fishes were injected with varying doses of pituitary glands, in one instalment in aquaria, plastic pools, breeding pits, paddy fields and shallow ponds.

2.4.1 Spawning of magur

2.4.1.1 With fish pituitary glands

In the year 1983, 3 sets were injected with homoplastic glands @ 40 to 60 mg kg^{-1} body weight of the fish and released in plastic pools. There was no positive response. Later the breeders were transferred to breeding pits where from 20 fingerlings of $\bar{x}$ size 10 g (98 to 110 mm) were recovered later.

During the period 1973 to 1984, 244 sets of magur were hypophysed with carp pituitary glands, Dose of pituitary hormone administered ranged from 10 to 200 mg kg^{-1}

recipient. The results of experiments carried out in plastic pools and aquaria the response was not satisfactory while in these conducted in breeding pits, shallow ponds and paddy fields, they were better (Table 65)..

2.4.1.2 Breeding in paddy field

The experiment was conducted at the Gunsar Experimental Fish Farm. Four paddy plots (size 3 x 3 m) were prepared to prevent the migration of spawners. One set of injected spawners were released, in each plot. Response was 100 %. The spawning in most cases occurred on the next day of the pituitary injection. No supplemental feeding was done and the young ones subsisted on natural food, Besides magur seed, the experiment also yielded about 12 kg of paddy.

In 1978, 9 sets of magur breeders injected with carp pituitary gland @ 500 mg kg^{-1} were released in the paddy fields near Doranda Fish Farm. The dykes of the plots were strengthened and several horizontal holes were made in them to facilitate egg laying and the inlets and outlets screened to prevent escape of spawners. A constant water flow was maintained in the plots. The water temperature ranged between 23 to 29° Celsius. The fishes bred next morning.

Mass breeding of magur without hypophysation was also attempted. 59 sets of magur breeders in 1:1 sex ratio were released on 24.06.1983 in the deep portion of the plot of 3,424 m^2 size in the campus of Birsa Agricultural College filled with tube well water. The plot was manured with cow-manure and the stock fed with mustard cake and kitchen waste. After the onset of monsoon, mass breeding of magur occurred in the plot, as confirmed by collecting fry and hatchlings on 04.08.1983. The experimental plot was completely dewatered on 02.11.1983 and 1,576 magur juveniles (size : 40 to 123 mm) were retrieved.

2.4.1.3 Breeding in pond

The pond selected had high, wide and steep embankments to prevent inflow of rain water. It had a water area of 274 m^2 with depth fluctuating between 1.0 to 2.5 m. 10 each of male and female magur ($\bar{x}$ weight : 196 g) were released in the pond on 17.06.1978 after injecting carp pituitary gland extract @ 120 mg kg^{-1} body weight.

On dewatering the pond on 09.11.1978, 156 juveniles of magur (32 to 119 mm) could be collected, the size range of the retrieved young ones suggested that there were probably two spawning spurts.

2.4.2 Spawning of singhi

During the years 1972 to 1984, 249 sets of singhi were hypophysed, of which 28 sets with marine catfish pituitary glands and the rest with carp pituitary glands. Doses administered ranged from 30 to 250 mg kg^{-1} of recipient. Glands of marine catfishes did not show any extra advantage in inducing breeding when compared with those of carps. Breeding experiments (Table 66) generally showed positive response with heteroplastic gland. However, survival of developing eggs and resultant hatchlings was poor. The failure of monsoon and continuous spell of drought with atmospheric temperature shooting up to 40 to 45 ° Celsius adversely affected the subsequent rearing of hatchlings and larvae.

2.4.3 Spawning of kawai

33 sets of kawai were hypophysed with carp pituitary gland. Unlike magur and singhi, the species responded with very low dose of carp pituitary gland @ 5 mg kg^{-1} body weight (Table 67).

2.5 COLLECTION OF SEED FROM NATURAL SOURCES

2.5.1 Seed survey

Surveys were carried out for ascertaining species-wise seed abundance in relation to time and space during the period 1981 to 1984 in villages and town hats of many districts of Bihar State. Details of landings is given in Table 68.

The surveys revealed that among air breathing fishes, magur is more common in South Bihar (Chotanagpur division). The districts of Darbhanga and Madhubani and Kosi division of North Bihar have abundant occurrence of singhi. After winter as the water level start receding in the low-lying areas, the fish is caught in huge quantities. Singhi seed is available in Western and Eastern North Bihar from October to December and from March to June, depending on the monsoon. Magur seed, in bulk is available in Singhbhum and Ranchi districts of Chotanagpur division, between October and November. Magur is more abundant in Chotanagpur Division and singhi in North Bihar. There seems to be scope for organising magur seed trade in Chhotanagpur division.

2.5.2 Seed collection

Terraced paddy fields of Chhotanagpur are ideal for natural seed collection of magur. Marshy lands, swamps and low-lying paddy fields in the districts of Darbhanga and Madhubani and Kashi division of North Bihar have abundant occurrence of singhi. Seed collection is done after monsoons, when water levels recede, employing '<u>chhoh</u>', '<u>apiyani</u>' or '<u>kumn</u>' fishing (trapping the migrating fishes moving against the artificially created current of water).

Kawai is regionalised in North Bihar in depressions and marshy lands with seasonal accumulations of rain water, wherein ripe fish migrate and breed. These waters serve as nursery grounds of the fish. Year-wise details of seed collection from nature are given in Table 69.

2.6 REARING OF FRY

The hatchlings obtained by induced breeding were reared in different stocking densities in plastic pools, monofilament hapas and specially prepared paddy plots. The best results were generally obtained in hapas. The survival was over 60 % even at stocking densities of 1.5 fry l^{-1}. Rearing of the induced bred spawn of singhi, magur and kawai are given in Table 70.

Newly hatched young ones can be reared without much mortality till yolk absorption i.e., the 4th to 5th day in the case of singhi and 2nd to 3rd day in kawai. After yolk absorption the larvae are prone to mortality due to several factors, including scarcity of right type of food. The young larvae at this stage feed actively on minute zooplanktors such as ciliates and rotifers. *Cyclops* occurring in the plankton attack them. The risk can be minimized by filtering plankton samples through monofilament cloth of 50 mesh linear cm^{-1}, to remove *Cyclops* and predatory insects. Mass scale rearing of fry can be done in monofilament cloth hapas fixed in ponds rich in zooplankton. When fry grow to about 20 mm, they can be transferred to hapas of larger mesh size for further rearing.

Air breathing fishes are very delicate in the early stages. Larvae reared in plastic pools kept in the open, during sunny weather, showed sudden mortality unlike larvae kept under shade. Transplantation of the seed from one water body into another, without acclimation also results in heavy mortality, as they are not able to withstand such sudden changes.

2.7 SUPPLEMENTARY FEEDING

2.7.1 Experiments on kawai

Studies were conducted to evolve suitable supplemental feeds for rearing the young ones of various species of air breathing fishes. Of the feeds tried, in the case of post-larvae of singhi, minute zooplankton such as Brachionus, Filinia, Moina and Ceriodaphnia gave the best results in terms of growth and survival. Among other feeds, fishmeal gave good survival for the initial two days. The post-larvae made good use of ricebran, gram flour and powdered mustard cake.

6 sets of experiments were conducted in laboratory aquaria holding specimens of kawai. A set of two specimens each were fed with continuously replenished stock of known number of Anisops for a week. The foraging capacity of different size groups of specimens was assessed in terms of weight of Anisops consumed by the fish day^{-1}. Fish of various size groups showed different rates of consumption of insects (Table 71). There was a progressive increase in the weight of Anisops consumed with the increase in the weight of the fish. The number of insects consumed $fish^{-1}$ day^{-1} by different size groups is high, suggesting the possible use of the fish for the biological control of aquatic insects.

In an experiment, 15 adult specimens of kawai were fed with the 10 Anisops each and the fish were killed at two hour intervals. The alimentary canal was examined and , the time taken for the passage of the given quantity of food from oesophagus to the rectum of the fish was 10 h.

Feeds of plant origin did not give good growth and survival. Amongst the feeds of animal origin, live insects such as Anisops and Corixa and nymphs of dragon or damsel-fly, gave the best results. Trash fish was second best in terms of weight gain.

2.7.2 Experiments on magur

An experiment was conducted to find out relative efficiency of Anisops, trash fish and mixture of Anisops and Vivipara bengalensis (1:1), trash fish, mustard cake and potato (1:1:1) and fish meal and potato (1:1) for the culture of magur. The fish were fed @ 5 % of their body weight. Maximum weight gain was observed with a diet of finely minced trash fish, followed by Anisops and a mixture of Anisops and V. bengalensis. Other feeds tried in this experiment resulted in loss of weight of the fish. Best conversion rate was observed with Anisops, followed by trash fish.

2.7.3 Feed mixtures for singhi

Experiments were taken up in order to evaluate the efficacy of two types of supplemental feed mixtures. Three nursery ponds of area 382, 287 and 307 m^2 respectively were stocked with fingerlings of singhi in February 1983 at the rate of 30,000 fry ha^{-1}. The $\bar{x}$ size of stocked fish were 91 mm/ 10.06g, 93 mm/ 10.46 g and 125 mm/ 10.91 g respectively.

The fish in ponds 1 and 2 were fed at the rate of 5 % body weight which was increased later, based on demand, whereas no supplemental feeding was done in control pond. In pond 1, supplemental feeds used were fishmeal, deoiled ricebran and groundnut cake in the ratio 2:13:4 with a trace of mineral mix. Initially in pond 2 supplementary food given was a mixture of ricebran and cowmanure in the ratio 1:1, then mustard cake and cowmanure in same ratio and later on groundnut cake and deoiled ricebran in the ratio 6:13.

Harvesting of the ponds was done in June 1983 by dewatering. The $\bar{x}$ weight of harvested fish, survival and gross production obtained from the three ponds were 16.48, 22.17 and 18.11 g, 62.48, 10.48 and 82.50 % and 308.9 kg ha^{-1} 101 $days^{-1}$, 574.91 kg ha^{-1} 123 $days^{-1}$ and 529.65 kg ha^{-1} 100 $days^{-1}$ respectively. Cost of production kg^{-1} fish worked out to Rs.20.68, 11.88 and 8.65 respectively.

The high production cost of fish was mainly due to low yield and high cost of inputs. Low production may be due to poor retrieval and the short duration of culture.

2.7.4 Enemies of fry, cannibalism

The hatched larvae ($<$ 2 mm in size), being sluggish and buoyant, are prone to predation by fishes and aquatic insects. Cyclops prey on it, clutching on its scaleless, soft body wall. Through laboratory trials the density at which Cyclops is harmful to kawai spawn and the size at which the fish can ward off Cyclops were determined.

Survival of spawn and fry of kawai under different densities of Cyclops in glass aquaria are given in Table 72.

2.8 SEED TRANSPORTATION

Consignments of seed of air breathing fishes were transported to distant places, the details of which are presented in Table 73.

2.9 CULTURE EXPERIMENTS

2.9.1 Air Breathing fishes and makhana culture

In 1976-77, mixed culture of air breathing fishes along with *E. ferox* was carried out in an abandoned carp nursery pond of 0.04 ha size. Juveniles of singhi, magur and kawai of $\bar{x}$ weight 9, 10 and 12 g respectively were stocked at the rate of 100,000 ha^{-1} in February 1976. From February 1976 to May, rice bran was given once daily at 1100 hour at the rate of 3 % weight of stock from June onwards the same was substituted by fishmeal. 47, 26 and 2 kg of singhi, magur and kawai, were harvested after 10 months, the survival rates being 60.2, 52.4 and 33.0 % respectively (gross production : 2,250 kg ha^{-1} 10 $months^{-1}$). The harvest of makhana was 30 kg in the form of seed, the dry edible seed being 10 kg.

2.9.2 Pond culture

The production of air breathing fishes in manageable water bodies such as abandoned carp nursery ponds was taken up at the Gunsar Experimental Fish Farm at Darbhanga. The first set of experimens were carried out in 1973-74 on monoculture of singhi and kawai (Table 74). The production was very poor, probably due to the young ones stocked were too small and not uniform in size, the stocking was not done in one instalment and the water column in the pond was low.

The second set of experiments conducted in the same year on the mixed culture of singhi and kawai gave a production of 524 kg ha^{-1} 10 $months^{-1}$ and singhi, magur and kawai gave a production of 1,200 kg ha^{-1} in 10 months (Table 74).

Mono- and mixed culture of air breathing fishes was undertaken in small ponds during 1976 to 1984 for studying the influence of stocking density on growth of magur in two nursery ponds at Mithapur fish farm, Patna (Tables 75 and 76 Feeding rates were same in both the ponds while the stocking densities were different.

Ponds 1 (307 m^2) and 2 (415 m^2) were stocked on 05.11.1983 and on 17.11.1983 respectively, the stocking sizes being 95 to 123 mm ($\bar{x}$ weight : 9.459 g) and 90 to 140 mm ($\bar{x}$ weight : 12.93 g) respectively. Feed comprising deoiled groundnut cake, trash fish and deoiled ricebran in the ratio 6:1:13 was given in both the ponds, in feeding trays, according to demand. Both ponds were fertilized with 50 kg cow manure.

In pond 1, the $\bar{x}$ weight of harvested fish, survival percentage and gross production obtained were 30.5 g and 29.0 g, 69.11 and 88.0 % and 987.3 kg ha^{-1} 213 $days^{-1}$ and 614.46 kg ha^{-1} 200 $days^{-1}$ respectively. Cost of production kg^{-1} fish worked out to Rs.23.38 and 25.54 respectively.

2.9.3 Cage culture

Culture of air breathing fishes was carried out in swamps in cages made of different materials. The experiments were mostly undertaken in the sewage fed Bhatwapokhar in the campus of Darbhanga Medical College and in a derelict ditch at Laheriasarai. The waste water of the Medical College campus is allowed to accumulate in Bhatwapokhar, which remained chocked with waterhyacinth for most part of the year. Size of the cages used was 2 x 1 x 1 m. The feed consisting of a combination of ricebran mustard cake, fishmeal and vegetable matter in equal proportion was given at the rate of 10 % weight of the stock in trays. The details of the experiments are given in Table 77.

2.9.4 Culture in cisterns

Experiments on culture of magur was taken up in cisterns to assess the feasibility of its adoption like poultry or cattle rearing. Two cement cisterns of 7 m^2 size and other two of 3.5 m^2 size in Mithapur Fish Farm, Patna were utilized for the experiments. A 10 cm layer of mud was given in the cisterns prior to filling with water upto a level of 65 cm. Fingerlings of magur ($\bar{x}$ size : 9.97 g) were stocked on 25.11.1978 at the rates of 50 and 75 m^{-2}. Feeding was done daily with rice bran and fish meal (1:1 ratio) at 5.0 % weight of the stock. The growth and survival of the fish were recorded monthly. The experiment was continued for a period of one year. The stock had two phases of relatively intensive growth (Table 78), from March till June and from September to November.

A total of 17.9 kg of magur was harvested from 4 cisterns (production : 1 kg m^{-2} yr^{-1}). The survival figures indicated that in cisterns, 50 magur m^{-2} may be the ideal stocking rate for the given management input.

2.9.5 Demonstration experiments

A monoculture experiment on magur was carried out in a farmer's pond in Patna. Magur fingerlings were stocked in two instalments, on 16.11.1979 (4,000) and 04.02.1979 (2,000). The $\bar{x}$ weight of the fingerlings at the time of stocking was 14 g. The fish were fed with a mixture of ricebran and poultry starter in the ratio 3:1 at the rate of 15 to 30 % weight of the stock. In all, 3,000 kg of ricebran and 1,000 kg of poultry starter were used. Water was partially (8 times) or totally (3 times) replenished in the pond from a bore well, in order to dilute the metabolites accumulated at the pond bottom and also to prevent Microcystis blooms. 376 kg of magur was harvested on 29.08.1974, giving gross and net productions of 3,760 and 2,260 kg ha^{-1} 8 $months^{-1}$. Survival was 80 %. The cost of production of fish came to Rs.9.04 kg^{-1}.

In the third year of 'lab-to-land' programme, production demonstration of singhi and common carp was carried out in another farmer's pond of area of 0.1 ha, situated in village Sipara in Patna district. The pond was repeatedly netted and bigger size fishes were removed. A few common carp were retained in the pond. The pond was stocked with 2,000 fingerlings of singhi, in two instalments on 24.02.1982 and 04.08.1982, at the rate of 20,000 ha^{-1}. The $\bar{x}$ weight of the fingerlings was 19.5 g. Feed containing fishmeal, groundnut cake and ricebran (ratio : 1:1:1) and mineral mix was given at the rate of 5 % body weight. Bigger size carps were harvested periodically. 265 kg carps and 61.2 kg (1,326 in number) of singhi were harvested from the pond. The gross ha^{-1} production from the pond was 3,262 kg in 10 months. The net production of carps could not be estimated as their initial weight was not known. However, the gross and net production of singhi was 612 kg and 422 kg ha^{-1} respectively in 127 days. The cost of production of fish worked out to Rs.6.50 kg^{-1}. The $\bar{x}$ weight of singhi was 47 g and its retrieval percentage, 66.3.

2.10 PARASITES AND DISEASES

2.10.1 Lymphocystis

Specimens of kawai reared in net cages in the sewage fed Bhatwapokhar developed prolif(i)erous growth of binding tissues on the fins and body. The disease appeared to be lymphocystis.

2.10.2 Cestode infestation

The alimentary canal of a number of magur were found to be severely infected with cestode worms which were found hanging in the lumen of the duodenum, penetrating deep in the wall. In heavily infected specimens, the outer surface of duodenum was studded with faint, pin-head dots which turned into holes when the worms were removed with forceps. A comparison of the histology of uninfested and heavily infested fishes revealed that while the muscle layers were very thin and the villi thick in the former, the muscels very thick and the villi shorter in the latter.

2.10.3 Trematode infestation

Digenetic trematode infection in singhi reared in cages was observed, causing heavy mortality. Some of the symptoms of the infection were loss of equilibrium, shivering of body at small intervals, spurts of frantic movement and frequent air breathing. Autopsied specimens showed countless minute cylindrical uniform sized worms (1.5 mm long) in the body cavity, crawling all over the visceral organs. They were wandering freely and could be washed out easily into a petridish. In heavily infected specimens, their number was over 30 to 35 thousand.

2.10.4 Bacterial infection

A number of singhi from the same batch of specimens in which trematode infections were noticed, developed reddish inflamatory lesions at the base of their anal fin, continuing up to the caudal tip in certain cases. Probably the bacterial attack was secondary infection in these specimens. Infected fishes floated on the water surface and were not in a position to make use of their anal fin for swimming. On being given a bath of potassium permanganate, although a good number of fish died, the surviving ones showed marked improvement in their condition.

2.10.5 Myxosporidiosis in magur

The disease caused by myxosporidian parasite (*Myxobolous* sp.) was found to be common in magur stocked in ponds and cement cisterns. The infection was first boticed in the form of a few small boils on the body. Subsequently the intensity of infection became severe. The fish developed these boils along their lateral line zone. In certain instances the abdomen or the fish had got bloated. A general growth retardation of the infected fishes was noticed. The disease disappeared during summer months.

2.11 OTHER STUDIES

2.11.1 Hermophroditism in magur

During the course of an examination of gonads of a batch of magur procured from Ranchi region, one of the specimens was found to be bisexual. It belonged to '0' year group (size 130 mm/ 15 g). By appearance, gonads looked like ovaries. The right gonad was thicker than the left one individually measured 11.5 and 11.0 mm, respectively. They were fixed in Davidson's fluid. Histological examination of sections of 10 micron stained with ECF green and Beibrich scarlet indicated that the major part of the tissue was testicular in nature. There were only a few ova located in between testicular tubules.

2.11.2 Teratological manifestations in magur

A consignment of about 8,000 fingerlings of magur during the course of transport from the collection centre in West Bengal to Patna on 16.12.1977 met with enmass mortality, because of prolonged detention, enroute. A sample of 1,565 specimens were utilized for studying frequency of teratological manifestations. The investigations indicated the possibility of the occurrence of about one abnormal fish for every 92 normal ones, the frequency of abnormality was fish having one or both pelvic fins missing. The next highest frequency was fish with aberrent caudal fin, followed by branched or forked barbels.

2.11.3 Teratological manifestations in singhi

Among 916 fingerlings of singhi (length range

91 to 116 mm) examined, 5 instances of abnormalities were recorded. The highest frequency of teratological manifestations was in barbels which was recorded in two specimens. Absence of pelvic fin was observed in one specimen. There was one instance of notched anal fin and one of deformed tail. The study indicated the possibilities of occurrence of one abnormal fish for every 183 normal ones (0.55 %).

2.12 FISHERIES EXTENSION AND TRAINING

2.12.1 Fisheries extension

Under 'lab to land' programme, efforts were made to transfer the technology of air breathing fish culture to the farmers' ponds, in collaboration with the Department of Fisheries, Bihar. The highlights of the programme were inauguration of the programme by Minister of Fisheries, Government of Bihar, 10 days training on induced breeding of singhi, magur and kawai at Sipara village and Extension Fortnight Celebration from 06.12.1979. Production demonstrations in farmers' ponds, demonstration of culture of air breathing fishes (with and without carps) and their breeding to farmers and other interested persons and publication of handouts and popular articles in Hindi and English for distribution amongst farmers and other interested parties.

Radio talks were given and screening of films and slide shows concerning air breathing fish culture were done and group discussions between farmers and scientists were held for the dissimination of the technology.

The Centre set up a demonstration stall at Sonepur mela twice, in collaboration with State Fisheries Department. The culture techniques of air breathing fishes were demonstrated to the fish farmers attending the mela.

2.12.2 Fisheries training

Lectures were delivered in the Training School on culture of air breathing fishes with practical demonstrations in 1978 for the trainees. A lecture on paddy cum fish culture was given to the farmers in the Kisan mela organised in 1981 by the Rajendra Agriculture University, Patna. During 1981-1982, training on breeding and culture of air breathing fishes were given to several batches of fish farmers under training programme organised by Fish Farmer's Development Agency, Patna.

2.13 SIGNIFICANT ACHIEVEMENTS

The significant achievements of the Centre are listed below

i) Length-weight relationship, relative condition, food and feeding habits, sexual dimorphism, maturity, spawning fecundity and embryonic and larvel development, of magur, singhi and kawai. were studied.

ii) Several sets of magur, singhi and kawai were bred by hypophysation. Magur was bred in a paddy plot of Birsa Agriculture University, Ranchi (without hypophysation). Rearing of the resultant hatchlings up to fingerling stage was done in the same plot.

iii) Surveys revealed that Chotanagpur division in South Bihar is endowed with magur seed while singhi and kawai seed are abundant in North Bihar.

iv) Culture of magur, singhi and kawai in a makhana pond at Darbhanga gave good production of makhana in 10 months.

(with moderate supplemental feeding). Likewise, good yields of magur, singhi and kawai were obtained in farmers ponds.

v) Transfer of technology to fish farmers was done by imparting training on culture and breeding of air breathing fishes, culture demonstrations in farmer's ponds, extension fortnight celebrations, publication and distribution of handouts in Hindi and English, radio talks and screening of films under lab to land programme.

2.14 ACKNOWLEDGEMENTS

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2.16 FUTURE LINE OF WORK

i) Success in air breathing fish culture depends on seed availability and in order to produce seed on a large scale, the breeding techniques needs to be improvised.

ii) High yields in air breathing fish culture depends on availability of suitable cheap supplemental feeds. Considerable research work will have to be done for formulating supplemental feeds.

iii) Techniques for efficient harvesting of air breathing fishes from derelict water bodies and ponds needs to be developed.

iv) Further studies on cage culture of air breathing fishes in derelict ponds will have to be conducted for standardising the technology. Possibilities of pen culture of these fishes also have to be studied for utilisation of derelict water bodies.

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3 ASSAM CENTRE

3.1 INTRODUCTION

The Centre established in June 1971, shared Office accomodation with other three Research Centres of the CIFRI in a building hired by the State Fisheries Department in Guwahati city. Five nurseries each of 0.02 ha were made available to the Centre at Ulubari Fish Farm, besides one derelict pond of 0.1 ha at Hajo Fish Farm, for production demonstrations.

Topography of the land being plain and low-lying and due to relatively heavy rainfall in the region, many water-logged areas called beels are found in Assam. Most of the beels covered with thick aquatic vegetation are virtually swampy in nature and a Project Centre was located in the State to develop technology for exploitation of such water bodies for production of air breathing fishes which are in great demand in the State. The work programme of the Centre included the breeding, seed collection and rearing and growout experiments on kawai, A. testudineus, singhi, H. fossilis and magur, C. batrachus in ponds and cages. Ecology of swamps was also studied.

3.2 ECOLOGICAL STUDIES OF SWAMPS

A preliminary survey of swamps in the districts of

Sibasagar, Darrang and Kamrup was made. The pH of water was neutral in some beels. The beels were generally covered with thick littoral, submerged, emergent and floating macrophytes. Notonecta, Anisops, Nepa, Ranatra and chironomid larvae, tubificids and leaches were encountered in these waters. Fishes caught from the beels comprised of catfishes, murrels, featherbacks, perches and minnows and other trash fishes. Major carps were less common.

Ecological studies of Sarania swamp (acidic), an Ghorajan beel (alkaline) and derelict pond were made in the district of Kamrup.

3.2.1 Studies in Sarania swamp

The perennial, acidic Sarania swamp (area : 5 ha) located in Eastern region of the Guwahati city at the foot hills of Sarania is encircled by human habitation. It receives rain water from the catchment area all round, especially from Sarania hill side. The $\bar{x}$ depth of water varied between 0.75 and 1.50 m.

The minimum and maximum values of temperature were obtained in January and October respectively. Diurnal variations in June (monsoon month) and December (winter month) ranged between 26.0 to 28.5 and 16.5 to 19.5° Celsius respectively. The water of the swamp was almost transparent during winter months (turbidity $<$ 10 mg 1^{-1}) and with the onset of monsoon, the turbidity increased , reaching maximum (29 mg 1^{-1}) in September. The maximum and minimum pH values were recorded in late winter and monsoon months respectively. In June pH was low (6.0 to 6.2).

The values of dissolved oxygen varied between 0.12 and 1.0 mg 1^{-1} and showed peak in premonsoon months.

During the day it was maximum, between 09-00 and 17-00 hours. Minimum free carbon dioxide was recorded in April (80 mg l^{-1}) and maximum in May (150 mg l^{-1}). Diurnal variations were between 80 and 120 mg l^{-1}. High values of free CO_2 were generally recorded in the forenoon. High values of free CO_2 with low dissolved oxygen was due to pollution, caused by sewage inflow. In June the phosphate values were low (0.30 to 0.84 mg l^{-1}), which improved in July (0.84 to 1.2 mg l^{-1}). Diurnal variations in dissolved PO_4 ranged from 0.06 to 0.34 mg l^{-1} in monsoon (June) and between 0.40 and 0.60 mg l^{-1}) in winter months. The nitrate nitrogen content of the water ranged between 0.00 and 0.19 mg l^{-1}. Diurnal variations in nitrate were insignificant.

Fluctuation in gross primary production in winter and early monsoon months ranged between 12.30 and 52.00 mg C m^{-3} h^{-1}. The values were very low in monsoon months.

Maximum phytoplankton (10,025 l^{-1}) was recorded in February due to blooms of Closteriopsis sp. and Navicula sp. Zooplankton showed first peak during February and second peak in April.

3.2.2 Studies in Ghorajan beel

The alkaline Gorajan beel situated in the northern bank of the river Brahmaputra opposite Guwahati city receives flood waters during monsoon months through a sluice gate. The hydrobiological conditions of the beel during February to July 1974 were as in Table 79.

The number of phyto- and zooplankton varied from 53 to 262 l^{-1} and 11 to 45 l^{-1} respectively. Maximum phyto- and zooplankton were encountered in April and July respectively, the predominant forms being Eudorina sp. (168 l^{-1})

and copepod nauplii (219 l^{-1}) respectively. Minimum numbers of phytoplankton (53 l^{-1}) and zooplankton (11 l^{-1}) were recorded in May and June.

3.2.3 Studies on derelict ponds

The ecology of 5 derelict ponds situated in Hajo Fish Farm (constructed by reclaiming shallow areas of Pitkati beel), Hajo block in Kamrup district, 36 km from Guwahati city, was studied. The bottom soil is clayey and the water depth of the ponds, covered with vegetation varied from 0.35 to 1.30 m. Physico-chemical conditions of water and soil and hydrobiological conditions are given in Table 00.

Minimum and maximum values of temperature were obtained in the months of January (17° Celsius) and September (34° Celsius). The pH was less than 7 except in the months of March and April. Water was turbid and visibility less than 100 mm. Maximum sechhi disc reading (540 mm) was recorded in February. The maximum oxygen value was recorded in June (8.64 mg l^{-1}) and minimum (0.80 mg l^{-1}) in September. The minimum value of free carbon dioxide (3 mg l^{-1}) was recorded in June and maximum (50 mg l^{-1}) in September. Alkalinity ranged between 34 (March) and 114 mg l^{-1} (December). The maximum (1.1 mg l^{-1}) and minimum (0.07 mg l^{-1}) phosphate values were recorded in January and November respectively. Nitrate content ranged between 0.05 (March) and 0.12 mg l^{-1} (July).

Month-wise changes in the gross and net primary productivity ranged between 10.35 and 30.68 mg C m^{-3} h^{-1} and 6.39 and 17.75 mg C $m^{-3}ha^{-1}$ respectively.

Phytoplankton was maximum in December (219 l^{-1}), due to blooms of Gaomphosphaeria sp. Zooplankton peak was in January (742 l^{-1}). Diatoms and copepods respectively dominated phyto- and zooplankton populations.

3.3 BIOLOGICAL STUDIES

3.3.1 Length-weight relationship of C. batrachus

178 specimens of magur (length range : 150 mm to 358 mm) were studied for computing the length-weight relationship of the species which was estimated as :

$$\text{Log } W = -4.8709 - 2.9105 \text{ log } L$$

The relative codition factor of magur ranged from 0.94 to 1.10.

3.3.2 Length-weight relationship of H. fossilis

The length-weight relationship of singhi based on 142 specimens was :

$$\text{Log } W = -1.5809 + 2.4676 \text{ log } L \text{ (Fig. 16)}.$$

3.3.3 Length-weight relationship of A. testudineus

The length weight relationship of kawai based on 79 specimens was found to be $\log W = -0.8112 + 2.0347 \log L$ (Fig. 17).

3.3.4 Food and feeding habits of air breathing fishes

The gut contents of 79 A. testudineus and 82 H. fossilis obtained from different beels and inundated areas of Kamrup district were studied.

In juvenile kawai (size : 22 to 75 mm), the bulk of the stomach contents was formed by cladocerans (volumetric and occurrence percentages 32.86 and 17.40). Detritus and Diaptomus sp. were next in importance (33.00 and 12.32 % by volume and 8.70 and 17.40 % by occurrence). Chironomid larvae, insect larvae, small fish, copepod eggs, Cyclops sp., Cypris sp., Synedra spp., Cymbella sp. and Chydorus sp. were also found in the gut contents of juvenile kawai (Table 81). Detritus formed the major part of stomach contents of adult kawai(size : 76 to 115 mm), both by volume (83.80 %) and occurrence (31.49 %). Small quantities of insects, Oscillatoria, Navicula, fish scales and molluscans were also encountered.

In the adult singhi (size : 102 to 180 mm), the major part of the stomach contents was contributed by detritus and mud (volume 47.76 % and occurrence 16.00 %), followed by nematodes (12.40 % by volume and 14.20 % by occurrence). Fish scales were next in order of importance. Small quantities of Cyclops sp., Synedra spp. Navicula sp. and rotifers were the other food items (Table 82).

3.4 COLLECTION OF SEED

During the year 1972, 550 kawai fry ($\bar{x}$ length : 20 mm) were collected from Pitkati beel. Private parties engaged for the purpose collected 2,000 to 3,000 fry with the help of the trap, jakoi.

During the years 1973 to 1976, 800, 1,200, 34,905 and 9,050 fry of A. testudineus, H. fossilis, C. striatus and C. punctatus respectively were collected from beels and channels located in district Kamrup and state owned ponds in district Darrang. Collections were made by fry net and jakoi and by dewatering the marginal areas of the beels.

A total of 10,250 fingerlings of singhi ($\bar{x}$ size :

106 mm/ 4.6 g) was collected from the beels of Kamrup district during the year 1979, mainly from Rangia and Nalbari blocks.

1,000 magur ($\bar{x}$ length : 62.5 mm), 10,750 singhi ($\bar{x}$ length : 172.8 mm) and 1,250 kawai ($\bar{x}$ length : 47.6 mm) were collected during 1981 and 1982 using various types of traps and drag nets.

3.5 INDUCED BREEDING EXPERIMENTS

Experiments on the hypophysation of H. fossilis, C. batrachus and A. testudineus were conducted (Table 83). Between 1972 and 1974 more than 200 sets of A. testudineus were hypophysed. Successful results could be achieved even when synthetic hormones like FSH and LH were used. During the same period 52 sets of H. fossilis and 7 sets of C. batrachus were injected with pituitary hormones. Positive results could be obtained in 30 % cases of the former and in a solitary case of the latter species.

3.6 LIFE HISTORY STUDIES

Life history of singhi and magur were studied.

3.6.1 Embryonic development of H. fossilis

The sequence of embryonic development of singhi was found tobe as follows, at a water temperature of 27 to 29° Celsius :

After fertilization (h)	Stages of development
00-30	Differentiation of blastodisc which is brick red in colour

00-42	2 celled stage
00-50	4 celled stage
01-12	8 celled stage
01-30	16 celled stage
01-53	32 celled stage
02-40	Formation of morula
03-03	Commencement of gastrulation
04-46	Gastrulation complete
05-42	Differentiation of head and tail region
06-45	Head and tail ends differentiated
09-15	Yolk plug stage
10-00	Appearance of myotomes
10-30	8 myotomes; appearance of optic vesicles
11-30	Twelve myotomes; distinct optic cup
13-15	16 myotomes; appearance of embryonic caudal fin fold
13-55	22 myotomes; appearance of Kaupffer's vesicle and heart
14-20	Slight movement of the embryo
15-00	24 myotomes; Kaupffer's vesicle diminishes in size; lens of the eye forming; embryo makes frequent movements
15-37	Embryo elongates and occupies the pervitelline space
16-10	28 myotomes; twitching movement of the embryo more frequent
16-30	32 myotomes; heart beat, 60 $minute^{-1}$
17-00	Embryo fills the perivitelline space
17-35	Vent formed
20-45	40 myotomes; optic lens conspicuous
24-40	The larva hatches out with tail coming out first.

3.6.2 Larval and post-larval development of *H. fossilis*

One day old larva : Pigmentation commenced eye; pectoral buds have appeared.

Two days' old larvae	:	Buccal invagination noticeable
Three days' old larvae	:	Mouth formed; two pairs of barbels prominent; pectoral fins formed; larva swims
Four days' old larvae	:	Very little yolk present; larva swims actively
Twelve days' old larvae	:	The full component of fins formed

3.6.3 Embryonic development of C. batrachus

The sequence of embryonic development of magur was found to be as follows at a water temperature range of 27 to 29° Celsius :

After fertilization (h)	Stages of development
00-30	Differentation of animal pole
00-45	2 celled stage
01-00	4 celled stage
01-14	8 celled stage
01-50	16 celled stage
02-13	32 celled stage
03-45	Formation of morula
05-10	Formation of gastrula
17-35	Formation of embryonic rudiment
11-05	Differentiation of head and tail regions
14-30	Formation of optic cup, 8 somite stage
15-15	14 myotomes formed
17-10	20 mytomes formed
17-40	Appearance of Kaupffers' vesicle
20-45	Twitching movement of the embryo starts
21-45	Optic cup conspicuous; Kaupffer's vesicle disappearing; caudal end free
22-10	Appearance of heart; heart beat, 48 minute^{-1}

26-45	Embryo fills the perivitelline space
27-30	Vent formed; heart beat 79 $minute^{-1}$
28-30	Frequent movement of the embryo
30-00	Larva hatches out

3.6.4 Incubation of eggs

At 27 to 29° Celsius, the incubation period was found to be 21 and 23 h in A. testudineus and H. fossilis respectively.

3.7 REARING OF SPAWN AND FRY

3.7.1 Rearing of spawn and fry of singhi and kawai

Experiments were conducted on the rearing of spawn and fry of both A. testudineus and H. fossilis in monofilament hapas (size : 100 x 90 cm; 50 mesh cm^{-1}). The hapas having 20 to 30 cm of water column and 1,000 spawn gave satisfactory results. 50,000 fry of kawai were reared to $\bar{x}$ size of 25 mm and handed over to State Fisheries Department.

Experiments on evolving supplemental feeds for the post-larvae of kawai and singhi were conducted. Both species accepted cooked poultry egg. 2 days old spawn of kawai preferred both cooked egg and unicellular zooplankton and the survival was 47 and 64 % respectively for a rearing period of 10 days. Singhi preferred copepods and cladocerans to cooked egg reflected by the percentage of survival (100.0 and 67.9) during 15 days rearing period.

3.7.2 Oxygen requirement of fry of A. testudineus

Preliminary experiments were conducted as the oxygen requirement of kawai are presented in the Table 84. The values of correlation (r) for 2, 4 and 6 days' old larvae were 0.97, 0.77 and 0.95 respectively. To determine whether these values are significant or not, 't' test was performed. The calculated values of 't' (9.90 and 7.51) clearly showed that the correlation coefficient r (0.93 and 0.95) is significant at 1 % probability level whereas the calculated value of 't' (2.95) showed that correlation coefficient r (0.77) is significant only at 5 % probability level.

3.5.5 Supplemental feeding

Experimental rearing of spawn of both singhi and kawai was done using dried prawn and silkworm pupae, wheatflour, fishmeal, mustard cake, ricebran and soyabean powder, alone and in combinations as supplemental feed. Cooked poultry egg was also used. The albumen and yolk were emulsified separately in water and used. Best results were obtained when both egg albumen and yolk was emulsified and cooked till the water evaporated (Tables 85 and 86).

3.8 CULTURE EXPERIMENTS

3.8.1 Monoculture

Seven experiments on the monoculture of singhi and magur were conducted. Gross production ranging from 380 kg ha^{-1} 8 $months^{-1}$ to 6,946.6 kg ha^{-1} 5 $months^{-1}$ was obtained (Table 87).

3.8.2 Mixed culture

In all, 5 experiments on the mixed culture of different species of air breathing fishes were conducted with gross production ranging from 02 kg ha^{-1} 9 $months^{-1}$ to 3,696 kg ha^{-1} yr^{-1} (Table 88).

3.8.3 Culture in cement cisterns

With a view to popularise air breathing fish culture in urban areas, rearing of kawai was done in cement cisterns of size 2.4 x 1.2 x 1.2 m. A mixture of cowmanure, straw and paddy husk was given at the bottom (9 cm thick) and the cisterns were filled with water up to a level of 45 cm. 300 kawai fingerlings ($\bar{x}$ size : 35 mm/ 1.05 g) were released in the prepared cisterns in June 1977. In 180 days, the fingerlings attained a $\bar{x}$ size of 99 mm/ 38 g. The experiment yielded a production of 8.12 kg and 7.41 kg (2.33 kg m^{-2} and 2.14 kg m^{-2}) with 80 % and 65 % survival respectively, from the two cisterns.

3.8.4 Cage culture in swamps

A part of Ghorajan beel was cleared of floating macrovegetation for rearing spawn of kawai and culture of both kawai and singhi in cages. In all, 12 cage culture experiments for periods ranging from 90 to 200 days were taken up. Cages made of bamboo mats and nylon webbing were used (size: 2 x 1 x 1 m). The experiments yielded gross/ net productions of 5.172/ 2.175 kg m^{-2} in 200 days, 4.023/ 3.256 kg m^{-2} in 90 days and 2.7/ 9.0 kg m^{-2} in 90 days respectively in *C. punctatus*, *H. fossilis* and *A. testudineus*. The growth of stock and yield at different stocking densities in cages in the case of singhi and kawai are given in Figs. 18 and 19.

3.9 PARASITES AND DISEASES

Trichodina sp. a facultative parasite, was encountered in the natural collection of seed of air breathing fishes. The parasite could be controlled when better water conditions were provided to the fry.

Tumours on caged A. testudineus were sometimes recorded which could be controlled when the stocking density was reduced.

3.10 FISHERIES EXTENSION AND TRAINING

3.10.1 Fisheries extension

'Fish Farmers' Day' and 'Lab to Land' programme were inaugurated at Ulubari Fish Farm, Guwahati on 02.06.1979 by Hon'ble Fisheries Minister of Assam, Shri Lilamoy Das. The inaugural session was followed by a seminar in which Scientists and Farmers participated. Discussions were held on culture of air breathing fishes in beels, ponds and cages. Selection of breeders and induced breeding of air-breathing fishes were demonstrated in the field. Radio talks (A.I.R., Guwahati) on air breathing fish culture were also given.

3.10.2 Fisheries training

Short term training programmes were conducted by the Centre for the benefit of F.F.D.A. trainees, Fish Farmers, Village Level Gram Sevaks, Village Sarpanchs and trainees of Assam Fisheries Training College, Sibsagar. Lectures on air breathing fish culture were given to students of North Eastern Hill University, Shillong and Dibrugarh and Guwahati Universities.

3.11 ACKNOWLEDGEMENTS

Thanks are due to Messrs S.N. Bhuyan, M. Ahmed and P.K. Dwarah, Former Directors, Department of Fisheries, Government of Assam, for providing facilities and help in the execution of the work programme.

3.12 PUBLICATIONS

3.12.1 Research papers

i) Thakur, N.K., R.N. Pal and H.A. Khan, 1974. Embryonic and larval development of Heteropneustes fossilis (Bloch). J. Inland Fish. Soc. India, 6 : 33-34.

ii) Dehadrai, P.V., R.N. Pal, M. Choudhury and D.N. Singh, 1974. Observations on cage culture of air-breathing fishes in swamps in Assam. Ibid., 89-92.

iii) Pal, R.N., 1976. Treatment of tumours in Anabas testudineus (Bloch) Ibid., 8 : 105-106.

iv) Pal, R.N., H.P. Singh and M. Choudhury, 1976. Oxygen consumption of the spawn of Anabas testudineus (Bloch). Ibid., 8 : 140-142.

v) Pal, R.N., S.C. Pathak, D.N. Singh and P.V. Dehadrai, 1977. Efficacy of different feeds in survival of spawn of Anabas testudineus (Bloch) Ibid., 9 : 165-167.

vi) Pathak, S.C., Y.S. Yadav and M.P. Singh Kohli, 1980. Semi-intensive culture of Heteropneustes fossilis (Bloch) in a small pond of Ulubari fish farm, Gauhati, Proc. Indo-Pacific Fish. Coun. 15th Session, Section III. Symposium on the development and management of small scale fisheries. 539-547.

vii) Pathak, S.C., Y.S. Yadav, D.N. Singh and P.V. Dehadrai, 1980. Observations on the mixed culture experiments on air breathing fishes conducted in derelict and freshwater ponds in Gauhati (Assam). J. Inland Fish. Soc. India, 12 (1) : 112 - 115.

3.12.2 Popular articles

i) Kohli, M.P. Singh, R.K. Singh, Y.S. Yadav and S.C. Pathak, 1983. Effect of solar eclipse on the ecology of a freshwater pond at Gauhati (Assam). Bull. Pure and Applied Sci. 2 (A & B) : 28-33.

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4 ANDHRA PRADESH CENTRE

4.1 INTRODUCTION

In Andhra Pradesh, particularly in the erstwhile Hyderabad State, air breathing fishes in general and the murrels in particular are sought after for their excellent taste and keeping quality. With a view to popularise the culture of murrels and air breathing catfishes in the State, the Centre was started in February 1976 at Palair Fish Farm, 26 km from Khammam town by the Government of Andhra Pradesh with funding by ICAR. The Centre was transferred to the Andhra Pradesh Agricultural University in 1978. The broad work programme of the Centre included the assessment of seed resources in time and space of murrels (C. marulius and C. striatus), their seed collection and rearing and table fish rearing.

Palair Fish Farm has a small building housing the Office and laboratory and 4 stocking (area : 0.1 ha each), 8 rearing (area : 0.04 ha each) and 4 nursery ponds (area : 0.02 ha each).

4.2 SURVEY AND COLLECTION OF SEED

Collection of seed of different air breathing fishes was initiated in 1976. Extensive surveys were undertaken till 1984 in and around Palair reservoir and along a 50 km stretch of river Palair. While seed of magur and singhi were not encountered, those of murrels was quite common.

The details of the fry and fingerlings of *C. striatus* collected during 1977-1980 were as follows :

Years	No. of fry (10 to 40 mm)	No. of fingerlings (40 to 80 mm)
1977-1978	406,000	2,000
1978-1979	515,000	14,500
1979-1980	12,050	--

While seed of *C. striatus* were collected during the months of April to July, those of *C. marulius* were obtained during May to August. However, quantitative studies were not made.

Seed of *C. striatus*, *C. marulius* and *C. punctatus* were collected during 1983-1984 also (Table 09). The occurrence of seed was greater during the months of August and September coinciding with the onset of south-west monsoon. The only shoal of *C. marulius* collected (during May 1983) comprised of about 4,500 fry.

4.3 BREEDING EXPERIMENTS

4.3.1 Induced breeding

Breeders of *C. batrachus*, *H. fossilis* and *Channa* spp. were procured from nearby village tanks and markets. Pituitary glands of carps were procured from Calcutta. During July 1976, induced breeding of *C. batrachus* and *H. fossilis* was attempted without success. In August the same year, another attempt was made on both species when females released eggs but were not fertile. The data on the experiments conducted are given in Table 90.

Induced breeding of C. striatus was attempted in 1978. Of the 8 sets hypophysed only one responded, yielding about 1,000 fry. In 1981, one set of C. striatus was induced to breed and 950 spawn produced.

4.3.2 Pond breeding

During 1984, an attempt was made for the natural breeding of C. striatus in farm ponds. 13 breeders (size: 325-530 mm/ 320-1,300 g) procured from nearby village tanks and 14 specimens (size: 233-388 mm/ 100-437 g) grown in the farm were utilised for breeding in the month of May. Sets (females and males) in the ratio 1:1 and 3:2 were released in 6 shallow ponds having abundant vegetation. During June to September, eight broods were seen in all the ponds. Each brood comprised of about 1,000 to 1,500 fry. It was observed that with the passage of time, the number of surviving seed declined.

4.4 REARING OF SEED

In 1980, early fry of C. striatus were reared in plastic pools and fed during the first one week with boiled egg, followed by minced forage fish for 15 days. Subsequently for a week they were fed with minced dry trash fish only. The resulting fingerlings were transferred to ponds for culture. During 1981, early fry of C. striatus and C. marulius were reared in cement cisterns for a period of 3 months using a mixture of dry trash fish, white flour and green gram husk (4:1:1) as feed at 10 % body weight. A survival of 56 % was obtained.

In another experiment, C. striatus seed were reared for the first 15 days, feeding with minced fresh trash fish. During the next 15 days, along with minced fresh fish and dry trash fish, sajja(millet) flour, wheat flour and green gram husk (2:1:1:1) and vitamin tablets were given. The survival and growth were satisfactory.

In 1983-84, to evaluate the growth and survival of C. striatus fry reared at moderate and high densities in cement cisterns, live tadpoles at 50% body weight were fed for one month and later minced freshwater trash fish at 20 % of body weight was given, (Table 91) experiment 1 batches A and B). The results indicated that growth of the stock is higher at lower density and survival is independent of density when food is abundant.

In another experiment conducted to compare the growth of C. striatus fry fed with two different feeds, viz., minced fresh trash fish and a mixture of fishmeal, wheat flour, $bajr_a$ flour and red gram husk (ratio: 3:1:1:1), were served at 10 % body weight Table 3; (Experiment 2, batches A and B). Over a period of 110 days, in the batch fed with minced fish there was a net $\bar{x}$ weight gain of 4.0 g with a survival of 85.4 %, while in the batch fed with the mixture, the net weight gain was 1.38 g with a survival of 27.4 %.

4.5 CULTURE EXPERIMENTS

4.5.1 Culture in ponds

During 1980, C. striatus was cultured in two farm ponds (area : 0.1 ha each) with dry trash fish as feed. The duration of the experiments was 7 months (Table 92).

Culture of C. striatus was undertaken at two densities viz., 50,000 ha^{-1} in 0.1 ha ponds in 1981. A mixture of dried trash fish powder, wheat flour, bajra and green gram husk (ratio : 3:1:1:1) with multivitamin tablets, in the form of small pellets at 10 % body weight, was given as feed. The growth of the stock was encouraging (Table 93) at the stocking density of 25,000 ha^{-1}. Over a period of 3 months, the $\bar{x}$ weight attained was 150 g and survival, 95 %.

C. striatus fingerlings were cultured in a 400 m^2 pond under near natural conditions, without supplemental feeding. The pond had a luxuriant growth of submerged vegetation (Ottelia, Vallisneria, Hydrilla, Chara, etc.) In addition to the forage fishes already present, the pond was seeded with shrimps such as Caridina sp. and Macrobrachium lamarreii, so that they would multiply and serve as natural food for the fingerlings. The details of the experiment are presented in Table 94, experiment 1). Over a period of 9 months, fingerlings having a $\bar{x}$ initial weight of 6.4 g attained a $\bar{x}$ weight of 182.4 g with a survival of only 5.6 %. The largest specimen had grown to 388 mm/ 437 g. The net yield was only 0.953 kg m^{-2} $month^{-1}$ fish from the pond. As has been reported by other workers, the results indicate that under confined conditions, culture of murrels without supplementary feeding would be of no avail.

In other experiment, fingerlings of C. striatus were cultured in a 200 m^2 pond at a density of 15,000 ha^{-1} on a diet of minced fresh trash fish at 10 % body weight, once a day. Over a period of 5½ months, a gross yield of 48.760 kg (2,436 kg ha^{-1}) and a net yield of 42,880 kg (2,144 kg ha^{-1}) were obtained from the pond (Table 94, experiment 2). Although the experimental fish had the capacity to consume more trash fish than that was served, owing to the fluctuations in the availability, the qqantity given at times was not more than 5 % of the body weight.

Yet another culture experiment was conducted to test the acceptability and growth of C. striatus when fed on different feed mixtures of animal and plant origin. The feeds were i) minced fresh trash fish, ii) dry fish (DF), groundnut cake (GC), ricebran (RB) in 1:1:4 ratio and iii) groundnut cake, ricebran in 1:2 ratio. The experiment was conducted for a period of 5 months, (experiment 3; batches A, B, C). The results are summarised below :

Feed	Final average weight (g)	Survival (%)	Net yield ($g\ m^{-2}$) in 5 months
Minced fish	116.6	05.3	(+) 27.059
DF + GC + RB	20.6	20.0	(-) 0.537
GC + RB	18.0	6.6	(-) 1.215

The data indicate that the conventional fish feeds (mostly of plant origin used in carp culture) are not suitable for murrel and animal protein is needed by the fish for satisfactory growth and survival.

4.5.2 Culture in cages

Attempts to rear fry of C. striatus and fingerlings of C. marulius in cages made of bamboo splits and monofilament nets, held in farm ponds were failures, owing to either total mortality or escape of the fish.

4.6 DISEASES

In one of the culture experiments (Table 94), experiment 3, batch A) a few C. striatus specimens were observed to have pinkish blotches on the body. It was found that they were sores caused by infection with Lernaea sp. Nearly 50 % of the fish in the pond had the infection.

The pond (area : 200 m^2) was dewatered and all the fish (256) were retrieved. They were given bath in 250 mg 1^{-1} formalin keeping in plastic pools for 15 minutes, and released in to another pond which had been treated with lime (@ 250 kg ha^{-1}). No mortality resulting from handling and treatment was observed. Subsequent netting revealed that the infection had subsided and that the sores had healed.

4.7 FISHERIES EXTENSION AND TRAINING

A one month training programme was conducted for rural youth on behalf of Nehru Yuvak Kendra, Khammam, during August to September, 1982 on ffeshwater fish culture, including production and rearing of murrel seed.

Leaflets on murrel culture in Telugu and on air breathing fish culture in English were brought out. Publicity was given about the programme of work of the Centre through "Andhra Pradesh", the official publicity bulletin of the Government of Andhra Pradesh.

4.8 PUBLICATIONS

4.8.1 Research papers

Ravindranath, K., K. Gopal Rao and M.Y. Kamal, 1985. Lerneosis and its control in an air breathing fish culture system. Curr. Sci., 54 (17) : 885-886.

4.8.2 Popular articles

Murrel culture (in English and Telugu). (Brochure).

4.19 FUTURE LINE OF WORK

Recommendations for future line of work are :

i) A permanent station may be established for collecting and rearing of natural seed of murrels for the purpose of distribution to prospective farmers and for stocking swamps and tanks. The proposed station could also take up artificial propagation of murrels to augment the natural seed supply.

ii) Owing to the carnivorous habit and low fecundity of murrels, maintenance of their breeders and production and rearing of seed would be expensive at the present technology level. Hence, seed production may have to be subsidised by the Government. Since murrels breed practically round the year, it would be possible to make their seed available for late stocking in carp culture ponds to supplement the income of the farmers.

iii) Owing to the carnivorous and cannibalistic habit of murrels, low survival under natural conditions and the high cost involved in rearing the fry to fingerling size, they may be stocked at low density (1,000-2,000 ha^{-1}) in natural water bodies with a view mainly to utilize the trash fish naturally available and introduced in the water body.

iv) Since murrels respond well to only trash fish as feed and survival is directly proportional to the quantum of food available, their intensive culture could be taken up in places where there is a glut of fresh and dry trash fish.

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5 WEST BENGAL CENTRE

5.1 INTRODUCTION

West Bengal Centre of the Project was started in November 1975 at Kalyani (Nadia district). Five small ponds ranging from 0.02 ha to 0.1 ha in area were allotted to the Project at Kalyani Fish Farm by the Department of Fisheries in West Bengal for field research. The Centre's work programme was mainly concerned with culture of magur, C. batrachus, singhi, H. fossilis and kawai, A. testudineus which are highly prized and are in demand in the State and production of their seed in order to supplement the seed collection from natural sources.

5.2 CULTURE EXPERIMENTS

5.2.1 Culture of magur

5.2.1.1 Culture in derelict ponds

Culture of magur to marketable size was attempted in two derelict ponds (area : 0.03 and 0.04 ha) at Kalyani in November 1975. Pond 1 and 2 were stocked with fingerlings of magur @ 20,000 ha^{-1} and 40,000 ha^{-1} ($\bar{x}$ size : 10 g). The stock was fed with low priced, dry marine trash fish (cut into small pieces), obtained from Contai coast of West Bengal, @ 5 % body weight (computed from time to time by sampling 25 to 30 fish). Rice bran was also given as an additional feed with the advent of summer. Feed was given in the afternoon at 14-00 hours. Quantity of feed given was as in Table 95. The growth rate of the stock was as in Table 96.

The physico-chemical qualities of water are summerised month-wise in Table 97.

The experiments were conducted for 5 and 6 months and the gross production ha^{-1} was 1,200 and 2,000 kg respectively. The production was less as the stocking was done in winter and there was predation by crabs and poaching, prior to harvesting.

5.2.1.2 Culture in large ponds

One pond of 0.1 ha area was stocked with fingerlings @ 70,000 ha^{-1} procured from the local markets and from Kalyani Fish Farm. Feeding was done with dry marine trash fish and rice bran once a day, @ 5 % body weight of the stock and based on periodic sampling, the feed given was gradually increased with gain in weight of the stocked fish. A total 1,070 kg of trash fish and 110 kg of rice bran were fed to the stock.

Physico-chemical properties (range) of the pond water during February to June, 1977 were : pH : 8.4 to 9.2, total alkalinity : 92 to 110 mg l^{-1}, free carbon dioxide: 0 to 2 mg l^{-1} and dissolved oxygen : 6.4 to 11.0 mg l^{-1}. Free ammonia increased from trace to 4 mg l^{-1} and above during the month of June, probably due to the decomposition of the leftover dry fish given as feed.

Mortality of fish occurred as a result of the unfavourable environmental conditions. The feeding had to be suspended and the pond water partially replaced in order to improve the quality. The growth of the fish, based on the sampling of 100 specimens, was as in Table 98. Harvesting was done by dewatering of the pond in December 1978, 4,912 adult magur ($\bar{x}$ weight : 64.49 g) were retrieved, the recovery percentage being 70.31. Besides, 7,000 fingerlings ($\bar{x}$ weight : 10 g) were also obtained from the pond, as a result of natural spawning.

During the latter part of the experiment, a small stock of carp fry was introduced in the pond along with magur for utilization of the plankton and 37 kg of advance fingerlings of carps could be raised in one month.

The economics of the operation were as follows :

Inputs	70 kg magur fingerlings (@ Rs.10.00 kg^{-1})	Rs.700.00
	1,070 kg dry trash fish (@ Re. 0.80 kg^{-1})	Rs.856.00
	110 kg ricebran (@ Re. 0.50 kg^{-1})	Rs.055.00
		Rs.1,611.00
Outputs	Value of 317 kg magur harvest (@ Rs.8.50 kg^{-1})	Rs.2,694.50
	37 kg carp fingerlings (@ Rs.5.50 kg^{-1})	Rs.0,203.50
		Rs.2,898.00

Income ha^{-1} Rs.12,870.00 (excluding cost of transport, management, etc).

In 1978, another 0.1 ha pond was stocked with magur fingerlings @ Rs.50,000 ha^{-1} and fed with dry, marine trash fish and rice bran. The proportion of rice bran was increased in this experiment to reduce the cost of feed and the possibility of water pollution in the summer months.

The range in water quality of the pond during the culture period of 4 months (March to June) was, pH : 8.2 to 9.0, free carbon dioxide : 10 to 7 mg l^{-1}, dissolved oxygen : 4.4 to 10.2 mg l^{-1} and total alkalinity: 103 to 129 mg l^{-1} (Table 99). Unlike in the previous experiment, free ammonia did not assume a serious problem in the summer months.

The growth of the fish during the culture period was as in Table 100. 311 kg of magur ($\bar{x}$ weight : 82 g) was harvested in June 1978 (number harvested : 3,800; survival : 7.6 %). The cost of the inputs and the value of the output were as follows :

Inputs	75 kg magur fingerlings (@ Rs.9-40 kg^{-1})	Rs.0,675.00
	650 kg dry trash fish (@ Re.0.80 kg^{-1})	Rs.0,520.00
	300 kg rice bran (@ Re.0.60 kg^{-1})	Rs.0,180.00
		Rs.1,375.00
Output	Value of 311 kg magur raised (@ Rs.8.50 kg^{-1})	Rs.2,643.00

Thus the profit was Rs.12,680.00 ha^{-1} in 6 months

5.2.1.3 Intensive culture in pond

In December 1978, one pond of 0.1 ha was stocked with magur and singhi fingerlings at a combined density of 300,000 ha^{-1}. The stock was fed daily with fishmeal and rice bran (ratio : 1:2) @ 4 to 5 % body weight. One quarter of the feed was given in the morning and the rest in the afternoon. A water depth of 1 m was maintained in the summer months, employing a pump.

With the commencement of summer, the water temperature in the pond steadily increased and the pH showed fluctuations. The alkalinity increased with the addition of water from a tube well. Accumulation of organic matter arising from the metabolites and residual feed made the pond water unfavourable for the healthy growth of fish. Concentration of free ammonia increased, causing mortality of fish. The water quality of the pond (Table 101) could not be improved by partial replenishment. Harvesting was commenced in August and was completed by December 1979. 6,018 fishes (474 kg: $\bar{x}$ weight : 80 g) were harvested, of which singhi comprised 20 %. The recovery was only 20 %. It appears that intensive culture of magur may be successful only in small ponds (0.02 to 0.03 ha) where replenishment of water is not a problem and the water temperature can be kept around 30° Celsius by maintaining adequate depth of water in the summer months.

5.2.1.4 Semi-intensive culture in pond

A 0.1 ha pond was stocked with magur fingerlings @ 50,000 ha^{-1} and fed with fishmeal and ricebran (1:2 ratio). Cowmanure was applied @ 20 kg day^{-1} for 10 to 12 days $month^{-1}$ for 2 months. The water quality and the growth rate of the fish, are given in Tables 102 and 103. With the rise in water temperature during summer, fish mortality occurred, probably due to increase in ammonia content in the water.

After 4.5 months (March to July) the pond was harvested and 300 kg of fish obtained. The recovery was 67 % and the $\bar{x}$ size of the fish, 90 g. Besides magur, a few large murrels and small quantities of carp and miscellaneous fishes (12 kg) which gained entry in the pond during the floods were also obtained.

The total quantity of feed given (fishmeal and rice bran) was 1,000 kg and the conversion ratio was 3.3 : 1. The total cost of magur fingerlings and fedd was Rs.2,400.00 and the amount raised by the disposal of the fish was Rs.3,600.00, @ Rs.12.00 kg^{-1}.

5.2.2 Culture of singhi

5.2.2.1 Culture in derelict pond

Culture of singhi was taken up in 1978 in a 0.04 ha pond. Fingerlings ($\bar{x}$ size : 10 g) were procured locally and stocked @ 75,000 ha^{-1} in April. Cowmanure was applied regularly in the pond as feed and fertilizer from May onwards. Ricebran (@ 2 to 3 % body weight of the stock) was broadcast along with cowmanure. In all, 590 kg of cowmanure and 142 kg of ricebran were applied in the pond.

Water quality of the pond growth of the fish are given in Tables 104 and 105. Harvesting of the pond could not be done as it got submerged due to the unprecedented floods.

5.2.2.2 Culture in large pond

In February 1980, one pond of 0.1 ha was stocked with singhi fingerlings ($\bar{x}$ weight : 8 g)

@ 90,000 ha^{-1}. The fish were fed daily with fishmeal and rice bran (1:2 ratio) @ 2 to 3 % body weight. Cowmanure was applied daily for two months. After 4 months' rearing, prior to harvesting, there was poaching in the pond and only 38 kg of singhi (number: 1, 147; recovery : 12.7 %) could be harvested.

5.2.2.3 Semi-intensive and intensive culture in ponds

Semi-intensive and intensive culture of singhi was conducted in 2 ponds (area: 0.04 and 0.034 ha). During the rearing period, cowmanure was applied in both the ponds and the fish were fed with fishmeal and rice bran (1:1 ratio) @ 2 to 3 % body weight, in the evening. Survival percentage of singhi was higher than that of magur and the fish showed greater tolerance to water pollution and no replacement of water was necessary. The harvest data are summerised in Table 105.

5.2.3 <u>Culture of kawai</u>

Culture of kawai was undertaken in a shallow derelict pond of area 0.02 ha after draining and refilling. The pond was stocked with 2,500 fingerlings, (length range : 50 to 70 mm; $\bar{x}$ weight : 5.3 g; rate of stocking: 125,000 ha^{-1}) collected from same pond in December 1976. The stock was fed with a mixture of fishmeal, mustard cake and rice bran (1:2:2 ratio), initially @ 500 g day^{-1} which was progressively increased. A total of 193.5 kg of feed was given.

The range in physico-chemical qualities of water were : pH : 7.2 to 9.3, total alkalinity: 100 to 237 mg l^{-1}, free carbon dioxide : 0 to 7 mg l^{-1} and dissolved oxygen: 5.4 to 14.4 mg l^{-1}.

During the summer months there was a sharp fall in water depth and the pond had to be frequently topped up, for maintaining the water level.

Harvesting was done in November 1977 by dewatering and 545 kawai, weighing 14.05 kg were obtained. The recovery of fish was low (21.8 %), probably due to predation by birds in the shallow pond and migration during the monsoon months, in the absence of proper fencing. Besides, the pond also yielded 3.78 kg C. punctatus and other fishes.

5.3 BREEDING EXPERIMENTS

5.3.1 Induced breeding of magur

In August 1976 a portion of a shallow pond (area : 0.05 ha) was screened with bamboo fencing and paddy saplings were planted. 42 mature magur in the ratio 1 female: 1 male (size : 180 to 200 g each) were released in the enclosure. 14 each of both sexes were injected with carp pituitary hormone @ 40 mg kg^{-1} body weight to the females and 30 mg kg^{-1} body weight to the males.

Due to heavy rains, the water level of the pond increased, rendering it difficult to collect the spawners or examine the presence of fry and fingerlings therein. The pond was dewatered in November and 36 adult specimens and about 100 fingerlings (80 to 120 mm in length; 15 g $\bar{x}$ weight) of magur were obtained.

In the year 1977, 11 small plots (size: 20 x 10 m) were dug out in the low-lying area of the fish farm in two rows. 8 plots received paddy saplings while 3 were not planted with paddy. One to two sets of magur breeders injected with carp pituitary hormones at the rate of 20 mg kg^{-1} were released in the plots. Magur fry (10 to 12 mm in length) were observed in several plots after a lapse of 15 to 20 days. They were fed with fishmeal, broadcast on the water surface. Unfortunately, the experiment got vitiated because of flooding of the plots.

5.3.2 Breeding of magur under simulated conditions

Breeding of magur was achieved in Jalpaiguri district as a part of extension programme in one pond of the Fish Producers' Group in 1982. In the tank (area: 0.4 ha) having embankment on all sides and a large catchment area, with facilities to cotrol the water level, about 100 horizontal holes (30 cm long, 8 cm wide and 30 cm deep) were made on the lower portion of the inner wall of the embankment on all sides. Aquatic plants were provided inside the holes. The level of water was maintained at 15 to 20 cm above the holes during the experiment. 100 each of magur breeders of both sexes (1:1 ratio) were released in the tank and successful spawning occurred. Rice bran and mustard cake (1:1 ratio) was given in the tank as feed. Over 100,000 fingerlings obtained from the tank were sold to the public.

5.3.3 Induced breeding of singhi in the laboratory

10 sets each of singhi injected with carp pituitary extract at the dose of 110 mg and 100 mg kg^{-1} body weight to the females and males respectively were released in plastic pools (120 cm diameter and 90 cm height) and in large aluminium hundies (50 l capacity). Spawning occurred in all the cases and the fertilized eggs were collected and kept in enamel trays (size: 45 x 30 cm). After hetching, the spawn was transferred to monofilament hapas fixed in ponds. About 15,000 hatchlings thus obtained were reared to 10 to 15 cm size and released in a nursery pond for rearing.

5.4 FISHERIES EXTENSION AND TRAINING

5.4.1 Fisheries extension

On 20th May 1976, Fish Farmer's Day was held at Kalyani Fish Farm to demonstrats the technique of air breathing fish culture, especially that of magur to interested fish farmers. On this occasion, fish farmers and fishery scientists exchanged views on air breathing fish culture. The Fish Farmer's Day provided a direct link between the Farmers and Scientists in identifying the problems and finding solutions. All the leading newspapers of Calcutta and All India Radio provided coverage of the programme.

Director of Fisheries, West Bengal has sanctioned a scheme for advance of loan for culture of magur to interested fish farmers. Air breathing fish culture was taken up by the State Government in a 0.5 ha pond in the Fisheries Technological Station at Junput, Contai in Midnapur district. Extension programme on culture of magur and singhi was taken up by farmers on a large scale, especially in Midnapur and 24 Paraganas districts.

For demonstration of magur culture among the fish farmers of Sunderbans in district 24 Paraganas, two ponds at Nimpith of Ramakrishna Mission Ashram and one at Basanti of the Department of Fisheries were stocked with magur fingerlings and were fed with fishmeal, oilcake and rice bran (1:1:1 ratio). The expenditure was met from the funds of the Project. The promising results encouraged the farmers to take up magur culture.

As cheap, low grade trash fish and fishmeal are abundantly available in Midnapur district which can be advantageously utilized for air breathing fish culture, a demonstration programme was taken up at the Fisheries Technological Station in the district to popularise the technology among the fish farmers.

Rearing of magur and singhi, feeding with cowmanure and dry fish was tried in ponds, cisterns (size: 2 x 1 x 1 m) and cages at the Government Fish Farm in Jhargram Sub-Division of Midnapore district with success. The district authorities helped the Scheduled Tribe people to adopt this type of fish farming for the dgought prone areas of Jhargram Sub-Division.

Vivekananda Loka Shiksha Mandir, affiliated to the Institute of Social Education and Recreation, Ramakrishna Mission Ashram, Narandrapur, district 24 Paraganas undertook magur culture in a few ponds at Murdapur village of Nandigram II Block of Midnapur district (area: 2.2 ha). 54 fish farmers of the village took up magur culture in 61 ponds. Some farmers earned good profits while some could not, due to inadequate management practices in the first year as the ponds were at remote corners of the district and cosequently, timely technical help could not be extended to them.

The Krishi Vigyan Mandir of Nimpith in Sunderbans, 24 Paraganas district undertook semi-intensive culture of magur in the rural areas under 'lab to land' programme. Under the same programme, 5 ponds of fish farmers of Chakda and Haringhatta blocks of Nadia district were stocked with magur and singhi fingerlings. The inputs consisting of fingerlings and fishmeal worth Rs.500.00 were supplied to the farmers by the Project.

Fish Farmers' Day was organised in September 1979 at Ramakrishna Mission Ashram, Nimpith, when techniques of air breathing fish culture and induced spawning of magur in paddy fields, were explained to the fish farmers. Leaflets on air breathing fish culture were also distributed.

The Officer Incharge of the Centre delivered lectures on the Fish Farmers' Day at Ballikalitola (Hooghly district)

Barupur (24 Paraganas district), Dhubulia (Nadia district) and Murapur, Mandigram II block (Midnapur district).

5.4.2 Fisheries training

A training programme for 33 fish farmers of different districts of the State in three batches, each of 4 days duration, was arranged on the culture of air breathing fishes. District Fishery Officers of Nadia, Howrah and 24 Paraganas (North and South) also arranged training programme of fish farmers. 22 Extension Staff of Comprehensive area Development Project and the newly recruited Fishery Extension Officers of the State also received training for 2 days on this subject.

5.5 PUBLICATIONS

5.5.1 Research papers

i) Banerjee, S.M. (in press). A preliminary note on the possibilities of culture of *Anabas testudineus* (Bloch) in derelict ponds. J. Inland Fish. Soc. India.

ii) _______, (in press). A preliminary note on the possibilities of culture of *Anabas testudineus* (Bloch) in circular bamboo cages in ponds. Sci & Cult.

iii) Culture of air breathing fishes in West Bengal. Fisheries Journal, 1978 (West Bengal Fisheries Officers' Association).

iv) Cultivation of air breathing fish, *Clarias batrachus* (magur) in ponds. J. State Junior Fishery Extension Officers, West Bengal (in press).

5.5.2 Popular articles

i) Pukure jeol machher chas (in Bengali). Nabanna Bharathi, 10 (11-12): 895-899

ii) Pukure magur machher chas (in Bengali). Director of Fisheries, West Bengal.

iii) Banerjee, S.M., 1980. Kalkata sahara moila vale maccher has cbong jeol machher sambhbana (in Bengali). J. 24 Paraganas Fish Producers Association.

5.6 FUTURE LINE OF WORK

i) A survey of the seed resources of air breathing fishes in nature may be undertaken through the Marketing, Statistics and Survey Section of the Government of West Bengal with the view of quantification and proper exploitation.

ii) Further studies on the breeding of magur may be undertaken in one or two established fish farms in the State.

iii) Culture of air breathing fishes using the concept of modern technology should be taken up in all the Government Fish Farms so that this may be demonstrated to the fish culturists to motivate them for adopting such culture practices.

iv) Training programme on the culture of air breathing fishes may be arranged in Block level through the Fisheries Extension Officers.

v) The services of voluntary organizations like Ramakrishna Mission Ashram may be utilized for the extension of air breathing fish culture.

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6 COORDINATING CENTRE

6.1 INTRODUCTION

The Coordinating (Main) Centre of the Project which commenced functioning in June 1971 at Darbhanga, Bihar was shifted to Barrackpore in 1974, the Head Quarters of the Central Inland Fisheries Research Institute, for sake of administrative convenience.

Work on the physiological and biochemical aspects of nutrition of air breathing catfishes and toxicity and metabolism of organophosphorus insecticides on these fishes were undertaken by the Centre in collaboration with the Biochemistry Department of University of Calcutta, Bose Research Institute and Institute of Chemical Biology, Calcutta. Intensive culture of air breathing fishes in ponds and investigations on the ecology of a typical beel were also taken up. Two ponds (area: 0.1 ha each) were made available to the Centre at Rahara Fish Farm, near Barrackpore, for field experiments.

6.2 ECOLOGICAL STUDIES OF DHAKARDHA BEEL

The pocketed nature of weed infested swamps permit little transfer of nutrients from soil to water, causing low productivity in both primary and secondary levels. Knowledge of the role of soil-bound nutrients and the mechanism of their transfer to [illegible] water phase and the nutrient level of the soil in derelict swamps will help in developing techniques for fuller utilization of the carrying capacity of swamps for culture of air breathing fishes.

Dhakardha beel (area: 29 ha; depth: 0.5 to 1.5 m) at Kalyani in Nadia district studied was completely choked with water hyacinth and other aquatic weeds over a long period. The bottom mud was about 35 cm thick. The beel is being used for fish culture after partial reclamation.

Two hollow cylinders (both sides open) made from bamboo mat of 107 cm height and 254 cm circumference with the inner wall covered with polythene sheets to prevent mixing of water were placed in the beel at two different spots, 30 cm deep inside the mud. Water and soil samples were collected before placing the cylinders. The mud and water inside the cylinders were thoroughly raked using a bamboo pole. Water samples were collected every 48 h from the experimental enclosures.

Prior to raking the bottom soil, the water had 72 % organic carbon, 2,386 kg ha^{-1} available nitrogen, 1,727 kg ha^{-1} available phosphorus (P_2O_5- P) and a C/N ratio of 19.5. The raking of the bottom soil (after partial removal of weeds) improved the nutrients content of water. Each raking released about 9.3 kg of available nitrogen and 2 kg phosphorus ha^{-1}, in the water from the bottom soil. One raking was sufficient to keep up the nutrients in the productive level for about 15 days. The decline in the nutrients level was mostly due to the sharp fall in the concentration of phosphorus, probably due to the higher microbial use and rapid reprecipitation.

Nitrogen, phosphorus and other nutrients were released into the water in large quantities after each raking. The effects of raking of the beel bottom (Table 106) are summarised below :

i) Water pH gradually increased to neutral range from the initial value of 5.2 to 5.8.

ii) Phophorus concentration increased to 0.4 mg l^{-1} from traces.

iii) Ammonia and nitrate concentrations increased to 0.63 and 0.61 mg l^{-1} respectively from their initial low values and ammonia was converted to nitrate form by microbial transformation.

iv) Dissolved oxygen became trace from the initial low value immediately after raking and thereafter gradually increased to 8 mg l^{-1}.

v) Primary production shot up from the initial low value to about 1,500 mg of C m^{-3} h^{-1} (observed between 0800 to 1200 hours) in the course of a week.

vi) When the concentration of other elements remained nearly constant, primary production was found to be a function of the phosphorus concentration.

vii) Concentration of dissolved organic carbon increased after raking.

viii) Carbon dioxide level declined to less than 20 mg l^{-1}.

ix) Alkalinity increased immediately after raking to 100 mg l^{-1} and above, from initial value of 50 to 75 mg l^{-1}.

The studies clearly indicated that the unexposed high carrying capacity of swamps can be exploited by periodically raking the bottom for higher yield of fish with very low investment.

6.3 EXPERIMENTS ON GROWTH OF MAGUR

Investigations were undertaken to determine the conversion of different combinations of natural and cheap artificial feeds of magur, with a view to develop commercial diets. Four cisterns (area: 1.8 m^2 each), with supply of water from a bore well, were stocked at the rate of 40 magur fingerlings m^{-2}. The experiment was conducted in duplicate in winter and summer months in 1976 to find out the effect of seasons on the growth of fish. The feed in the winter (November-December) experiment consisted of low grade dried trash fish, groundnut cake and rice bran in the ratio 8:1:1. In addition 1 g yeast 100 g^{-1} feed was given to one group of fingerlings. The feed for the summer experiment (April-May) was trash fish and groundnut cake in the ratio 4:1 (1 g yeast 100 g^{-1} feed was also added). The feed was powdered and mixed with water and made into small balls and given at the rate of 10 % body weight of the stock in two instalments, in the morning and evening. Water was completely replenished every third day. Water quality in the experimental cisterns was as in Table 107. The fingerlings were acclimatized to the new environment and artificial feeding. The fingerlings supplied with yeast in their feed showed better growth (Table 108).

The $\bar{x}$ increase in size of the fish was 18.85 mm/ 19.2 g $month^{-1}$ in the experiment conducted during the summer months. The mortality was insignificant (3.1 %). Although the $\bar{x}$ growth rate of magur was low when compared to the growth of the fish in nature, this type of culture has considerable prospect for reasons of ease in rearing and harvesting in small backyard water bodies.

6.4 DIGESTIVE PHYSIOLOGY OF MAGUR

Studies on the digestive physiology with particular reference to enzymes in the alimentary canal of air breathing fishes would give a clear picture of the types of feed that would be efficiently assimilated by the air breathing fishes. Based on the results, suitable supplemental feeds could be prepared for these fishes.

Specific activity of the enzymes amylase, protease and lipase in the intestine of C. batrachus were assessed to obtain basic information on digestion of carbohydrate, protein and fat. Effect of dietary protein level on the proteolytic enzyme activity in the fish was studied (Tables 109 to 111). Activity of proteolytic enzymes showed increasing trend in the fish with increase in the dietary protein level (Table 111). Still higher dietary protein percentage showed no further increase in enzyme activity. While studying the subcellular localisation, it was noted that protease activity was more in lysosomes than in any other cell organelle (Table 110). Sixty-fold purification of alkaline protease from the intestine of magur was achieved by ion exchange chromatography on DEAE cellulose, which was further checked by polyocrylamide gel electrophoresis (Table 112 and Fig. 20).

6.5 NUTRITION AND BIOCHEMICAL STUDIES OF MAGUR

Magur responds to supplemental feed containing dried trash fish. However, it is essential to minimise the feed input cost and develop inexpensive and balanced feeds for this species to obtain better production. Knowledge of the effect of dietary regime on growth, feed conversion, enzyme activities of nutrients and energy metabolism in blood and tissues will help in the formulation of supplemental diets.

Four isonitrogenous diets (Table 113 and Fig 21) containing 330 g protein kg^{-1} and energy levels varying from 3,276.8 to 4,174.2 Kcal were fed to groups of C. batrachus at 4 % body weight for 120 days. The levels of protein included in the diets were considered optimum for the fish. The protein energy ratio (P/E) in these diets were 103, 95, 87 and 80 mg protein $Keal^{-1}$. At constant dietary protein level, weight gain, feed efficiency and protein utilization increased (Tables 114 to 116) with increase in dietary energy level upto 3,831.7 Kcal kg^{-1} (P/E = 87.59). Further elevation of dietary energy showed reduction in weight gain. Protein efficiency ratio (PER) remained negatively correlated to P/E ratio up to the optimum energy level (3,831.7 Kcal kg^{-1}). Dietary carbohydrate and to some extent dietary lipid showed a protein sparing action, indicating that part of protein could be replaced by lipid or carbohydrate calorie for reducing the cost of the feed.

Growth and metabolic activity of magur were studied after feeding the fish with methyl testosterons supplemented diets for 63 days at doses 0.0, 1.0, 2.5, 5.0 and 10.0 mg kg^{-1} feed (Table 117). Significantly higher growth and PER could be obtained in fish fed with methyl testosterons (MT) up to a concentration of 5.0 mg kg^{-1} (Tables 117 and 118). With further increase in the dose of MT there was a decrease in the growth rate (Fig. 22) and PER. Conversion ratio in fish fed MT at lower doses up to 2.5 mg kg^{-1} was better than the higher doses as well as the cotrol. The two transaminate in liver showed increased activities beyond 2.5 mg kg^{-1} doses of MT treatment over control (Fig. 23), suggesting that probably some hepatocellular disfunction might be responsible for the poor growth at higher doses. The enhanced growth rates, better conversion and PER noticed as a result of dietary administration of MT at 1.0 to 2.5 mg kg^{-1} feed was substantiated by the effect of this hormone on the rate of in vivo incorporation of l-leucine-U-^{14}C into liver protein (Table 119).

Highest specific growth rate and PER could be observed in magur fed on standard test diet followed by the fish fed on diets containing fishmeal, dried silkworm pupae, meatmeal and groundnut cake in that order, for 8 weeks (Table 120 and Fig. 24). Protein synthesis in liver measured as incorporation of 1-lysine-U-^{14}C was found to be maximum in fish under standard test diet followed by silkworm pupae, fishmeal, meatmeal and groundnut cake. Intestinal protease activity in the fish fed on silkworm pupae and on standard diet was normal, whereas fish fed on groundnut cake showed a lowering of the enzyme activity. No significant differences were discernible in the level of total serum protein, and erythrocyte and haemoglobin count in the blood of different groups of test fishes (Table 121). A positive correlation was evident between the growth of fish and serum Ca : P ratio. The results suggest that animal protein (fishmeal, silkworm pupae, etc) is superior to plant protein for satisfactory growth of magur.

6.6 TOXICITY, METABOLISM AND DETOXIFICATION OF ORGANO-PHOSPHORUS PESTICIDES IN MAGUR

Fishes have the ability to metabolically modify exogenous chemicals, contaminants, etc and non-nutrients present in natural food ingredients. Swampy and derelict waters contain a variety of chemicals and also get contaminated with pesticides from agricultural fields. The purpose of the investigation was to study the toxic actions of these contaminants in magur as also mechanism responsible for detoxification of chemicals including pesticides and insecicides. A knowledge on the sublethal effects of environmental contaminants on the physiology, cell structure, behaviour, growth and finally the induction of hepatic microsomal enzymes responsible for bio-transformation are useful for the successful culture of air-breathing fishes in swamps. Besides, studies on effect of chronic exposures and the resultant accumulation on the physiology of fishes in relation to nonacute doses are important from human health point of view.

Studies on biochemical and pathobiological changes on exposure of magur to sublethal concentration of malathion were conducted. Investigations on the activities of mitochondrial and lysosomal enzymes were carried out in the liver and gills for characterisation of the enzymatic changes under malathion exposure to the fish. Levels of certain serum indices and electrophoretic serum protein pattern were ascertained (Tables 122 to 129 Fig. 25 A, B and 26). Studies were carried out on the histopathological changes in different organs of the fish exposed to malathion. Increased activities of the microsomal drug metabolising enzymes N- and O- demethylase and the haemoprotein, cytochrome P-450 in the liver and gills of magur exposed to 1.2 mg l^{-1} malathion (Table 130 and Fig. 27) indicated that organs other than liver may be important in the biotransformation of environmental xenobiotics. Sustained increase in the activity of enzymes in magur under malathion indicated gradual development of tolerance mechanism by virtue of which the fish could thrive in the pesticide contaminated environment.

Investigations relating to the effects of 0.5 mg l^{-1} malathion in ambient water on the activities of mitochondrial ATPAse (Mg^{2+} and Na^{1+} mg^{2+} dependent) from liver and gill tissues of magur revealed a significant lowering of activities of the enzymes in experimental groups of fish compared to controls (Table 129 and Fig. 28 to 33). This indicated that toxicity of malathion is related to disruption of oxidative phosphorylation in tissues, besides causing inhibition of brain acetylcholinesterase activity and some other cellular biochemical reactions.

Measurement of the distribution of major phospholipids and fatty acids in liver tisue of magur (exposed to 0.5 mg l^{-1} malathion) were carried out (Tables 131 to 133). The phospholipids-sphingomyelin, phosphatidyl choline, lysophosphatidyl choline, phosphatidyl ethanolamine and cardiolipin responsible for characteristic and vital properties of cell membrane) did not reveal much changes in their level in experimental fish, compared to controls. The essential fatty acids in liver were also quantified by gas chromatography and the results showed no significant alteration in their make up in experimental groups of fishes from controls.

Studies conducted on the effects of malathion on reproductive functions in the fish following exposure to sublethal concentration (0.5 mg 1^{-1} in the present study) involving assessment of the level of bioaccumulation of the pesticide in gonads and histological observations of the tissue revealed that when exposed to the compound for 40 days at 0.5 mg l^{-1} level, testis accumulated it in traces, unmeasurable on chromatogram scale. Light microscopic studies of testis indicated minor change in the cellular architecture of the tissue.

6.7 TOXICITY AND METABOLISM OF MALATHION AND CARBOFURAN UNDER SHORT TERM EXPOSURE OF MAGUR

Fishes exposed to pesticides absorb them through their gill membrances which behave as typical hypoprotein barriers, thereby developing cumulative concentration of the same in their system. The object of the study was to get information about the in vivo effects of sublethal concentration of pesticides in magur under short term and chronic exposure. A knowledge of the sublethal effects of extensively used pesticides on the cell structure, growth, maturity, reproduction and finally tissue accumulation in magur will be of help in the successful culture of this species in paddy fields and other areas prone to pesticide contamination, besides assessing the general environmental effect of pesticides on inland aquaculture.

In view of the recent restrictions imposed on the use of a number of organochlorine pesticides, the carbamate pesticides and especially carbofuran (2, 3 dihydro- 2, 2 dimethyl 7 penzo-furanyl methyl carbonate) finds wide agricultural applications. Acetylcholinesterase inhibiting activity of carbofuran and its additional biochemical effects, though suspected, have not been investigated in detail, particularly in the food fishes. After a preliminary assessment on the dose response relationships and determination of 96 h LC_{50} of carbofuran of magur, the fish were exposed to 0.5 mg l^{-1} carbofuran for 30 days. Activities of some key enzymes involved in ammonia detoxification and energy metabolism were found to be markedly altered in the fish (Table 134 to 139). Studies on the bioaccumulation in various tissues indicated presence of carbofuran in gills, liver, intestine and testes. Light microscopic studies also showed disturbances in normal tissue architecture of testis of the fish. Impairment of intestinal transport processes was observed from significant decrease of Na^{1+}, K^{1+} - ATPase in intestine of the fish following carbofuran treatment.

Biochemical changes in magur exposed to sublethal level of carbofuran at 0.5 mg l^{-1} concentration in ambient water for a period of 30 days were assessed. A small reduction in growth rate was observed in the fish treated with 0.5 mg l^{-1} carbofuran for 60 days (Fig. 3, 4) although neither any mortality nor apparent symptom of toxicity could be noted. Studies were carried out on the activities of certain enzymes of intermediary metabolism <u>viz</u>., glucose 6 phosphatase, alkaline phosphatase, acid phosphatase, Na^{1+}, K^{1+} - ATPase, GOT and GPT in certain vital tissues of the fish exposed to carbofuran (0.5 mg l^{-1}) for 30 days. Exposure to carbofuran resulted in sharp inhibition of acetycholinesterase activity in the brain of the fish which recovered rather rapidly after terminating pesticide exposure and maintaining the fish in clean freshwater. Ratio of calcium/ phosphorus in serum showed significant diminition in experimental groups of fish compared to controls. Levels of ammonia in serum of experimental fish markedly increased while excretion of ammonia by fish showed concomittant decrease. The bioaccumulation level of the pesticide and its degraded product 3 hydroxycarbofuran in liver tissue was measured by gas chromatography.

6.3 NON- PROTEIN NITROGEN (NPN) UTILISATION BY MAGUR AND SINGHI

The capacity of magur and singhi to feed on organic detritus and to tolerate high concentration of ammonia in culture ponds encouraged assessing their capacity to assimilate non-protein nitrogen. This is also relevant with regard to exploration of a cheap feed combination and achieving better growth of catfishes in culture operations. Utilisation of non-protein nitrogen and subsequent formulation of tissue protein and energy will bring the culture prospects of air-breathing catfishes to the fore.

Substitution of dietary protein with partial (1 to 7 %) non-protein nitrogen from urea and feeding to magur and singhi resulted in encouraging growth response. Urea administration at 3 % in diet did not cause any significant change in the activities of hepatic aspartate and alanine aminotransferase compared to those fed on diet without NPN (control; Table 140 to 142: 143 to 145). The activities of hepatic glucose 6 phosphatase (Table 146) and intestinal urease were enhanced following urea diet treatment. Exogenous supply of ureolytic sources in the form of rumen digesta from goat did not further increase the capability of fish to utilise urea. Activity of intenstinal alkaline phosphatase in urea diet fed fishes remained unaltered compared to control. No major change could be noted with regard to the level of total protein, essential and non-essential aminoacids, urea, glucose and total ascorbic acid in serum or ingross content of protein, fat, moisture, ash, nitrogen free extract, creatine and creatinine in muscles with respect to those in control. Assimilation of NPN from urea by the fishes was studied through tracing ^{15}N and ^{14}N by mass spectrometry after ^{15}N urea administration through diet (Fig. 35 and 36).

6.9 INTENSIVE CULTURE OF MAGUR AND SINGHI

The study was undertaken to demonstrate intensive culture of magur and singhi adopting high stocking density, intensive feeding and water management. Two ponds (0.1 and 0.04 ha) were constructed at Rahara fish farm for magur and singhi respectively. A deep tube well with 90 mm bore was installed and operated on electricity.

The culture operation was conducted with feeding and water management. There was delay in commissioning the installations for the water management and the system repeatedly failed due to certain unforeseen technical difficulties. This seriously affected the targets of production.

Heavy bloom of <u>Microcystis</u>, <u>Osciliatoria</u>, <u>Euglena</u>, etc. caused oxygen depletion in water and mortality of the stock. Decaying algal matter, unconsumed feed and high concentration of ammonia (> 25 mg l^{-1}) caused water pollution. Dissolved oxygen was almost nil during the early hours of the day in both the ponds. High water temperature ($> 40°$ Celsius) in the month of June caused mortality. Details of harvesting and mortality are presented in Table 147.

Magur ($\bar{x}$ weight 10 g) was stocked at 40 m^{-2} and singhi ($\bar{x}$ weight 5 g) at 50 m^{-2} in February 1979. Magur was fed with dried marine trash fish and 'epic fish feed' supplied by commercial animal feed manufacturing firm in the ratio 1:2, mixed with biogass slurry during the first 3 months and in the ratio 3:1 for the rest of the period. Singhi was fed with 'epic fish feed' mixed with slurry. Feed was provided in bamboo baskets at night. In case of magur, trash fish was soaked in water before mixing with slurry and 'epic feed'.

Some important indices have been found for further guidance in intensive culture of magur and singhi under humid tropical climate. Monoculture of these fishes with high inputs invariably causes Microcystis bloom in summer months, particularly in May and June, when the transparency (measured by Secchi disc at 12.00 hour) of water decreases sharply. Magur was seen to be under stress at a transparency $<$ 160 mm and high mortality has been noted at transparency $<$ 120 mm. The measurement of transparency by Secchi disc being easy, the farmers can overcome the problem of Microcystis bloom by changing the water at a transparency of 160 to 300 mm.

Air breathing fishes can withstand very low oxygen concentration in water but the surfacing activity of the fish for aerial respiration increases to a great extent, resulting in more physical activity and loss in body weight by dessipation of energy. Therefore optimum oxygen value in water (5 to 6 mg l^{-1}) should lead to higher growth rate and production.

Growth of magur and singhi was not adversely affected up to a water temperature of 32° Celsius and mortality started from 38° Celsius onwards. Hence, in summer season water depth should be so controlled that its temperature does not go beyond 35° Celsius. Although shallowness of water body (30 to 50 cm) reduces the surfacing effort of the air breathing fishes and thereby increases the production, this cannot be advocated for the summer season.

Intensive culture of magur and singhi with protein rich diet showed wide diurnal variation in the ecological conditions of ponds. Large quantities of metabolites and residual feed (if any), resulted in extreme oxygen deficiency, accumulation of carbon dioxide and ammonia, and reduction in pH and alkalinity in early morning hours and the fishes showed very

very high surfacing activity and no eagerness to feed. Hence it may be desirable to give only one third of the total feed in the morning. This reduces the decomposition of the residual feed in the noon in the summer season under high temperature. The rest of the feed may be given in the evening when the water will have high dissolved oxygen concentration, low CO_2, high pH, low ammonia, high alkalinity and reduced temperature. Fishes also show higher appetite at this time.

6.10 FEED FORMULATION FOR MAGUR AND SINGHI

Although a feed consisting of a mixture of dried, marine trash fish and rice bran yielded high production in magur and singhi, the feed component constituted 70 % of the operational cost due to expensive animal protein ingredient. Substitution of the animal protein in the feed with organic matter will bring down the overall operational cost of culture.

Experiments were conducted to evolve a balanced feed mixture for air breathing catfishes with organic wastes, biogas slurry, poultry droppings and urea to replace expensive animal protein component in the feed in view of their capacity to assimilate organic detritus and even non-protein nitrogen.

To get an idea on the optimum protein required to obtain significant growth response in magur, synthetic test diets were formulated according to Halver's formula. The diets contained purified ingredients such as casein, gelatin, dextrin, starch, shark liver oil, groundnut oil, d-cellulose, vitamins and mineral mixtures (Supradyn , multivitamin and mineral tablets manufactured by Roche India). 6 groups (25 fish in each group) were fed for 5 weeks with diets containing 15, 30, 45, 60 and 75 % protein respectively and the water temperature in the experiment was 28 + 2 Celsius. Highest growth performances was found in fish fed with a diet having 60 % protein. Protein levels > 60 % showed no significant improvement, probably indicating that the requirement lies somewhere between 45 and 60 %.

The maximum feeding rate of magur and singhi in winter (temperature : 20 to 22° Celsius) was found to be 4 and 3 % of the body weight respectively when fed once a day. When the feed was given in 2 to 3 instalments, magur could consume up to 12 % and singhi up to 5 % of their respective body weight. At higher water temperature of 30 to 32° Celsius the maximum consumption rate was 12 % of the body weight in magur and 6 % in singhi. However, when feed was provided in instalments at higher temperature, there was no increase in consumption rate in singhi while magur consumed up to 14 % of its body weight.

To find out the circadian rhythm of assimilation of feed in magur, growth rate and conversion efficiency of fish in fed at different hours of the day (0600 to 1200, 1800 and 2000 hours) were studied. Although there were no significant differences in the specific growth rate of fishes at different hours, the best protein efficiency and conversion ratios were recorded in fish fed at 0600 h followed by fishes fed at 1200 and 0600 h. followed by those fed at 1200 and 0600 h, indicating that the optimum assimilation of feed takes place during evening hours.

6.10 DEVELOPMENT OF COMPOUNDED FEEDS FOR KAWAI AND MAGUR

The feed component constitutes 50 to 70 % of the operational cost in culture of air breathing fishes. The objective of the study was to develop feed formulations suitable for commercially important air breathing fishes, keeping their nutritional requirements in view.

Two feeds were compounded with cowmanure, active sludge, fishmeal and dried sloughterhouse offal for kawai. Cowmanure alone was used as feed in the control. Bioassay of the feeds was conducted in cisterns. 10 fish were taken for each feeding group, in duplicate in cement cisterns having 250 l water. The feed was offered once a day at the rate of 5 % the total biomass. The $\bar{x}$ water temperature remained around 27° Celsius during the period of bioassay of 21 days.

Best results were obtained with feed compounded from slaughterhouse offal, active sludge and cowmanure in 1:1:1 ratio (Table 148). Kawai of $\bar{x}$ weight 8.251 g achieved 27 % increase in weight in 21 days. The feed compounded from fishmeal, active sludge and cowmanure (1:1:1) registered 21.3 % gain during the same period. The control group showed 14.1 % gain only. All the feeds showed survival rates ranging between 80 to 90 %. A feed efficiency of 3.2:1 was recorded with slaughterhouse offal based diet while fishmeal based feed showed feed efficiency of 3.7:1.

6.12 PADDY-CUM-AIR BREATHING FISH CULTURE

Experiments were undertaken on the culture of magur and singhi along with the paddy at Pundooah, Hooghly, in collaboration with the Operational Research Project and the Directorate of Agriculture, Government of West Bengal, during the Kharif season, 1982.

The paddy variety, radhunipagal (scented) was transplanted on 18.11.1982 in 3 plots (size : 6 x 28 m) having a shallow perimeter canal of 75 cm wide. A water column of 8 to 10 cm was maintained in the paddy plots throughout the cultivation period from a borewell. Magur and singhi (1:1 ratio) were stocked in two plots at the rate of 1 fish m^{-2} on 14.10.1982. The third plot served as control without any fish. Fishes in one plot were fed at the rate of 5 % body weight with a mixture of fishmeal and rice bran (1:2 ratio) mixed with cowmanure. Harvesting was done on 04.11.1982 (much before the stipulated date because of low rainfall). However, paddy was harvested on 04.12.1983. Use of pesticides was avoided in the experiment. A fish production of 375.0 kg ha^{-1} in 30 days was obtained from the plot where supplemental feed was given. In addition to fish, paddy at 1,887.97 kg ha^{-1} and straw at 4,047.61 kg ha^{-1} in 60 days were obtained. A fish production of 199.4 kg ha^{-1} of magur and singhi in 30 days was obtained from the plot where supplemental feed was not provided. In addition to fish, paddy at 1,839.28 kg ha^{-1} and straw were obtained in 60 days from the plot. The control plot yielded paddy at 1,794.64 kg ha^{-1} and straw at 4,345.23 kg ha^{-1}. The production of fish, paddy and straw are given in (Table 149).

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Table 1

Maximum size of air breathing fishes recorded from tanks, reservoirs and rivers

Species	Maximum size (length in mm/ weight in g) recorded from		
	tanks	reservoirs	rivers
C. marulius	1,015/ 6,350	1,056/ 8,4[illegible]	949/ 5,200
C. striatus	603/ 2,100	604/ 2,200	604/ 2,000
C. punctatus	285/ 230	261/ 210	257/ 180
C. orientalis	231/ 155	208/ 105	237/ 165
C. batrachus	481/ 685	402/ 425	405/ 440
H. fossilis	326/ 500	269/ 350	295/ 420
N. notopterus	219/ 450	235/ 545	228/ 510

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Table 2

The physico-chemical conditions of water (range) in the tanks

Tanks	Water depth (m)	Secchi disc visibility (mm)	Water temp (°C)	D.O. (mg l^{-1})	Free CO_2 (mg l^{-1})	pH	Total alkalinity (mg l^{-1})	NH_4-N (mg l^{-1})	NO_3-N (mg l^{-1})	P_2O_5 (mg l^{-1})	SiO_2 (mg l^{-1})
Rangenahallikere	2.45-3.60	365-1,050	19.5-27.6	2.08-7.68	2.08-12.0	6.7-8.4	25.6-74.8	Tr.-0.50	Tr.0.16	Tr.0.22	07.4-23.8
Doddakere	2.40-3.20	530-1,405	21.1-28.3	4.40-8.40	2.40-11.0	6.6-8,0	48.8-68.0	Tr.-0.33	Tr.-0.13	Tr-0.13	10.4-20.4
Belasokere	1.5 -3.20	120- 640	21.2-27.6	0.20-8.46	0.0 -31.2	6.8-8.4	72.8-180.0	Tr.-0.95	Tr.-0.16	0.4-0.33	6.6-25.0

Tr. = traces

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Table 3

The quality of soil (range) in the tanks

Tanks	pH	Total soluble salts (mg 100 g^{-1})	organic carbon (%)	Available P_2O_5 (mg 100 g^{-1})	Available K (mg 100 g^{-1})
Rangenahallikere	4.7 - 6.8	Traces - 0.91	0.25 - 1.26	Traces - 22.0	129 - 270
Doddakere	5.0 - 6.6	Traces - 0.54	0.62 - 1.26	Traces - 19.8	124 - 270
Belasokere	5.0 - 7.1	Traces - 2.20	0.4 - 1.26	4.4 - 39.6	178 - 270

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Table 4

1/ Catch effort $^{-1}$ of gill net fishing in tanks

Mesh bar (mm)	Catch effort^{-1} through seasons in								
	Rangenahallikere			Doddakere			Belasokere		
	summer	monsoon	winter	summer	monsoon	winter	summer	monsoon	winter
15	9.4	5.3	17.1	27.5	18.0	3.0	71.1	86.5	9.3
20	15.1	21.4	36.0	23.2	27.3	12.3	16.9	33.2	20.0
25	3.5	10.0	nil	1.8	nil	0.7	0.2	3.8	0.4
30	4.9	1.7	6.5	4.0	nil	0.6	4.3	3.3	0,7
35	1.1	8.8	4.8	nil	nil	2.1	nil	3.2	nil
40	0.7	1.7	1.3	nil	0.8	0.5	0.4	1.2	0.8
45	1.0	4.9	nil	nil	nil	0.9	nil	nil	nil
50	1.4	5.3	nil	nil	nil	12.8	nil	nil	nil
60	nil	3.4	15.4	nil	nil	5.3	nil	nil	nil
70	nil	nil	5.9	nil	nil	nil	nil	nil	nil
80	nil	nil	nil	nil	nil	nil	nil	nil	nil

1/ weight of fish (in g) caught 100 m^{-2} 12 h^{-1}

Table 5

Size range of fishes caught in gill nets of various mesh sizes

Mesh bar (mm)	Length range (mm) of fishes caught		
	C. punctatus	C. striatus	C. marulius
15	120 - 187	-	-
20	160 - 206	166 - 212	-
25	205 - 265	195 - 260	210 - 274
30	-	264 -331	260 - 315
35	-	355 - 385	297 - 351
40	-	377 - 464	332 - 448
45	-	-	430 - 505
50	-	-	550 - 786
60	-	-	550 - 786
70	-	-	676 - 902
80	-	-	893 - 1,000

Table 6

1/ Catch effort^{-1} of long lines in tanks

Code No. of hooks operated	Catch effort^{-1} (number 2/ and weight in g) through seasons in								
	Rangonahallikore			Doddakere			Belasokere		
	summer	monsoon	winter	summer	monsoon	water	summer	monsoon	winter
7	1,900 (2)	2,150 (1)	850 (1)	1,210 (1)	1,685 (2)	1,250 (2)	- (0)	1,020 (2)	470 (1)
8	550 (1)	2,410 (2)	970 (27)	825 (1)	1,020 (1)	825 (1)	380 (1)	430 (1)	- (0)
9	- (0)	1,070 (2)	530 (1)	- (0)	680 (2)	630 (2)	425 (1)	540 (2)	390 (1)
10	505 (1)	400 (1)	385 (1)	745 (2)	525 (1)	- (0)	385 (1)	385 (1)	610 (2)
11	725 (2)	885 (3)	- (0)	300 (1)	- (0)	305 (1)	310 (1)	- (0)	355 (1)
12	350 (1)	630 (2)	290 (1)	680 (2)	300 (1)	- (0)	- (0)	460 (2)	290 (1)
13	540 (2)	- (0)	330 (1)	- (0)	590 (2)	395 (1)	305 (2)	410 (3)	315 (2)
14	- (0)	540 (2)	535 (2)	255 (1)	255 (1)	230 (1)	390 (4)	240 (2)	260 (2)
15	280 (2)	615 (3)	180 (1)	- (0)	210 (1)	410 (2)	270 (3)	405 (4)	350 (3)

1/ 100 hooks operated for 12 hr

2/ in parentheses

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Table 7

1/ Catch effort^{-1} of cast net fishing in tanks

	Catch effort^{-1} in g through seasons		
	summer	monsoon	winter
Rangenahallikere	295.3	111.7	156.1
Doddakere	216.5	190.2	188.6
Belasokere	373.9	237.1	205.4

1/ 10 operations

Table 8

Length ($\bar{x}$) at various ages in *C. marulius*

Age in years	$\bar{x}$ length (mm) obtained by		
	Probability analysis of length frequency	Study of growth checks on scales	von Bertalanffy's growth equation
1	273	262.2	259.6
2	400	393.6	414.2
3	505	513.6	502.0
4	615	619.5	611.6
5	715	716.9	702.0
6	790	793.4	778.0
7	890	878.0	851.0
8	948	932.0	911.0
9	-	970.0	967.0

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Table 9

Length ($\bar{x}$) at various ages in C. striatus

Age in years	$\bar{x}$ length (mm) obtained by: Probability analysis of length frequency	study of growth checks on scales	von Bertalanffy's growth equation
1	155	169.2	169.6
2	239	240.0	241.4
3	310	304.1	304.0
4	365	359.4	359.3
5	411	408.5	407.9
6	445	444.9	450.5

Table 10

Length ($\bar{x}$) at various ages in C. punctatus

Age in years	$\bar{x}$ length (mm) obtained by: Probability analysis of length frequency	study of growth checks on scales	von Bertalanffy's growth equation
1	115	113.5	111.5
2	153	153.8	153.9
3	192	189.5	187.0
4	231	216.3	215.7
5	265	-	259.3
6	302	-	257.7

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Table 11

Length (mm)-weight (g) relationship of murrels

Species	General	Male	Female
C. marulius	$W = 0.000007612\ L^{2.9621}$	$W = 0.000006049\ L^{2.9977}$	$W = 0.000005375\ L^{3.0204}$
C. striatus	$W = 0.000009322\ L^{2.9854}$	$W == 0.000009296\ L^{2.9843}$	$W = 0.000007943\ L^{3.0179}$
C. punctatus	$W = 0.00001415\ L^{2.9348}$	$W = 0.00006902\ L^{3.0703}$	$W = 0.00004901\ L^{2.7920}$

Table 12

Sexual dimorphism in murrels

Species	Male	Female
C. marulius	1. No bulging of abdomen 2. Vent pale	1. Slight bulging of abdomen 2. Vent round and reddish
C. striatus	1. No bulging of abdomen 2. Vent pale 3. Anal papilla-like structure prominent, its tip pointed	1. Slight bulging of abdomen 2. Vent round and reddish 3. Anal papilla-like structure broad, slightly reddish and tip blunt with a reddish dot
C. punctatus	1. No bulging of abdomen 2. Numerous minute black dots on the dark vertical bands 3. Vent oblong and pale with brown to dark periphery, a pinkish dot may be present at the centre.	1. Slight bulging of abdomen 2. Diffused dark blotches, a few minute black dots may or may not be present 3. Vent round, slightly protruding and reddish.

Table 13

Sex ratio of murrels

Species	No. examined	Sex ratio	Probability (P)
C. marulius	653	1 : 1.0535	0.508
C. striatus	1009	1 : 1.0550	0.396
C. punctatus	504	1 : 1.0225	0.790

ink

Table 14

Minimum age and size at first maturity of murrels

Size at first maturity	Male	300 mm/235 g	173 mm/36 g	103 mm/18 g
	Female	300 mm/252 g	179 mm/39 g	105 mm/21 g
Age at maturity		2 years	1 year	1 year

ink

Table 15

Fecundity of murrels ($\bar{x}$ in parentheses)

	C. marulius	C. striatus	C. punctatus
No. of specimens studied	17	47	40
Length range (mm)	320 - 994	206 - 405	122 - 287
Weight range (g)	252 -6240	80 - 830	23 - 205
Weight of ovary as per percentage of the body weight	2.008 - 2.858 (2.385)	3.651 - 6.951 (4.796)	8.72 - 13.70 (10.82)
No. of ova g^{-1} ovary	257 - 351 (302)	616 - 882	778 - 1,172 (1,124)
No. of ova g^{-1} body	6.13 - 8.41 (7.08)	29.34 - 55.04 (35.24)	91.36 - 142.84 (119.82)
Range in fecundity	1,799 - 38,375	2,794 - 28,046	2,477 - 25,483
Length-fecundity equation	$F = 0.0001972\ L^{2.76055}$	$F = 0.00005255\ L^{3.3203}$	$F = 0.0004901\ L^{3.38183}$
Weight-frcundity equation	$F = 1.03926\ W^{0.03998}$	$F = 13.56\ W^{1.17625}$	$F = 83.75\ W^{1.07501}$

ink

Table 16

Water condition (range and $\bar{x}$) in breeding containers

Water samples	DO ($mg\ l^{-1}$)	Free CO_2 ($mg\ l^{-1}$)	Total alkalinity ($mg\ l^{-1}$)	pH	NH_4-N ($mg\ l^{-1}$)
Initial	8.72 - 8.92 (8.88)	2.0 - 3.2 (2.4)	16.0 - 18.4 (17.6)	7.1 - 7.3 (7.2)	0.192 - 0.208 (0.200)
Without weeds	2.80 - 4.00 (3.20)	13.6 - 14.8 (14.4)	26.4 - 27.6 (27.2)	6.7 - 7.0 (6.8)	0.741 - 0.740 (0.739)
With weeds	12.00 - 16.00 (14.40)	1.2 - 2.4 (1.6)	14.4 - 17.2 (16.0)	8.0 - 8.3 (8.2)	0.196 - 0.204 (0.200)

ink

Table 17

Characters of developing eggs of murrels

Characters	Species			
	C. striatus	*C. marulius*	*C. punctatus*	*C. orientalis*
Size range				
(diameter in mm)				
Egg shell	1.1484 - 1.4652	1.8414 - 2.1384	1.0296 - 1.3068	0.8118 - 1.1880
Egg proper	1.0098 - 1.2672	1.6038 - 1.8216	0.8118 - 0.9900	0.6336 - 0.8712
Oil globule	0.7920 - 1.0296	1.1180 - 1.5840	0.6336 - 0.7128	0.5544 - 0.8312
Colouration				
Fertilized eggs	Translucent and bright yellow	Translucent and bright golden yellow	Translucent and straw yellow	Translucent and golden yellow
Early embryo	Transparent and brownish yellow	Transparent and brownish yellow	Transparent and brownish yellow	Transparent and brownish yellow
Advanced embryo	Amber coloured	Amber coloured	Dark brown	Dark brown

ink

Table 18

Physico-chemical conditions of water (range) in the breeding ponds

Parameters	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
Temperature (°C)	18.6 - 26.2	18.3 - 25.5	18.3 - 25.5	18.4 - 25.3	18.1 - 25.0
Transparency (mm)	585 - 625	425 - 530	560 - 995	445 - 520	425 - 505
DO (mg l^{-1})	4.8 - 16.4	6.2 - 6.8	4.6 - 13.8	6.0 7.2	6.4 - 7.0
Free CO_2 (mg l^{-1})	Nil - 14.0	2.2 - 4.4	Nil - 12.0	1.8 - 4.6	2.0 - 4.2
pH	6.4 - 7.6	7.3 - 7.6	6.5 - 7.5	7.4 - 7.6	7.3 - 7.6
Total alkalinity (mg l^{-1})	44.2 - 68.4	88.6 -122.6	44.6 - 66.8	76.2 -112.0	86.8 -120.4

Table 19

Data on induced breeding of magur and singhi

Species	Weight of breeders (g)			Dose of pituitary mg kg^{-1} breeder				Fertilization (%)	No. of	
	female	male 1	male 2	Ist female	IInd female	male 1	male 2		eggs obtained	hatchlings
C. batrachus	100	80	85	20	30	20	20	-	-	-
"	80	120	100	20	30	20	20	-	-	-
"	120	100	80	20	30	20	20	-	-	-
H. fossilis	40	30	40	20	30	20	20	-	-	-
C. batrachus	145	60	80	20	40	20	20	74.9	475	Eggs got spilled
"	65	45	85	20	40	20	20	-	-	-
"	125	85	80	20	40	20	20	-	-	-
±										
C. batrachus	60	60	45	30	60	30	30	-	-	-
"	80	40	100	30	90	30	50	-	-	-
"	40	40	60	30	120	30	60	-	-	-
H. fossilis	40	35	40	30	60	30	30	80.0	1,600	1,200
"	100	80	60	30	90	30	50	95.00	4,300	3,890
"	60	45	40	30	120	30	60	84.00	1,800	1,400
C. batrachus	85	100	-	4	80	40	-	-		-
"	100	110	-	4	80	40	-	-		-
"	80	100	-	8	160	80	-	-		-
"	120	110	-	8	160	80	-	<2		nil
H. fossilis	25	20	-	4	80	40	-	-do-		-do-

ink

Table 20

Identifying characters of young of murrels

Species	Characters
C. marulius	Dorsally dark grey and bluish below, becoming pale ventrally: a conspicuous orange yellow longitudinal band laterally running from snout to the tip of caudal fin; on caudal fin the fore runner of characteristic ocellus appears as a light dark spot surrounded by an orange hue (the orange hue anteriorly more concentrated).
C. striatus	Body vermillion red: a bright reddish golden longitudinal band laterally and a dark band below
C. punctatus	Brownish dorsally and pale ventrally: a bright golden yellow longitudinal band laterally from snout to caudal base and a yellow line mid dorsally from snout, towards dorsal fin.
C. orientalis	Brownish to dark dorsally, becoming pale to bluish ventrally: no district blotches or bands on the body: pectoral and caudal fins have vertical dark bands.

ink

Table 21

Number of broods of murrel seed collected from the tanks through months

Tanks	Species	Number of broods collected during									
		March	April	May	June	July	August	September	October	November	December
Lakkavallikere	*C. marulius*	1	1	1	2	2	1	1	1		
	C. striatus	1	2	4	10	18	8	5	3	6	26
	C. punctatus			1	2	2					
Rangenahallikere	*C. Marulius*	1	1	1	1	2	1	1			
	C. striatus	1	1	3	5	9	5	4	2		
	C. punctatus		1	1	1	2	1				
Boddakere	*C. marulius*		1	1	1	2	1	1	1		
	C. striatus			1	2	2	2	1	1		
Milghatte	*C. marulius*				1	1					
	C. striatus			1	2	2	2	1			
	C. punctatus					1					
Nidige	*C. marulius*					1	1	1			
	C. striatus				1	3	2	1			
	C. punctatus				1	1	1				
	C. orientalis				1	1	1				
Belasokere	*C. striatus*			1	2	2	2	2	2		
	C. punctatus			1	2	3	1	1			
	C. orientalis				1	1	1				

ink

Table 22

Number of seed brood^{-1} in murrels through months

Month	Range and $\bar{x}$ 1/number of seed brood^{-1} in *C. marulius*	*C. striatus*	*C. punctatus*	*C. orientalis*
March	1,855 - 2,361 (2,108)	1,780 - 3,642 (2,652)		
April	2,073 - 2,906 (2,490)	1,296 - 4,528 (2,565)		
May	1,277 - 3,649 (2,220)	1,456 - 5,290 (2,562)	1,235 - 1,531 (1,341)	
June	805 - 2,528 (1,423)	1,392 - 2,992 (2,016)	805 - 1,864 (1,345)	1,237
July	681 - 1,316 (1,084)	985 - 2,113 (1,656)	543 - 1,144 (805)	959 - 1,255 (1,121)
August	357 - 825 (595)	803 - 1,361 (1,094)	477 - 969 (707)	458 - 1,024 (784)
September	408 - 752 (526)	618 - 1,085 (836)	720	619
October	766	538 - 947 (677)		
November		665 - 736 (693)		
December		647 - 702 (678)		

ink

Table 23

Seed of air breathing fishes collected from natural sources

Species	Number of seed collected furing the years											
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
C. marulius	7,307	38,339	24,124	5,250	4,813	2,065	2,500	1,850	5,026	10,265	4,543	7,428
C. striatus	182,274	164,542	104,181	16,300	17,505	9,172	14,750	4,560	9,508	-	-	2,602
C. punctatus	12,750	15,575	-	-	-	-	-	-	-	-	-	-
C. orientalis	3,804	5,463	-	-	-	-	-	--	-	-	-	-
C. batrachus	-	-	-	2,152	905	-	-	6,500	3,000	1,700	340	-
H. fossilis	-	-	-	3,500	-	-	3,620	7,550	-	-	-	-

- collections not made

ink

Table 24

Nursery rearing of *C. striatus*

Density of stocking (million ha^{-1})	$\bar{x}$ increment of fry: length (mm)	$\bar{x}$ increment of fry: weight (mg)	Survival of fry (%)	Yield ha^{-1}: number (fry)	Yield ha^{-1}: production (kg)	Grading based on: Survival	Grading based on: Production
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Experiment 1	Initial size of fry :	5.53 mm/ 1.0 mg		Supplemental feed :	Nil		
1.5	7.50	22.5	1.76	28,160	-0.839	5	5
1.0	9.46	33.5	7.46	74,600	1.574	2	4
0.6	11.23	49.0	14.85	89,100	3.855	1	1
0.4	12.43	57.0	18.16	72,640	3.813	3	2
Experiment 2	Initial size of fry :	5.50 mm/ 1.0 mg		Supplemental feed :	goat's blood		
1.5	7.74	23.0	2.49	39,840	-0.544	5	5
1.0	9.80	39.0	6.27	62,700	1.108	3	4
0.6	11.40	54.0	15.76	94,560	4.600	1	1
0.4	12.50	59.0	18.64	74,560	4,074	2	2
0.2	13.50	69.0	26.36	52,720	3.490	4	3
Experiment 3	Initial size of fry :	9.10 mm/ 9.3 mg		Supplemental feed :	Nil		
1.5	7.22	36.0	8.52	120,320	-8.500	4	5
1.0	9.25	54.5	12.27	122,700	-1.472	3	4
0.6	10.77	68.7	24.09	144,540	5,692	1	2
0.4	11.33	74.2	31.93	127,720	6.495	2	1
0.2	11.96	81.6	40.91	81,820	5.577	5	3

.... Contd....2......

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Experiment 4	Initial size of fry :		8.90 mm/ 8.9 mg	supplemental feed :	goats blood		
1.5	13.65	111.3	13.03	208,480	11.709	4	5
1.0	19.53	261.4	42.00	420,000	104,626	1	3
0.6	23.66	331.0	63.43	330,540	124.832	2	1
0.4	25.35	409.7	70.11	200,440	113.032	3	2
0.2	27.60	490.6	77.95	155,900	76.092	5	4
Experiment 5	Initial size of fry :		0.96 mm/ 9.0 mg	supplemental feed :	notonectids		
1.5	12.40	106.6	10.49	167,040	6.406	4	5
1.0	19.00	263.0	39.00	390,000	97.392	1	3
0.6	22.90	327.4	50.71	352,260	113.100	2	1
0.4	25.07	396.0	69.09	276,360	100.326	3	2
0.2	26.05	461.2	76.02	153,640	70.442	5	4
Experiment 6	Initial size of fry :		0.55 mm/ 0.2 mg	supplemental feed :	goat's blood + yeast		
1.5	17.46	194.3	15.64	250,240	30.374	4	5
1.0	24.96	377.5	52.00	520,000	192.364	1	1
0.6	27.33	467.0	60.21	409,440	109.646	2	2
0.4	29.36	532.1	77.73	299,920	150.767	3	3
0.2	31.02	500.6	07.72	175,440	101,659	5	4
Experiment 7	Initial size of fry :		0.50 mm/ 0.0 mg	supplemental feed :	notonectids + yeast		
1.5	15.17	157.5	12.55	200,000	21.232	4	5
1.0	23.06	312.7	47.00	470,000	142.729	1	3
0.6	26.75	452.4	65.00	390,000	174.756	2	2
0.4	20.46	512.6	75.00	300,000	152,900	3	2
0.2	29.94	557.9	05.91	171,020	9.33	5	4

Contd ...... 3 ....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Experiment 8	Initial size of fry :		8.66 mm/ 8.4 mg	supplemental feed :	goat's blood + vitamin B complex		
1.5	14.45	127.8	14.30	214,500	13.615	4	5
1.0	22.23	292.3	48.73	487,300	138.231	1	1
0.6	25.85	412.6	64.17	385,020	157.053	2	1
0.4	27.38	467.0	73.13	292,720	135.799	3	3
0.2	28.93	527.5	82.27	164,540	86.497	5	4
Experiment 9	Initial size of fry :		8.48 mm/ 8.0 mg	supplemental feed :	notonectids + vitamin B complex		
1.5	13.92	110.4	12.30	184,500	9.845	4	5
1.0	21.83	288.9	43.64	436,400	121.567	1	3
0.6	25.00	367.5	59.54	357,240	129.344	2	1
0.4	27.06	452.0	72.41	289,640	130.034	3	1
0.2	28.75	519.3	79.82	159.640	34.686	5	4
Experiment 10	Initial size of fry :		8.75 mm/ 8.5 mg	supplemental feed :	goat's blood + notonectids		
1.5	12.85	110.0	11.82	189,120	9.661	4	5
1.0	19.25	261.7	38.64	386,400	95.905	1	3
0.6	20.05	326.9	59.60	357,120	114.678	2	1
0.4	20.20	391.4	69.40	277,660	107.636	3	2
0.2	27.07	460.9	76.36	552 720	69.987	5	4
Experiment 11	Initial size of fry :		8.69 mm/ 3.4 mg	supplemental feed :	goat's blood + notonectids yeast		
1.5	15.30	163.5	16.18	258,880	31.901	4	5
1.0	23.15	326.3	49.18	491.800	156.205	1	2
0.6	26.45	441.8	66.66	399.960	175.022	2	1
0.2	30.86	566.0	87.27	174.540	98.576	5	4
Experiment 12	Initial size of fry :		8.72 mm/ 8.5 mg	supplemental feed :	goat's blood + notonectids + vitamin vitamin B complex		
1.5	14.16	123.7	13.21	198,150	13.945	4	5
1.0	22.10	291.4	45.27	452,700	127.265	1	3
0.6	26.07	426.5	61.36	368,160	155.050	2	1
0.4	27.20	471.3	72.50	290,000	135.742	3	2
0.2	28.85	536.6	80.00	160,000	85.116	5	4

- negative

ink

Table 25

Seed rearing of giant murrel and magur in cages

Species	No. of cages	No.of fry cage^{-1}	Initial size ($\bar{x}$) length (mm)	Initial size ($\bar{x}$) weight (g)	feed	Rate of feeding (% body weight)	Duration of feeding (days)	Final size ($\bar{x}$) length (mm)	Final size ($\bar{x}$) weight (g)	Survival (%)
C. marulius	3	1,500	44.3	0.475	Trash fish	20	30	63.1	1.5	38.4
C. batrachus	3	1,000	30.7	0.250	Trash fish +rice bran	10	30	46.3	1.2	53.1

ink

Table 26

Rearing of seed of *C. marulius* in nursery ponds

Ponds	Stocking rate pond^{-1}	Initial size ($\bar{x}$)		Feed	Rate of feeding (% body weight)	Duration of rearing (days)	Final size		Survival (%)
		length (mm)	weight (g)				length (mm)	weight (g)	
1	2,800	52.3	0.950	Trash fish	3	163	157.5	24.750	24.88
2	2,100	86.9	4.550	-do-	3	180	241.0	91.250	20.95

ink

Table 27

Feeding experiments with murrel fingerlings in aquaria
(duration of experiment)

Species	No. in 25 l. water	Feed	Quantity of food given (g day^{-1})	Initial size		Final size	
				length (mm)	weight (g)	length (mm)	weight (g)
C. marulius	5	FTF	1,500	72.6	3,180	89.4	5.235
-do-	-do-	FSWP	-do-	-do-	-do-	75.1	3.810
-do-	-do-	FRF	2,500	100.7	7,630	115.5	11.015
-do-	-do-	FSWP	-do-	-do-	-do-	116.6	9.855
-do-	-do-	FTT	2,750	115.9	11,250	127.5	15.430
-do-	-do-	FSWP	-do-	-do-	-do-	122.7	12.820
C. striatus	5	FTF	1,250	54.3	1,385	65.8	2,375
-do-	-do-	FSWP	-do-	-do-	-do-	62.4	1,860
-do-	-do-	FTF	1,500	72.4	3,000	81.6	3,805
-do-	-do-	FSWP	-do-	-do-	-do-	75.9	3.410
-do-	-do-	FTF	2,000	107.1	9,440	115.7	11.645
-do-	-do-	FSWP	-do-	-do-	-do-	101.2	8.120

FTF = Fresh trash fish; FSWP = Fresh silk-worm pupae

ink

Table 28

The proximate composition of different supplemental feeds

Type	Proximate composition (in %)				
	moisture	protein	fat	ash	carbohydrate
F1	7.27	32.50	9.93	4.70	45.60
F2	7.66	19.25	4.53	12.49	57.07
F3	6.61	30.19	4.78	21.32	37.10
F4	5.74	15.42	1.74	26.57	50.53
F5	4.75	16.50	1.99	34.92	41.84
F6	5.84	20.13	5.12	11.50	57.41

Table 29

Growth performance of singhi fingerlings with different supplemental feeds

Type	$\bar{x}$ initial size of fish		final size of fish		$\bar{x}$ increment in weight	$\bar{x}$ fish loss	Grading of the feeds
	length (mm)	weight (g)	length (mm)	weight (g)	(g)		
F1	114.90	8.2	119.30	12.00	3.80	2.0	4
F2	-do-	-do-	119.10	11.95	3.75	1.5	5
F3	-do-	-do-	118.55	11.70	3.50	3.0	6
F4	-do-	-do-	124.40	13.15	4.95	0.5	2
F5	-do-	-do-	128.55	14.20	6.00	Nil	1
F6	-do-	-do-	121.65	13.10	4.90	0.5	3

Table 30

Growth of magur and singhi in captivity under supplemental feeding

Species	No. of fish	Initial size ($\bar{x}$)		Initial biomass	Biomass after 80 days	Increase in biomass
		length (mm)	weight (g)	(g)	(g)	(g)
C. batrachus	20	128.40	20.00	400.00	605.00	205.00
H. fossilis	50	112.60	8.00	400.00	490.00	90.00

ink

Table 31

Oxygen packing experiments with eggs of C. striatus

Density of packing (No. of eggs 1^{-1})	Physico-chemical conditions of water at commencement[1/] and conclusion of experiment						
	Survival (%)	Temperature (°C)	DO (mg 1^{-1})	Free CO_2 (mg 1^{-1})	alkalinity (mg 1^{-1})	NH_4-N (mg 1^{-1})	pH
Experiment 1. Size of eggs : 1.0 mm in diameter, duration : 24 h							
		23.3	8.2	3.8	17.6	0.1	6.9
2,000	77.3	23.4	10.1	28.3	71.2	2.9	6.9
1,500	86.6	23.5	18.8	25.5	63.8	2.2	6.9
1,000	92.4	23.5	16.8	21.2	55.9	1.7	7.0
600	100.0	23.4	20.2	16.7	44.2	1.3	7.0
400	100.0	23.3	22.4	13.1	38.3	1.0	7.1
Experiment 2. Size of eggs : 1.0 mm in diameter, duration : 48 h							
		23.4	8.2	3.6	16.8	0.1	6.9
2,000	69.4	23.4	9.3	34.4	84.8	4.9	6.8
1,500	76.2	23.4	10.2	29.6	77.3	3.9	6.8
1,000	82.3	23.4	13.5	26.4	69.9	2.8	6.9
600	88.6	23.3	15.7	22.5	64.2	2.0	6.9
400	94.7	23.3	17.3	19.8	56.4	1.5	7.0
Experiment 3. Size of eggs : 1.2 mm in diamater, duration ; 72 h							
		23.3	8.1	3.3	18.2	0.1	6.8
1,500	71.5	23.4	7.5	38.3	82.9	7.3	6.6
1,000	86.8	23.4	9.6	31.1	73.2	5.1	6.7
600	90.0	23.2	12.4	25.3	69.5	2.8	6.8
400	97.1	23.3	14.8	23.7	64.4	2.0	6.8

1/ First set of values under different columns denote the initial water quality

Table 32

Oxygen packing experiments with yolked hatchlings of *C. striatus*

Density of packing (no. of hatchlings 1^{-1})	Survival (%)	Physico-chemical conditions of water at commencement 1/ and conclusion of experiments					
		temperature	DO (mg 1^{-1})	dissolved free CO_2 (mg 1^{-1})	alkalinity (mg 1^{-1})	NH_4- N (mg 1^{-1})	pH
Experiment 1. Size of hatchlings, 3.2 mm : duration : 24 h							
		23.2	8.3	3.2	18.4	0.1	7.0
1,500	75.4	23.4	9.6	31.1	86.2	3.3	6.8
1,000	83.5	23.3	11.4	25.5	79.4	2.4	6.9
600	95.5	23.2	16.4	18.2	62.5	1.7	7.0
400	99.9	23.3	20.0	15.4	47.1	1.2	7.1
Experiment 2. Size of hatchlings : 3.0 mm, duration : 48 h							
		23.4	8.2	3.6	17.6	0.1	7.0
1,500	71.4	23.5	8.3	49.5	102.1	5.8	6.8
1,000	77.6	23.4	10.3	38.5	86.5	4.2	6.8
600	89.1	23.5	15.2	29.7	72.0	3.0	6.9
400	96.3	23.3	17.4	24.3	63.3	2.3	7.0
Experiment 3. Size of hatchlings : 3.5 mm, duration : 72 h							
		24.1	8.0	3.4	16.8	0.1	6.8
1,000	71.3	24.4	6.4	57.8	97.9	5.3	6.6
750	80.2	27.2	9.3	47.3	82.3	4.1	6.7
600	86.7	24.3	12.4	42.9	74.5	3.4	6.7
400	93.9	24.2	13.8	34.5	69.9	2.9	6.7

1/ First set of values under different columns denote the initial water quality

ink

Table 33

Oxygen packing experiments with fry of C. striatus

Density of packing (No. of fry l^{-1})	Survival (%)	Physico-chemical conditions of water at 1/ commencement and conclusion of experiments					
		temperature (°C)	DO (mg l^{-1})	dissolved free CO_2 (mg l^{-1})	alkalinity (mg l^{-1})	NH_4-N (mg l^{-1})	pH
Experiment 1. Size of fry : 9.0 mm , duration 24 h							
		23.0	8.3	3.8	28.0	0.1	6.9
750	72.5	23.0	8.9	94.8	126.6	18.9	6.9
600	80.4	22.8	7.8	80.4	102.2	10.7	6.8
500	87.5	23.0	9.5	72.7	88.4	9.2	6.8
400	94.8	22.9	11.9	62.3	75.1	7.5	6.9
Experiment 2. Size of fry : 9.0 mm, duration : 24 h : exposed to sunlight							
		23.0	8.3	143.0	28.0	0.1	6.9
750	63.3	28.5	3.9	145.5	182.8	19.4	6.3
600	72.6	28.1	4.6	128.9	152.1	16.6	6.4
500	79.3	28.2	6.0	109.4	123.3	14.2	6.0
400	85.3	28.2	7.2	94.7	97.6	12.3	6.5
Experiment 3. Size of fry : 9.0 mm., duration : 36 hr							
		23.2	8.2	3.4	32.0	0.1	6.8
600	71.7	21.4	5.8	11[illegible].5	128.8	13.1	6.5
500	78.5	21.2	7.2	92.7	112.4	11.5	6.6
400	87.3	21.3	9.6	80.5	82.5	9.6	6.7
300	92.1	21.3	11.9	69.7	68.7	8.3	6.7
Experiment 4. Size of fry : 9.0 mm, duration : 40 h							
500	21.1	21.1	8.2	3.6	32.0	0.1	6.9
500	68.2	23.2	6.0	118.6	160.7	14.2	6.6
400	73.0	23.1	8.2	105.4	132.9	12.4	6.6
300	78.6	23.0	9.8	89.2	85.2	10.8	6.7
250	84.3	23.1	10.4	76.5	53.1	9.1	6.7
Experiment 5. Size of fry : 9.0 mm, duration : 72 h							
		23.1	8.2	3.6	32.0	0.1	6.9
300	58.4	23.2	3.8	127.5	155.0	13.7	6.5
250	66.2	23.2	5.9	106.2	142.4	11.8	6.5
200	70.5	23.0	7.4	86.6	116.5	10.6	6.6
125	79.1	23.1	8.0	67.3	86.8	8.7	6.7

1/ First set of values under different columns denote the initial water quality

Table 34

Oxygen packing experiments with fry of _C. striatus_

Density of packing (No. of fry 1^{-1})	Survival (%)	Physico-chemical conditions of water at commencement 1/ and conclusion of experiments: tempe-rature (°C.)	DO (mg 1^{-1})	dissol-ved free CO_2 (mg 1^{-1})	Alkali-nity (mg 1^{-1})	NH_4-N (mg 1^{-1})	pH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Experiment 1. Size of fry : 12.2 mm; duration : 24 h							
		24.2	7.8	2.3	34.3	0.1	6.8
600	53.3	24.2	6.4	126.9	117.5	24.1	6.5
500	76.4	24.3	8.1	109.6	102.0	21.8	6.5
400	83.4	24.2	9.2	97.8	95.3	18.5	6.6
300	94.5	24.3	10.5	84.5	72.1	13.4	6.7
Experiment 2. Size of fry : 12.2 mm; duration : 36 h							
		24.1	7.8	2.4	32.4	0.1	6.8
500	59.4	22.0	4.9	116.4	128.9	25.6	6.4
400	72.2	22.1	6.3	105.2	106.6	22.5	6.5
300	88.1	22.0	8.2	89.7	82.5	18.6	6.6
250	93.5	22.2	8.9	83.7	73.4	16.9	6.6
Experiment 3. Size of fry : 12.2 mm; duration : 48 h							
		24.2	7.8	2.3	34.0	0.1	6.8
400	71.2	24.2	6.2	132.4	142.5	25.5	6.5
300	79.5	24.3	7.0	106.5	138.7	23.1	6.6
250	85.4	24.2	7.8	73.3	106.9	20.6	6.6
200	94.6	24.1	8.2	58.8	82.4	18.4	6.7
Experiment 4. Size of fry : 16.3 mm; duration : 24 h							
		25.6	7.2	3.4	18.8	0.1	6.9
400	76.77	25.6	7.4	120.4	114.5	24.4	6.6
300	83.4	25.5	8.3	81.3	88.2	20.1	6.7
200	97.9	25.5	8.9	64.3	75.2	17.7	6.8
Experiment 5. Size of fry : 16.3 mm; duration : 36 h							
		25.2	7.4	3.4	18.0	0.1	6.9
400	69.1	22.1	7.8	120.7	136.5	27.2	6.6
300	80.5	22.2	11.3	54.4	96.4	24.2	6.7
200	96.7	22.4	13.4	49.5	84.3	21.5	6.8
Experiment 6. Size of fry : 16.3 mm; duration : 48 h							
		25.4	7.8	3.6	17.8	0.1	6.8
300	43.5	25.3	3.4	134.5	157.6	28.1	6.4
250	66.3	25.3	5.8	64.0	120.0	24.3	6.5
200	77.7	25.2	6.3	59.4	85.3	22.8	6.6
125	88.2	25.3	7.8	56.5	63.2	17.6	6.7
Experiment 7. Size of fry : 23.5 mm; duration : 24 h							
		25.7	7.2	4.6	24.2	0.1	6.8
300	76.1	25.6	6.8	148.8	163.2	31.4	6.5
250	82.3	25.5	7.4	137.4	153.4	28.7	6.6
200	88.7	25.6	8.2	128.5	139.6	25.6	6.7
150	95.3	25.7	9.5	115.2	107.2	21.4	6.7

Contd ... p/2

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Experiment 8. Size of fry : 23.5 mm; duration : 36 h							
		25.7	7.2	4.6	24.2	0.1	6.8
250	69.2	21.6	4.2	156.7	165.3	30.5	6.4
200	78.6	21.7	6.9	144.4	150.5	27.9	6.5
150	86.9	21.7	8.2	128.4	123.6	24.7	6.5
100	92.4	21.6	9.4	93.2	100.4	22.2	6.6
Experiment 9. Size of fry : 23.3 mm; duration : 48 h							
		25.7	7.2	4.6	24.2	0.1	6.8
200	66.7	25.6	4.6	160.5	188.4	32.6	6.4
150	72.4	26.6	6.8	141.4	152.2	28.9	6.5
125	78.5	25.7	7.3	125.7	136.9	24.8	6.5
100	89.3	25.6	8.0	106.4	119.8	22.3	6.6
Experiment 10. Size of fry : 32.1 mm; duration : 24 h							
		24.2	8.6	8.0	18.4	0.1	6.7
250	76.6	24.2	6.3	192.7	176.3	30.2	6.3
200	84.3	24.3	7.6	154.1	162.4	27.6	6.4
150	92.5	24.5	8.6	123.2	140.8	24.2	6.5
100	100.0	24.3	12.2	102.5	125.2	21.6	6.5
Experiment 11. Size of fry : 32.1 mm; duration : 36 h							
		24.2	8.6	8.0	18.4	0.1	6.7
200	72.5	21.5	3.2	184.1	183.7	31.5	6.2
150	77.5	21.5	6.7	151.7	169.2	27.1	6.2
100	83.4	21.4	8.0	127.9	143.5	23.7	6.3
75	94.6	21.4	8.9	98.5	114.4	20.9	6.5
Experiment 12. Size of fry : 32.1 mm; duration : 48 h							
		24.2	8.6	8.0	18.4	0.1	6.7
150	69.4	24.2	4.6	174.5	181.3	29.6	6.4
100	75.8	24.3	6.3	146.7	148.6	26.8	6.5
75	83.5	24.2	7.4	119.2	127.9	23.4	6.5
50	96.7	24.2	8.8	28.4	87.6	20.4	6.6
Experiment 13. Size of fry : 32.1 mm; duration : 72 h repacked at 48 h							
		24.2	8.6	8.0	18.4	0.1	6.7
150	51.8	24.2	7.9	158.6	126.7	26.9	6.6
100	66.5	24.2	10.4	128.9	11.9	23.4	6.6
75	77.3	24.1	12.6	109.2	94.4	21.7	6.7
50	84.6	22.2	13.7	93.4	81.8	19.1	6.7
Experiment 14. Size of fry : 35.2 mm; duration : 24 h							
		26.7	6.8	1.6	28.4	0.1	7.6
200	72.5	26.5	4.3	182.5	185.3	32.8	7.0
150	78.2	26.4	6.5	144.6	162.7	29.4	7.3
100	84.2	26.4	7.9	125.3	144.6	25.7	7.4
75	89.5	26.5	9.0	96.9	117.6	23.2	7.4

Contd p/3

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Experiment 15. Size of fry : 35.3 mm; duration : 36 h							
		26.8	6.6	11.8	32.0	0.1	7.6
150	68.7	22.4	4.8	176.7	177.8	36.7	7.2
125	75.6	22.3	6.2	156.5	158.4	32.2	7.3
100	82.1	22.4	7.0	135.9	149.6	29.6	7.4
75	86.4	22.4	8.2	118.3	128.8	27.7	7.4
Experiment 16. Size of fry : 35.3 mm; duration : 48 h							
		26.7	6.7	1.4	30.2	0.1	7.6
150	52.5	26.6	3.2	197.8	210.5	38.9	7.0
125	64.9	26.7	3.9	171.4	182.2	34.5	7.1
100	72.7	26.6	4.4	154.9	161.9	31.4	7.1
75	78.3	26.6	5.8	132.6	144.4	29.8	7.3
50	88.8	26.5	7.4	106.0	123.7	26.5	7.3
Experiment 17. Size of fry : 35.3 mm; duration : 72 h repacked at 48 h							
		26.7	6.2	1.4	30.2	0.1	7.6
150	46.2	26.6	7.4	151.3	142.8	29.4	7.2
125	59.6	26.5	8.5	137.6	128.0	27.4	7.3
100	68.6	26.8	9.2	132.8	115.4	24.7	7.3
75	75.1	26.6	10.0	118.5	113.1	23.2	7.3
50	84.3	26.7	11.3	104.2	86.7	22.5	7.4

1/ First set of values under different columns denotes the initial water quality.

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Table 35

Layout of the experiments on the culture of C. striatus in swampy ponds

Swampy ponds	Pond area (ha)	Rate of stocking of trash fishes (No.ha^{-1})	Fertilization with		initial size ($\bar{x}$)		Rate of stocking (No.ha^{-1})
			cow manure kg ha^{-1} month^{-1}	lime kg ha^{-1} month^{-1}	length (mm)	weight (g)	
1	0.0420	50,000	Nil	Nil	44.0	0.800	50,000
2	-do-	20,000	-do-	-do-	48.0	1.034	20,000
3	0.0285	50,000	1,000	100	44.0	0.800	50,000
4	-do-	-do-	-do-	-do-	-do-	-do-	-do-
5	-do-	20,000	-do-	-do-	48.0	1,034	20,000
6	-do-	-do-	-do-	-do-	-do-	-do-	-do-

ink

Table 36

Survival percentage and production of C. striatus from swampy ponds

Swampy pond	Survival of murrels (%)	c production (kg) of		c total production (kg ha^{-1} yr^{-1})
		trash fishes	murrels	
1	1.3	30.5	128.7	159.2
2	5.7	50.0	145.6	195.6
3	5.2	114.0	713.1	827.1
4	11.7	431.7	894.8	1,326.5
5	41.0	291.3	797.4	1,088.7
6	11.9	301.9	772.2	1,074.1

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Table 37

Culture of *C. marulius* in earthen pond (area : 0.06 ha).

Stocking of fry (19.06.1984)					Recovery of fish (15.11.1984)			
		size of fish				size of fish		
No.	$No.ha^{-1}$	length (mm)		$\bar{x}$ weight	No.	length (mm)		$\bar{x}$ weight
		range	$\bar{x}$	(g)		range	$\bar{x}$	(g)
900	15,000	91 - 165	119.5	3.25	375	170 - 255	197.8	75.00

Gross fish production : 28.125 kg $pond^{-1}$ in 145 day

Gross fish production : 469.000 kg ha^{-1} in 145 days

ink

Table 38

Details of stocking of magur in the ponds

Pond	$\bar{x}$ size		Stocking	
	length (mm)	weight (g)	$pond^{-1}$	ha^{-1}
1	122.2	11.4	1,500	30,000
2	122.2	11.4	5,000	100,000
3	122.2	11.4	5,000	100,000

Table 39

Supplemental feed given

Pond	Quantity of feed given (kg)		
	Chickmash	fishmeal	1/ whiteflour
1	270.0	20.1	20.1
2	784.0	62.9	58.1
3	821.0	66.4	61.9

1/ used as binder

ink

Table 40

Proximate composition of supplemental feeds (range in %)

Feeds	Protein	Carbohydrate	Fat	Fibre	Moisture
Chickmesh	15.6 - 22.0	52.2 - 58.0	4 - 8	6.4 - 7.2	6 - 10
Chickmash fortified with 13 % fishmeal	23.1 - 24.2	45.0 - 51.0	8 - 9	7.6 - 8.0	8 - 9

Table 41

Water quality (range) in the ponds

Ponds	Temperature (°C)	pH	DO ($mg\ l^{-1}$)	Dissolved free CO_2 ($mg\ l^{-1}$)	Total alkalinity ($mg\ l^{-1}$)
1	26.0 - 31.0	8.1 - 8.3	6.2 - 8.0	Nil to 2.0	120 - 200
2	26.5 - 31.5	7.3 - 8.1	4.6 - 8.1	Nil to 1.8	146 - 220
3	25.8 - 31.0	7.1 - 8.2	4.8 - 8.2	Nil to 2.0	200 - 246

ink

Table 42

Growth, survival, production and food quotient of magur in the ponds

Ponds	Recovery of fish		$\bar{x}$ size		Net $\bar{x}$ increment $fish^{-1}$ in weight (g)	$\bar{x}$ daily increment in weight (g)	Food quotient	Production (kg) in 220 days		
	No.	%	length (mm)	weight (g)				gross	net	gross ha^{-1}
1	1,357	90.47	192.8	55.6	44.2	0.200	5.18	75.450	99.980	1508.980
2	3,553	71.04	168.3	40.0	28.6	0.130	8.91	142.590	101.590	2841.600
3	3,335	66.70	166.2	39.9	28.5	0.130	9.99	133.070	95.050	2661.330

ink

Table 43

Growth, survival and production of magur in nursery pond

Stocking of fry					Recovery of fish				Production of fish (kg)			
		$\bar{x}$ size					$\bar{x}$ size		in the pond		ha^{-1}	
No.	$No.ha^{-1}$ (million)	length (mm)	weight (g)	period days	No.	%	length (mm)	weight (g)	gross	net	gross	net
340	0.17	48.90	0.94	250	217	63.82	179.30	46.54	10.10	9.68	5,050	4,840

ink

Table 44

Growth, survival and production of magur in cages

Cage	$\bar{x}$ growth of fish			survival (%)	Fish production (kg) in 3 months	
	length (mm)	weight (g)				
		gross	net		$cage^{-1}$	m^{-2}
1	140.5	35.2	27.0	89.0	6.265	3.132
2	145.2	38.5	31.3	96.6	7.430	3.715
3	143.9	37.1	29.7	94.5	7.012	3.506

ink

Table 45

Stocking of Lalbagh swampy pond (area : 0.1 ha)

Species	Actual number stocked	Initial size ($\bar{x}$)		Total weight (kg)
		length (mm)	weight (g)	
C. marulius	3,000	79.8	4.2	12.600
C. punctatus	150	85.5	5.7	0.855
C. orientalis	100	73.4	3.8	0.380
H. fossilis	200	102.2	9.9	1,980

ink

Table 46

Growth particulars of <u>C</u>. <u>marulius</u> in swampy pond

Particulars	At stocking	Months 1	2	3	4	5	6	7
Size ($\bar{x}$) (length mm/ weight g)	79.8/4.2	178.7/44.8	211.7/75.2	258.3/110.8	269.4/131.8,	281.7/154.4	298.0/192.6	320.3/211
Monthly growth (length mm/weight g)		98.9/40.6	39.0/30.4	40.6/25.6	11.1/20.2	12.3/23.4	16.3/38.2	22.2/29.0

Table 47

Fish harvest from Lalbagh swampy pond

Species	Size (range)		weight (g)	Survival	Total weight of fish harvested (g)	Conttibution (%) in total production
	length (mm)	weight (g)				
C. marulius	187 - 445	50 - 550	167.25	46.16	231.640	98.26
C. punctatus	185 - 225	65 - 120	82.50	6.00	0.495	0.22
C. orientalis	153 - 175	30 - 50	40.00	2.00	0.080	0.03
H. fossilis	173 - 275	40 - 205	66.70	26.50	3.535	1.49

ink

Table 48

Expenditure on inputs and income on sale of fish from Lalbagh tank

	Particulars	For 0.1 ha 7 months^{-1} (Rs)
1	Expenditure on inputs and labour	
	During culture operation	
	Fish seed (3,500) Rs.100.00 1,000 fingerlings^{-1}	350.00
	Fresh trash fish (30 kg for initial training) Rs.1.50 kg^{-1}	45.00
	Dried marine trash fish (286 kg) Rs.2.50	715.00
	Lime (30 kg) Rs.1.00 kg^{-1}	30.00
	For harvesting	
	Diesel oil (14 l) Rs.3.40 l^{-1}	47.60
	1/ Wages of 2 labourers (2 days) Rs.10.00 labourer^{-1} day^{-1}	20.00
	Miscellabeous	50.00
		1,257.60
2	Income on sale of fish 2/ (235.750 kg) Rs.12.00 kg^{-1}	2,829.00

1/ Harvesting was done with Departmental fishermen. Labour for daily feeding not accounted

2/ At then prevailing wholesale rates.

ink

Table 49

Details of tagged fingerlings of C. marulius released

Habitat	Area of water	Release of tagged specimens			length (mm) range of the specimens
		date	habitat^{-1}	ha^{-1}	
Lalbagh tank	5.5	10.4.1977	105	19.0	143 to 289
Carp breeder pond	0.3	24.4.1984	10	33.3	137 to 165
Carp breeder pond	0.3	24.4.1984	10	20.0	114 to 180
Hessaraghatta reservoir	320	24.4.1984	100	0.8	120 to 170
Sankey tank	12	11.5.1984	200	18.3	94 to 129
		19.8.1984	20	"	117 to 180
Hebbal tank	26	11.5.1984	100	3.8	90 to 122

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Table 50

Recovery of tagged C. marulius from different habitats

Habitat	Date of release	Tag No.	Recovery date	Recovery duration	Initial size length (mm)	Initial size weight (g)	Final size length (mm)	Final size weight (g)	Growth month^{-1} (g)
Lalbagh tank	10.4.1977	A50	15.7.1977	96	134	16	272	150	41.875
-do-	-do-	B18	-do-	96	147	22	296	176	47.812
Carp breeder pond (1)	24.4.1984	M4	14.7.1984	81	150	18	320	250	92.592
-do-	-do-	Q2	17.1.1985	263	145	18	322	300	30.422
-do-	-do-	D9	01.2.1985	282	160	20	480	700	74.468
-do-	-do-	D5	-do-	282	165	20	415	440	47.808
Hessaraghatta tank	24.4.1984	03	10.7.1984	77	142	10	226	40	15.584
-do-	-do-	E6	16.1.1985	262	132	15	350	280	32.061
-do-	-do-	L8	-do-	262	136	15	360	320	36.641
Sankey tank	11.5.1984	206	24.2.1985	306	133	15	505	950	93.189
-do-	-do-	120	17.3.1985	327	115	0	530	1,300	119.275
-do-	-do-	130	24.5.1985	378	110	8	493	1,150	91.270
-do-	-do-	377	2.6.1985	386	86	5	454	920	71.503
-do-	-do-	200	2.6.1985	386	130	10	504	1,450	112.694
-do-	-do-	169	30.7.1985	445	124	10	596	1,260	84,944
-do-	-do-	87	30.7.1985	445	101	6	575	1,340	90.337
-do-	-do-	102	1.9.1985	477	157	18	642	1,800	113.208

ink

Table 51

Time (min.) taken for measuring 100 specimens of murrel, magur and singhi using the conventional and modified measuring board

(1) Specimens of fish	(2) Conventional measuring board	(3) Modified measuring board	(4) Difference in time (2) - (3)	(5) Timed saved ((4)x100 / 2)
Murrel	42.3	20.3	23.0	52.00
Magur	54.3	25.3	29.0	53.41
Singhi	71.2	37.6	33.5	47.11

ink

Table 52

Stocking density, growth and production of air breathing fishes in a pond under 'lab to land' programme

Species	Number stocked $Pond^{-1}$	Density of stocking ha^{-1}	Initial size ($\bar{x}$)		Feed	Final size (range)		Survival	Harvest of fish (kg)
			length (mm)	weight (g)		length (mm)	weight (g)		
Cl striatus	5,000		47.2	0.925	Trash fish	195-421	85-750	5.86	65.925
H. fossilis	1,000	42,000	63.8	3.733	Groundnutcake (1:1)	115-275	10-150	32.00	32.960
C. batrachus	300		64.9	2.246	-do-	145-300	35-245	61.66	21.090

Ink

Table 53

Stocking and harvesting details of a fish farmer's pond (area 0.15 ha) at Kodigehalli (culture period : 20 months)

Species	Stocking				Harvesting					Increment in growth	
	No. of fish	$No.ha^{-1}$	$\bar{x}$ size length (mm)	$\bar{x}$ size weight (g)	No.of fish	$\bar{x}$ size length (mm)	$\bar{x}$ size weight (g)	total weight (kg)	Recovery (%)	length (mm)	weight (g)
<u>C. marulius</u>	1 500	10,000	63.1	1.5	195	397.5	362.6	70.7	13.00	334.4	361.1
<u>C. batrachus</u>	1 500	10,000	46.3	1.2	203	280.0	130.2	26.4	13.53	233.7	129.9
<u>B. fossilis</u>	1 000	6,667	52.7	0.8	120	200.1	200.1	6.1	12.00	147.4	50.3
Total	4 000	26,667	-	-	518	-	-	103.2	12.84	-	-

Total <u>c</u> gross production of fish 688.3 kg ha^{-1} 20 $months^{-1}$

ink

Table 54

Monthly variations in physico-chemical conditions of water in swamps

Name of swamp	Month	Colour	Temperature (°C)	Secchi disc transparency (mm)	pH	Dissolved oxygen ($mg\ l^{-1}$)	Free CO_2 ($mg\ l^{-1}$)	Alkalinity: bicarbonate ($mg\ l^{-1}$)	Alkalinity: Carbonate ($mg\ l^{-1}$)	Phosphate ($mg\ l^{-1}$)	Total carbon ($mg\ C\ m^{-3}h^{-1}$)
Balabhadrapur	February	Brownish grey	19	320	8.8	1.3	16.9	240	Nil	4.6	7.0
	March	-do-	24-27	200-250	8.9-9.0	4.4-5.3	Nil	250	10	0.51-0.64	3.0-7.4
	April	-do-	27	110	9.2	4.5	Nil	245	60	00.41	2.6
	May	Greenish brown	33	240	9.0	8.1	Nil	240	2	1.1	0.6
	June	Dirty green	34.4	196	8.9	6.8	Nil	262	28	1.25	0.3
	July	-do-	32.4	170	9.6	2.5	Nil	480	118	2.1	0.8
	August	Deep green to dirty green	30.5-32.7	125-175	9-9.3	3.3-5.0	Nil	142-430	14.84	0.27	-
	September	-do-	27.5	290	8.2	0.2	20	23	-	-	-
	October	-do-	25.2	280	8.0	1.6	10	280	Nil	-	-
Bahadurpur	March	Dark grey to blackish	22-29.5	600-660	8 8.2	0.6-2.7	10-42.4	160-208	Nil	0.9	7.0
	April	-do-	32	530	8.6	3.1	Nil	234	1	4.4	1,7
	May	-do-	33	240	8.1	0.6	20	260	Nil	2.4	-
	July	Clear	29.7	Bottom visible	8.0	0.9	20	432	Nil	3.3	-
	August	-do-	29.5	-do-	8.0	1.2	15.5	122	Nil	2.4	8
	September	-do-	28.0	-do-	8.0	1.0	16.0	180	Nil	1.05	-
	October	-do-	26.7	-do-	8.0	1.8	12.0	300	Nil	1.8	-

Table 55

Diet fluctuations in physico-chemical conditions in Balabadrapur swamp

Season	Time (hrs)	Colour of water	Temperature (°Celsius)	Secchi disc transparency (mm)	pH	Dissolved oxygen (mg l^{-1})	Free CO_2 (mg l^{-1})	bicarbonate	carbonate	Phosphate (mg l^{-1})	Total carbon (mg C m^{-3} h^{-1})
Winter	1200	Brownish grey	19.00	320	8.0	1.3	16.0	240	-	4.60	7.0
	1600	-do-	20.40	295	8.0	2.2	16.0	240	-	4.60	7.4
	2000	-do-	19.25	-	8.4	1.6	20.0	236	-	4.60	2.4
	2400	-do-	18.00	-	8.4	0.8	18.0	234	-	4.60	2.4
	0400	-do-	17.00	-	8.4	0.3	26.0	228	-	4.60	2.8
	0800	-do-	16.50	345	8.4	0.5	14.0	216	-	4.60	4.0
Summer	1200	Dull greenish	33.00	200	9.0	8.1	Nil	462	28	1.10	0.6
	1600	-do-	32.00	285	9.1	7.5	Nil	424	64	1.05	0.8
	2000	-do-	30.00	-	8.9	4.2	Nil	262	58	1.10	0.8
	2400	-do-	29.00	-	8.2	1.1	18.0	418	Nil	1.10	0.6
	0400	-do-	28.00	-	8.2	0.4	20.0	540	Nil	1.10	0.6
	0800	-do-	27.00	190	8.0	1.0	12.0	363	Nil	1.10	0.6
Monsoon	1200	Dirty green	30.50	125	9.0	3.3	Nil	142	14	0.27	10.0
	1600	-do-	32.25	118	9.6	7.5	Nil	200	40	0.27	10.0
	2000	-do-	31.00	-	9.0	5.8	Nil	140	28	0.16	10.0
	2400	-do-	30.00	-	9.1	2.5	Nil	190	16	0.16	10.0
	0400	-do-	29.75	-	8.8	0.9	10	140	Nil	0.16	10.0
	0800	-do-	29.00	135	8.0	1.2	Nil	210	10	0.16	10.0

Table 56

Diel fluctuations in physico-chemical conditions in Bahadurpur swamp

Season	Time (hrs)	Colour of water	Temperature (°Celsius)	Secchi disc trans-parency (mm)	pH	Dissolved oxygen (mg l^{-1})	Free CO_2 (mg l^{-1})	Alkalinity (mg l^{-1}) bicar-bonate	carbo-nate	Phosphate (mg l^{-1})	Total carbon (mg C m^{-3} h^{-1})
Summer	1200	Light greenish	33.00	240	8.1	0.6	20.0	260	--	2.4	0.4
	1600	-do-	34.75	275	8.1	1.7	16.0	254	--	2.4	0.4
	2000	-do-	32.75	-	8.0	0.4	20.0	234	--	2.4	0.4
	2400	-do-	31.50	-	8.2	0.2	22.0	240	--	3.3	0.4
	0400	-do-	30.75	-	8.0	0.3	26.0	244	--	3.3	0.4
	0800	-do-	30.25	300	9.0	0.4	16.0	230	--	3.3	0.4
	1200		29.5	Bottom visible	8.0	1.2	15.5	122	Nil	2.4	8.0
	1600		30.4	--	8.0	1.0	10.0	120	Nil	2.4	8.0
	2000		29.5	--	8.0	1.0	20.0	150	-	2.4	8.0
	2400		28.8	--	8.0	0.8	22.0	142	-	2.4	8.0
	0400		28.4	--	8.0	0.5	20.0	130	-	2.4	8.0
	0800		29.8	---	8.2	0.7	14.0	128	-	2.4	8.0

Table 57

Diel fluctuations of plankton in Bahadurpur swamp

Season	Collection time (h)	No. of plankton					
		Balabhadrapur		Bahadurpur		Jano-mano	
		Phyto-	Zoo	Phyto -	Zoo	Phyto-	Zoo
Winter	1200	8,304	37,728				
	1600	7,560	26,334				
	2000	1,835	18,380				
	0400	2,052	27,702				
	0800	10,000	42,480				
Summer	1200	--	--	949	76	39	26
	1600	30,970	2,250	,993	164	2,163	201
	2000	60,390	1,170	4,817	26	152	240
	2400	31,020	1,500	1,802	221	52	64
	0400	16,170	1,554	832	1250	52	100
	0800	--	--	326	190	-	-
Rainy	1200	4,746	452	2,651	663	.684	76
	1600	25,544	772	884	663	2,235	1,224
	2000	14,444	123	1,480	148	3,264	3,052
	2400	1,03,896	650	5,978	196	224	560
	0400	92,128	1,110	1,200	200	Nil	2,244
	0800	43,618	904	3,348	194	Nil	9,632

Table 58

Primary productivity in swamps

Name of swamp	Month	Temperature (°Celsius)	Gross photosynthesis (mg l^{-1})	Primary productivity (mg C m^{-3} h^{-1})	
				net	gross
Bahadurpur	April	32.0	1.9	148.437	99.27
	May	30.25	1.4	109.375	281.25
	July	29.75	0.6	46.875	11.458
	August	29.5	1.1	85.937	23.437
	September	28.0	0.8	62.5	46.875
	October	27.5	3.4	531.25	171.875
Balabadrapur	February	17.5	0.9	281.25	166.56
	March	27.0	10.3	804.687	710.93
	April	27.0	15.5	1210.937	1210.92
	May	30.0	10.6	828.125	742.18
	June	34.4	6.4	500.0	500.0
	July	32.4	3.5	273.437	156.25
	August	32.7	5.3	414.062	218.75
	September	27.5	0.4	31.25	31.25
	October	24.7	2.0	156.25	31.25
Jano-mano	June	32.0	0.2	15.625	23.437
	August	29.5	0.4	31.250	11.458

Table 59

Nutrient content of bottom soil of swamps

Season	Swamp	Available P_2O_5 (mg 100 g^{-1})	Available Nitrogen (mg 100 g^{-1})	Silicate %
Winter	Balabadrapur	20.25	33.04	57
	Bahadurpur	22.25	24.36	49
	Janomano	2.25	55.44	67
Summer	Balbadrapur	45.4	40.88	--
	Bahadurpur	47.8	53.2	--
	Janomano	6.25	59.7	--

Table 60

Fecundity of *H. fossilis*

Sl. No.	Size of fish: length (mm)	Size of fish: weight (g)	Ovary weight (g)	Total mature eggs
1	285	112.0	13.6	36,706
2	255	97.0	12.5	20,391
3	226	74.1	12.6	27,675
4	226	79.0	12.3	20,069
5	240	67.0	7.73	14,773
6	256	92.0	11.5	19,953
7	251	84.0	10.7	23,228
8	239	80.0	12.2	27,443
9	220	75.8	7.7	15,280

Table 61

Body measurements of larvae post-larvae in the various stages of development of *H.fossilis*

Measurements (mm)	On hatching	6-8 hrs. old	Days old: 1	2	3	4	5	10	15
Total length	2.72	3.80	4.60	5.50	5.70	5.80	6.60	7.50	11.90
Standard length	2.71	3.70	4.30	5.00	5.10	5.30	6.10	6.80	10.30
Length to vent	-	2.10	2.20	2.30	2.40	2.50	2.80	3.30	4.80
Length of yolk-sac	1.10	1.60	1.10	1.00	0.90	0.80	-	-	-
Max.height of yolk-sac	1.10	1.00	0.90	0.80	0.70	0.60	-	-	-

Table 62

Index of preponderance of the diet of magur.

Food items	Postlarvae: 15 mm	Postlarvae: 16-30 mm	Juvenile: 31-100 mm	Adult: 101 - 357 mm
Crustacea	94.56	47.78	6.79	0.54
Oligocheta	0.11	19.41	1.05	0.02
Insects	0.06	19.14	80.16	62.29
Fish	-	-	0.05	1.67
Plant matter	-	0.03	1.41	9.64
Miscellaneous	55.28	13.65	10.55	25.83

Table 63

Monthly fluctuations in the values of gastrosomatic index, mean food index, gonadosomatic index and relative condition of magur

Months	Gastrosomatic index		Food index		Gonadosomatic index		Relative condition	
	male	female	male	female	male	female	male	female
January	1.21	1.70	0.22	0.49	0.04	0.20	1.004	1.009
February	2.33	2.02	0.66	0.58	0.07	0.47	1.000	1.003
March	3.43	3.25	1.89	1.61	0.08	0.56	1.001	1.014
April	1.94	1.93	0.68	0.01	0.10	0.58	1.005	1.012
May	1.69	1.44	0.53	0.38	0.12	1.75	0.995	1.010
Jume	1.31	2.17	0.35	0.37	0.20	10.07	0.985	1.001
July	1.85	2.00	0.41	0.47	0.20	10.51	0.994	1.012
August	1.42	1.65	8.49	0.73	0.20	7.05	0.972	0.995
September	5.56	4.76	3.29	2.78	0.08	1.43	0.997	1.002
October	3.50	2.51	1.97	0.90	-	-	1.014	1.002
November	2.24	2.43	0.69	0.80	0.03	0.31	1.013	1.020
December	2.31	2.43	0.61	0.77	0.04	0.31	1.001	1.013

Table 64

Calculated values of body weight, ovary weight and fecundity of magur of different lengths

Total length (mm)	Body weight (g)	Ovary weight (g)	Fecundity (x 1,000)			No. of ova g^{-1} body weight	No. of ova g^{-1} ovary weight
			length	weight	ovary		
150	26.63	2.019	1.06	1.03	1.28	39	635
160	32.37	2.558	1.34	1.36	1.53	42	599
170	39.14	3.197	1.66	1.76	1.83	45	573
180	46.63	3.942	2.04	2.20	2.18	47	552
190	55.07	4.809	2.47	2.70	2.58	49	537
200	64.48	5.800	2.07	3.26	3.04	51	525
210	74.90	6.939	3.53	3.88	3.57	52	515
220	86.42	8.230	4.17	4.56	4.17	53	507
230	99.06	9.688	4.88	5.31	4.85	54	501
240	112.90	11.330	5.68	6.13	5.62	54	496
250	129.00	13.250	6.57	7.02	6.46	55	491
260	144.40	15.200	7.56	7.99	7.42	55	488
270	162.10	17.460	8.64	9.04	8.47	56	485
280	181.30	19.950	9.84	10.18	9.63	56	483
290	282.00	22.680	11.15	11.40	10.90	56	481
300	224.20	25.680	12.85	12.72	12.29	57	479
310	247.90	28.980	14.14	14.12	13.83	57	477
320	273.30	32.570	15.84	15.63	15.50	57	476
330	300.40	36.440	17.68	17.23	17.30	57	475
340	329.20	40.670	19.66	18.94	19.27	58	474
350	359.90	45.240	21.79	20.75	21.39	58	473

Table 65

Hypophysation of *C. batrachus*

Year	Breeders		Carp pituitary dose ($mg\ kg^{-1}$)	Breeding environment	Result	Remarks
	female	male				
1973	4	8	100-200	PP	No response	-
1974	16	18	80-200	PP & A	Nil to profuse egg shedding, No fertilization	Weeds and stone chips provided
1975	7	7	50-130	PP	6,600 eggs	-do-
	7	7	80-90	PF	723 fry	-
1976	15	15	100	BP	Nil to profuse spawning	Bottom ploughed & manured
1977	17	17	120	PF & P	No response	-
1978	8	8	100	PP & A	No response	-
	6	8	100	PF	No response	-
	10	10	100	P	156 fingerlings (32 to 119 mm)	-
1979	21	21	100	BP	A few young ones	-
1980	32	40	30-150	PP & BP	No response	-
1981	15	27	80-150	PP; BP & P	Success in one set by stripping	A few hatchlings survived
1982	28	38	80-110	P & PP	No response	Poor fertilization
1983	*3	6	40-60	BP	Bred	20 fingerlings (98-110 mm) obtained
	35	73	60-100	P	Nil	-
	3	6	150-200	PP	No response	-
1984	22	44	80	PP	550 viable eggs	Died subsequently

P = Pond; PP= Plastic pool; A = Aquaria
BP = Breeding pit; PF = Paddy field;

* Fish injected with homoplastic glands

Table 66

Hypophysation of *H. fossilis*

Year	Breeder female	Breeder male	Carp pituitary dose (mg kg^{-1})	Breeding environment	Result	Remarks
1972	6	12	40-250	Plastic pool	Egg shedding 10-70% in 3 sets	-
1973	36	72	150-200	Plastic tank	60,000 fry	-
1974	17	-	100-200	Plastic tank	10,000 fertilized eggs	Only 10 sets responded
1975	22	40	100-200	Plastic tank	35,000 hatchlings	Response was over 90%
1976	39	60	150-	Plastic tank	70,000 hatchlings	Response about 70%
1977	27	27	100-200	Plastic pool	50,000 hatchlings	Response about 90%
1978	17	17	100-200	Plastic tank	21,000 hatchlings	Response about 82%
1979	15	20	100-200	Plastic tank	25,000 hatchlings	Response about 53%
1980	38	50	30-150	Plastic pool & paddy field	35,000 fertilized eggs yielding 7,000 hatchlings	Marine catfish glands were used in 28 sets
1981	3	6	80-100	Pond	No response	-
	5	10	80-100	Pond	A few fingerlings	25,000 fingerlings
1982	2	4	80-110	Plastic pool		
	1	2	80-110	(at room temperature)	50,000 eggs	
	7	11	80-110	Breeding pit	No response	
1983	3	6	100-120	Plastic pool	20,000 viable eggs	15,000 hatchlings
	6	11	100	Breeding pit	No response	
1984	5	13	9.4	Plastic pool	8,800 viable eggs	Died next day

Table 67

Hypophysation of *A. testudineus*

Year	females	males	Pituitary dose (mg kg^{-1})	Breeding environment	Result	Remarks
1973	9	9	05	hapa & plastic pool	45,000 eggs	7 sets responded
1974	7	7	05	-	20,000 eggs	3 sets responded
1975	4	4	05	plastic pool	50,000 eggs	2 sets responded
1978	8	8	05	plastic pool	80,000 hatchlings	6 sets responded
1979	5	5	05	plastic pool	2,000 hatchlings	All sets responded, egg shedding very poor

Table 68

Seed of air breathing fishes landed in the markets in Bihar during 1981-84

Month	District	No. of markets	Quantity in kg		
			Magur (size range: 40-124 mm)	Singhi (size range 80-130 mm)	Murrels
November'81	Ranchi	15	0.300	Nil	Nil
	Gumla	3	5.500	Nil	Nil
August'82	Ranchi	18	0.500	Nil	Nil
September'82	Gumla	3	2.500	Nil	Nil
November '82	Ranchi	8	7.700	Nil	Nil
	Gumla	3	17.000	Nil	Nil
March'83	Patna	4	Nil	76.000	Nil
June'83	W. Champaran	1	Nil	4.000	Nil
	Darbhanga	2	Nil	18.000	Nil
September'83	Gumla	3	0.880	18.000	Nil
	Ranchi	1	6.000	Nil	Nil
	Singbhum	2	2.700	Nil	Nil
October'83	Ranchi	8	20.200	Nil	Nil
	Singbhum	5	34.500	Nil	Nil
	Lohardaga	3	3,200	Nil	Nil
	Gumla	4	180.300	Nil	Nil
	Singbhum (Hatgambharia)	1	400.000	Nil Nil	Nil
November '83	Ranchi	6	16.000	2.000	Nil
	Singbhum	6	60.000	Nil	Nil
	Gumla	3	125.000	Nil	Nil
	Gumla (Simdega Sub-division)	7	37.500	Nil	Nil
April'84	Purnea	2	Nil	169.250	Nil
	Katihar	1	Nil	62.000	Nil
	Saharsa	3	Nil	209.400	Nil
	Darbhanga	1	Nil	21.250	131.0
May'84	Darbhanga	2	Nil	1.700	Nil
	Saharsa	3	Nil	180.750	Nil
	Purnea	3	Nil	111.800	Nil
	Katihar	1	Nil	88.950	35.0
	Muzaffarpur	2	Nil	23.200	Nil

Table 69

Collection of air breathing fish seed from nature

Species	Year	Place of collection	Collection source	Number collected	Length range (mm)
C. punctatus	1973	Dharbhanga District	Swamp and Paddy field	25,358	12-20
C. striatus	1973	-do-	-do-	5,446	14-70
H. fossilis	1973	Saharsa and Darbhanga	-do-	1,688	90-200
-do-	1978	Darbhanga District	-do-	5,250	80-150
-do-	1979	-do-	-do-	6,000	90-150
C. batrachus	1973	Ranchi District	Paddy Field	360	90-150
-do-	1977	-do-	-do-	1,800	80-280
-do-	1977	West Bengal	-do-	23,442	112-225
-do-	1978	Ranchi	-do-	7,000	100-200
-do-	1979	West Bengal	-do-	1,509	90-200
-do-	1979	Ranchi	-do-	3,000	90-175
-do-	1981	Jaispur (MP)	-do-	2,760	109-147
A. testudineus	1973	Saharsa and Darbhanga	Swamp, marshy land and Paddy field	285	30-127

Table 70

Seed produced by induced breeding of singhi, magur and kawai

Fish	1973	1974	1975
Singhi	8,000 (12-15 mm)	5,000 (20-30 mm)	3,500 (30-68 mm)
Magur	Nil	119 (20-57 mm)	357 (15-45 mm)
Kawai	9,000 (15-20 mm)	10,000 (10-12 mm)	10,000 (8-9 mm)

Table 71

Feeding propensity of kawai on <u>Anisops</u>

Group	No.of fish	$\bar{x}$ length of fish (mm)	$\bar{x}$ weight of fish (g)	$\bar{x}$ No. of Anisops consumed by fish day^{-1}	Total weight of Anisops consumed by fish ($g\ day^{-1}$)	Concumption(%) body wt. of fish
I	8	3.66	1.98	21	0.315	15.9%
II	8	4.95	3.29	31	0.465	19.7%
III	8	5.12	3.55	38	0.570	16.1%
IV	8	13.10	36.3	123	1.845	5.0%
V	8	13.53	37.2	130	1.950	5.2%
VI	8	13.15	37.5	152	2.280	6.1%

Table 72

Feeding experiments with kawai on <u>Cyclops</u>

Sl. No.	Density of Cyclops. l^{-1} water	Survival of spawn (size range 5 to 7 mm) in			Survival of spawn (size range 6 to 9 mm) in		
		6 h	12 h	24 h	6 h	12 h	24 h
1	3000	9	Nil	Nil	14	13	13
2	1500	11	Nil	Nil	12	10	9
3	750	22	22	16	25	23	23

REMARKS: Survived ones between 8 & 9 mm in length.

Table 73

Data on seed transportation

Species	Number transported	Size	Containers capacity (volume of water used, half of the containers capacity)	Time taken (h)	Mortality at the end of journey
H. fossilis	1,100	10-20 (mm)	15 l	10	2.0
	1,200	25-30 "	12 l	1	20.0
	4,225	10-50 "	12 l	1	33.0
	1,200	20-50 "	12 l	1	6.0
	1,834	07-35 "	12 l	1	48.0
	53	90-18.5"	12 l	2	0
	5,250	6.4 g($\bar{x}$ wt.)	0.53 m^3	9	0
	5,000	6.0 g "	40 l	10	5.2
	6,000	14.7 g "	0.53 m^3	-	6.7
C. batrachus	60	10-20 mm	0.53 m^3	10	0
	360	10-15 "	12 l	12	17.0
	1,800	12.0 g($\bar{x}$ wt.)	1.5 m^3	12	74.0
	7,000	11.0 g "	15 l	28	100.0
	1,600	11.0 g "	15 l	28	10.0
	10,192	11.0 g "	0.53 m^3	8	0.3
	657	27.0 g "	0.53 m^3	9	5.2
	3,500	10.0 g "	1.4 m^3	14	0.4
	3,500	10.0 g "	1.4 m^3	14	7.6
	4,124	8.9 g "	15 l	10	1.6
	1,190	-	40 l	55	20.3
	2,700	-	0.53 m^3	55	5.0
	67	7-8 mm	45 l*	16	3.0
	226	44-93 "	0.53 m^3	16	0.9
	1,350	95-123 "	0.53 m^3	75	13.4
A. testudineus	164	3.0-5.0 mm	12 l	10	0
	1,447	0.6-2.5 "	12 l	1	6.0
	1,050	0.6-2.0 "	12 l	1	9.0
C. punctatus	2,200	1.0-2.0 mm	12 l		
C. striatus	296	5.0-7.0 mm	12 l	2	0
	2,663	1.4-1.6 "	12 l	1	0

*under oxygen packing.

Table 74

Experimental data on production of air breathing fishes in abandoned nurseries

Expt. No.	Type of culture	Species	$\bar{x}$ size (mm)	stocking density ha^{-1}	Gross production (kg ha^{-1})
1	Monoculture	Singhi	28	170,000	200
2	Monoculture	Kawai	55	80,000	125
3	Mixed culture	Singhi	130	40,000	524
		Kawai	83		
4	Mixed culture	Singhi	90	70,000	1,200
		Magur	105		
		Kawai			

Table 75

Culture experiments during 1978-1984

Sl. No.	Water area (ha)/ location	Species	Stocking rate ha^{-1}	Supplementary feed	$\bar{x}$ weight (g) Initial	Final	Survival (%)	Gross Production	Cost of production (kg^{-1})
1	0.04/Mithapur fish farm, Patna	Magur and major carps	25,000 magur residual stock of carp seed	RB, FM, PF	11.8	37.05	75	2,501 kg in 8 months (magur's contribution 58.32%	Rs. 6.45
2	0.03/Doranda fish farm, Ranchi	Magur	75,000	RB	12.6	42.51	82.57	2,630 kg in 7½ months	Rs. 7.36
3	0.02/ Mithapur fish farm, Patna	Magur	1,01,000	RB.FM/ PF 1:1 @ 3-5% of body weight	10.0	53.32	78	4,212 kg in 11 months	Rs.11.75
4	0.02/Mithapur fish farm, Patna	*H. Singhi*	2,25,000	C.W.PF RP @ 10% of body weight	11.6 & 8.7	25	15.6	1,397.5 kg 2 $years^{-1}$	--
5	0.01/ Mithapur fish farm, Patna	*C. magur*	80,000	Initially to 60 days PF & RB (1:1). Then RB:FM GOC, & M (5:3:1.7) @ 6-10% of body wt.	13.0	29	86.6	2,100 kg 130 $days^{-1}$	Rs.12.44

RB = Rice bran   M = Mineral mix   CW = Cowmanure   GOC = Groundnut cake
MOC = Mustard cake   FM = Fish meal   PF = Poultry feed

Table 76

Culture experiments carried out during 1976-1978

Place	Water area (ha)	Species	Stocking rate ha^{-1}	Supplemental feeding	Production
Phulwari-sarif, Patna	0.18	Magur	55,000	Rice bran, mustard cake and cattle dung @ 3% of the body weight	170 kg of magur + 830 kg of carps, murrels and other fishes ha^{-1}. 5 $months^{-1}$
Mithapur (Patna)	0.02	Singhi	250,000	Rice bran, crushed molluscs, & cut minnows doughed in cattle dung @ 5% of the body weight	The entire stock escaped during the course of a heavy downpour. The production otherwise at 80% survival would have been 4400 kg ha^{-1} 4 $months^{-1}$

Table 77

Culture of air breathing fishes in cages (1972-75) conducted at Lahrisarai(cage area: 2 x 1 x 1 m)

Water body	Species	Initial stocking		Rearing period (days)	Production assessment		Fish production cage^{-1} (kg)	Survival (%)
		No.	Weight (kg)		No. recovered	Weight (kg)		
Derelict pond	*H. fossilis*	150	1.497	180	81	1.175	-	54.0
-do-	-do-	200	2.212	180	87	1.627	-	43.0
-do-	-do-	300	1.500	180	103	1.197	-	34.3
-do-	-do-	50	0.016	200	Nil	Nil	Nil	Nil
-do-	-do-	100	0.032	200	Nil	Nil	Nil	Nil
-do-	-do-	150	0.046	200	100	0.564	0.518	66.6
-do-	-do-	200	0.066	200	100	0.712	0.646	50.0
-do-	-do-	250	0.083	200	133	0.790	0.707	53.2
-do-	*A. testudineus*	221	0.628	425	127	1.099	0.471	57.5
-do-	*O. striatus*	155	0.636	455	81	1.004	0.368	52.3
Bhawapokhar	*H. fossilis*	450	1.000	112	11	0.200	-	7.3
-do-	-do-	100	0.750	60	2	0.040	-	1.3
-do-	-do-	150	1,500	106	100	1.061	-	66.6
-do-	*C. batrachus*+	18+	0.631+	45	18	0.725	-	100.0
	H. fossilis	100	0.606		Nil	Nil		Nil
-do-	*H. fossilis*	100	1.000	132	97	1.353	0.353	97.0
-do-	*C. batrachus*	60	2.350	150	60	3.017	0.667	100.0
-do-	-do-	50	2.030	142	49	2.674	0.644	98.0
	-do-	60	2.080	138	60	3.052	0.972	100.0
	-do-	20+	1.040+	131	20	1.258	0.218	100.0
					40	0.700	0.450	100.0

Table 78

Growth ($\bar{x}$ in g) of magur in cisterns through months

Month	Cistern 1	Cistern 2	Cistern 3	Cistern 4
November'78	9.2	10.18	9.75	10.73
December'78	10.46	10.83	10.82	11.47
January'79	9.90	9.92	8.95	10.00
February'79	11.18	10.76	11.88	11.11
March'79	12.94	12.42	13.38	12.59
April'79	18.28	16.46	15.23	15.97
May'79	21.13	22.99	24.70	25.15
June'79	31.51	28.14	37.77	32.44
July'79	33.24	28.50	39.47	35.88
August'79	33.37	32.20	36.94	35.87
September'79	36.23	33.51	39.78	40.96
October'79	37.55	37.14	37.84	43,97
November'79	39.19	40.19	40.86	51.35

Table 79

Physico-chemical parameters and plankton of Ghorajan *beel*

Parameters	Temp. (°Celsius)	pH	Turbidity (mg l^{-1})	Free CO_2 (mg l^{-1})	DO (mgl^{-1})	Alkalinity (mgl^{-1})	NO_3 (mg l^{-1})	PO_4 (mg l^{-1})	Phytoplankton (l^{-1})	Zooplankton (l^{-1})
February	20.2	7.5	10	2.0	4.00	48	0.07	0.3	175	79
March	24.0	7.1	10	5.0	1.92	42	0.06	0.4	100	100
April	24.5	6.9	10	6.0	3.52	40	0.07	0.34	262	316
May	27.0	6.0	176	-	2.64	-	0.06	0.20	53	78
June	22.4	6.2	30	12.0	2.24	80	0.04	0.24	55	11
July	31.0	6.4	10	12.0	5.12	96	0.06	0.06	68	415

Table 80

Soil and water conditions of ponds at Ulubari Fish Farm, Gauhati

Pond	Soil (available nutrients) mg 100 g^{-1}					Water			
	pH	N_2(%)	P_2O_5	K_2O	Organic carbon	pH	Total alkalinity (mg l^{-1})	Dissolved oxygen (mg l^{-1})	Free CO_2 (mg l^{-1})
1	6.6	0.097	10.0	175	1.8	7.0	54.0	10.0	4
2	7.0	0.079	12.0	155	high	7.0	55.0	8.0	4
3	7.0	0.101	14.0	200	high	7.1	56.0	10.0	6
4	7.2	0.088	11.0	98	high	7.1	54.5	10.0	4

Table 81

Diet of *A. testudineus*

Food items	Volume % Vi	Occurrence % Oi	Vi Oi	$\frac{Vi\ Oi}{\Sigma Vi\ Oi} \times 100$
		Adult (76 mm and above)		
Synedra	0.46	6.00	2.76	0.09
Cymbella	-	-	-	-
Navicula	0.50	7.27	3.65	0.12
Cyclotella	0.25	2.00	0.50	0.02
Diatoma	0.05	1.34	0.07	*
Closterium	0.18	4.02	0.72	0.02
Spirulina	0.05	0.66	0.03	*
Spirogyra	0.01	0.66	0.01	*
Oscillatoria	0.95	8.60	8.17	0.28
Filina	0.04	0.66	0.03	*
Keratella	0.03	0.66	0.02	*
Rotifera	0.03	0.66	0.02	*
Cyclops/Copepods	0.21	3.35	0.70	0.02
Copepod eggs				
Diaptomus				
Semidigested copepods	0.01	0.67	0.01	*
Cladocera	0.03	1.34	0.04	*
Cypris	0.07	2.00	0.14	*
Nauplii	0.03	0.66	0.02	*
Chironomid larvae	0.22	2.00	0.44	0.01
Insect larvae	0.22	2.00	0.44	0.01
Insect	1.00	13.90	13.90	0.48
Nematode	0.39	1.34	0.52	0.02
Fish eggs	0.10	2.01	0.20	*
Ctenoid scales	0.82	3.35	2.75	0.09
Mollusc larvae	0.61	4.02	2.45	0.08
Debris	93.80	31.49	2953.76	98.76
Rice particles	0.16	1.34	0.20	*
	100.00	100.00	2991.11	* 0.01
		Juveniles (upto 75 mm)		
Synedra	0.41	4.35	1.78	0.14
Cymbella	0.41	4.35	1.78	0.14
Cyclops	2.46	4.35	10.70	0.87
Copepod eggs	2.06	8.70	17.92	1.45
Diaptomus	12.32	17.40	214.37	17.26
Cladocera	32.86	17.40	571.76	46.10
Chironomid	8.25	8.70	71.77	5.81
Cypris	2.06	4.35	8.96	0.72
Insect larvae	2.46	13.00	31.98	2.59
Chydorus	0.41	4.35	1.78	0.14
Debris	33.00	8.70	287.10	23.16
Scale	3.30	4.35	14.35	1.62
			1234.25	100.00

Table 82

Diet of *H. fossilis*

(Size : 102-180 mm)

Food items	Vi	Oi	Vi Oi	$\frac{Vi\ Oi}{\Sigma Vi\ Oi} \times 100$
Euglena	0.64	0.94	0.60	0.50
Synedra	3.60	5.64	20.30	1.68
Rotifer	4.03	3.76	15.15	1.25
Diatoma	0.42	0.94	0.39	0.03
Blue green algae	0.74	1.88	1.39	0.11
Algal filaments	0.95	3.76	3.57	0.30
Cyclops	4.24	9.50	40.28	3.33
Insects	2.65	7.52	19.93	1.65
Nematodes	12.40	14.20	176.03	14.55
Semidigested insects	2.33	8.46	19.71	1.63
Chironomid	0.53	1.88	0.99	0.08
Fish scale	10.48	11.38	119.26	9.86
Bosmina	1.17	3.76	4.40	0.36
Insect larvae	1.70	3.76	6.39	0.53
Navicula	4.98	2.82	14.04	1.16
Cyclotella	1.06	2.82	2.99	0.25
Diaptomus				
Debris	47.76	16.00	764.16	63.16
nauplii	0.32	0.94	0.30	0.02

$v_i o_i$ 1209.93

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19x87

Table 83

Induced breeding of air breathing fishes

Year	*C. batrachus*					*A. testudineus*									
	Sets tried	Sets successful	dose (mg kg^{-1} body weight)	spawn produced	Remarks	Sets tried	Sets successfull	dose (mg kg^{-1} body weight)	spawn produced	Remarks	sets tried	sets successful	dose (mg kg^{-1} body wt.)	Spawn produced	Remarks
1973	7	1	100-360	a few	-	45	38	12.5-400	1 lakh	-	14	4	85-200	10000	-
1974				-	-	82	66	10 -100	1.65 "		39	10	80-204	14500	
1975	8	nil	130-280	-	-	75	65	20-82.5	1.3 "	-	7	2	60-220	6200	
1976	3	2	120-180	3,000	Died subsequently	11	11	12-40	10 "	Given to Assam	5	4	60-80	15[illegible]00	used for stocking
1977	3	1	50-100	300	Sent to Allahabad University	12	11	10-25	25 "	"	8	6	60-80	3 lakh	-do-
1978	21	7	50-80	3,569	-	-	-	-	-	-	-	-	-	-	-
1979	19	10	5-10	6,000	-	-	-	-	-	-	13	13	6-10	1.95 lakh	-
1980	17	6	5-15	350	Pond got inundated	-	-	-	-	-	29	14	50-180	1.35 lakh	stocked
1981	39	30	5-15	*	-	-	-	-	-	-	55	50	50-180	15 lakh	5000 retrieved due to inundation
1982	20			No. could not be assessed	-	3	3	2-12	50,000	-	54	46	50-100	-	-
1983	66	-	4-10	-	-	12	12	0-5	-	spawn died due to rise in temperature	83	76	3-10		
1984	6	5	10-20	15-200		-	-	-	-	-	19	18	10	2600 (20-25 mm)	

Table 84

Oxygen requirement of 25 fry (2 to 6 days old) of <u>A. testudineus</u>

Time (min)	Oxygen consumption (mg l^{-1})		
	2 days' old	4 days' old	6 days' old
15	0	0	0
30	0.13	0	0
45	0.25	0.9	0.13
60	0.29	0.13	0.38
75	0.25	0.13	0.38
90	0.38	0.25	0.50
105	0.42	0.50	0.50
120	0.52	0.75	0.55

Table 85

Rearing of hatchling of *H. fossilis*, fed with natural and artificial food

Expt. No.	No. of hatchlings in volume of water	Composition of feed supplied	Quantity of feed given per hatchling (day^{-1})	% survival	No. of replicates	$\bar{x}$ length of hatchlings (mm) initial	final
1	2	3	4	5	6	7	8
I	$1\ l^{-1}$	Ciliates, Mastigophores, *Spirogyra* and *Microcystis*	1,000 nos. (approx.)	50	3	5.5	10
	$1\ l^{-1}$	Ciliates, Mastigophores and *Microcystis*	1,000 nos. (approx.)	64.3	3	5.5	10
	$1\ l^{-1}$	Ciliates and algae	500 nos. (approx.)	35.7	3	5.5	9
II	$2\ l^{-1}$	Ciliates and Mastigophores	500 nos. (approx.)	57.1	3	5.5	1
	$2\ l^{-1}$	Dried prawn and wheat	0.025 g	28.6	3	5.5	9
	$2\ l^{-1}$	Cooked egg (1:1 ratio)	0.062 ml	67.9	3	5.9	9
III	$10\ l^{-1}$	Copepods and cladocerans	500 nos. (approx.)	13.3	2	5.5	11
	$10\ l^{-1}$	Egg yolk	0.04 ml	nil	2	5.5	-
	$10\ l^{-1}$	Egg albumen	0.04 ml	nil	2	5.5	-
	$10\ l^{-1}$	Cooked egg (1:1 ratio)	0.04 g	46.6	2	5.5	9

Contd...2

1	2	3	4	5	6	7	8
	1.5 l^{-1}	Wheat flour and dried prawn powder (1:1 ratio)	0.1 g	62.5	3	10	13
VI	1.5 l^{-1}	Wheat flour and dried prawn powder (1:1 ratio)	0.1 g	62.5	3	10	13
	1.5 l^{-1}	Cladocerans and copepods	0.1 g	100.0	3	10	15
	1 1.5 l^{-1}	Wheat flour and fish meal (1:1 ratio)	0.1 g	52.4	3	10	12.5
V	1 1.5 l^{-1}	Wheat flour and dried prawn (1:1 ratio)	0.1 g	57.1	3	10	13.0
	1 1.5 l^{-1}	Wheat flour, fish meal and dried prawn (1:1 : 1 ratio)	0.1 g	57.1	3	10	12.5
VI	3 2 l^{-1}	Copepods and cladocerans	0.1 l	12.5	2	10	16
	3 2 l^{-1}	Wheat flour and dried prawn (1:1 ratio)	0.1 g	47.1	2	10	13

Table 86

Survival of *A. testudineus* spawn with different feeds

Feed items	Replicates	Quantity of feed supplied day^{-1} (mg)	Survival % after 10 days	Survival % after 15 days
Wheat flour (maida)	2	2	10-12	nil
Rice bran	2	2	10-16	nil
Soyabean	2	2	0	suspended
Prawn powder	2	2	0	suspended
Zooplankton (ciliate, mastigophores)	3	100 1/	62-70	48-58
Cooked poultry egg	3	2	84-90	70-74

(Volume of water: 5 l; No. of hatchlings l^{-1} water: 10 ; duration of experiment: 15 days)

1/Number

Table 87

Monoculture of air breathing fishes

Year(s)	Species	Stocking density (ha^{-1})	Pond area $(m)^2$	Culture period (months)	Gross production (kg ha^{-1})	Net production (kg ha^{-1})
1978-79	*H. fossilis*	300,000	150	5	6,947	5,567
1979-80	*C. batrachus*	80,000	700	5	3,878	3,265
1980	*H. fossilis*	127,000	200	12	4,844	4,047
1980	*H. fossilis*	25,000	500	5	1,300	1,020
1982	*H. fossilis*	100,000	200	12	1,379	- 121 *
1983	*H. fossilis*	40,000	500	8	380	60 *
1984	*H. fossilis*	25,540	500	7.5	602	50 *

*Remarks: Poor retrieval and limited supply of feed.

Table 88

Mixed culture of air breathing fishes

Year	Species stocked	Stocking density (ha^{-1})	Pond area (ha)	Culture period (months)	Gross production (kg ha^{-1})	Net production (kg ha^{-1})	Remarks
1976	A. testudineus C. batrachus, H.fossilis	55,000	0.1	12	782.8	-46	
1977		80,000	0.1	12	1,352	965	Poor production due to non-supply of feed low retrieval
1977-78	A.testidineus C. striatus	43,000	0.07	6	742.9	710.7	
1978-79	C. batrachus H. fossilis	1,20,000	0.1	12	3,695.7	2514	
1982	C. striatus A. testudineus	1,20,000	0.05	9	82.2	-13.8	

Table 89

Murrel seed collection during March 1983 to April 1984

Sl. No.	Year/Month	Place of collection	Species	No. of broods	Total seed collected (No.)	Length range (mm)
1	1983 March	Creak joining middle reaches river Palair (left bank)	C. striatus	3	4,650	-
2	April	Middle reaches of river Palair (left bank)	C. striatus	5	5,990	-
3	May	Greek feeding Kodada tank	C. marulius	1	1,325	-
4	August	Palair reservoir (north-west edge	C. striatus	2	2,110	30-50
5	September	Palair reservoir (north-west edge)	C. striatus	2	5,000	9-16
6	1984 January	Kodada tank (eastern side)	C. striatus	2	1,786	27-83
7	April	Kodada tank (eastern and western side)	C. striatus	2	6,232	23-30

ink
88x87

Table 90

Induced breeding of air-breathing fishes

Year/species	No.of sets m^{-2}	Pituitary doze in mg kg^{-1} body weight female	male	Respønse
1976 :				
C. batrachus	8	100-120	60-90	4 females released eggs; not fertilized
H. fossilis	5	100-120	60-90	3 females released eggs, not fertilized
1978 :				
C. striatus	8	40-120	40-80	set responded; 1,000 fry obtained
1981 :				
C. striatus	1	80	40	950 spawn obtained

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18x87

Table 91

Rearing of C. striatus seed in cement cisterns

Expt. No./ Batch	Area of cistern (m^2)	Stock		Period of rearing (days)	Feed	Initial size		Final size		Survival		Net yield (kg) for the period	
		cistern^{-1}	ha^{-1}			length range (mm)	$\bar{x}$ weight (g)	length range (mm)	$\bar{x}$ weight (g)	Actual No.	%	Actual	ha^{-1}
1/A	13.5	500	0.37	100	Live tadpoles @ 50 % body weight for one month, later minced traced fish @ 20 % body weight	30-50	1.0	112-155	10.6	316	63	5.377	3.983
1/B	5.0	650	1.3	105	-do-	40-60	1.1	90-110	9.3	650	100	5.330	10.660
2/A	5.0	500	1.0	110	Minced trash fish @ 10 % weight	27-43	0.4	65-113	4.42	427	85.4	1.687	3.374
2/B	13.5	700	0.52	110	Mixture of dry fish powder, wheat flour, bajra flour and redgram husk (3:1:1:1 ratio) @ 10 % body weight	27-43	0.4	57-69	1.78	192	27.4	0.062	46

Table 92

Growth survival and production of *C. striatus* when fed with dry trash fish (area: 0.1 ha each; Period : 7 months)

Date of stocking	Initial $\bar{x}$ size			Final $\bar{x}$ size			Yield (kg)	Production kg ha^{-1} 7 $months^{-1}$
	length (mm)	Wt. (g)	No. stocked	length (mm)	wt. (g)	No. recovered		
04-10-1980	105	9.5	250	420	350	95	33.25	3,325
06-10-1980	95	8.5	250	390	320	115	33.80	3,380

Table 93

Growth of *C. striatus* in ponds when stocked at densities of 25,000 and 50,000 ha^{-1}

Date of stocking	Stocking density: 50,000 ha^{-1} x size		Stocking density : 25,000 ha^{-1} x size	
	length (mm)	weight (g)	length (mm)	weight (g)
30-09-1981	95	6.5	65	6.5
15-10-1981	128	14.5	145	20.5
30-10-1981	130	22.5	185	50.0
15-11-1981	145	30.0	225	70.0
15-12-1981	165	41-5	325	120.0
31-12-1981	175	52.5	385	150.0

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19x87

Table 94

Culture of C. striatus in farm ponds

Expt. No./ Batch	Area (m^2)	Stocking			Duration (months)	Feed	Initial size		Final size		Survival		Net yield (kg) for the period	
		$pond^{-1}$	no. ha^{-1}				length range (mm)	$\bar{x}$ weight (g)	length range (mm)	$\bar{x}$ weight (g)	No.	%	$pond^{-1}$	ha^{-1}
1	400	250	6,250	20-07-83 27-04-84	9	Nil	80-126	6.4	233-388	182.4	014	5.6	0.953	2.4
2	200	316	15,000	15-11-83 28-04-84	5½	Minced trash fish @ 20% body weight	112-155	18.6	137-379	184.0	265	84	42.883	2.144
3/A	200	300	15,000	05-12-83 30-04-84	5	Minced trash fish @ 20% body weight	90-118	9.3	181-340	116.6	256	85.3	27.059	1.350
3/B	75	150	20,000	05-12-83	5	Dry fish + GC + RB (1:1:4) @ 20% body weight	90-118	9.3	120-245	28.6	30	20	-0.537	-
3/C	75	150	20,000	05-12-83	5	GC + RB (1:1) @ 20% body weight	90-118	9.3	122-154	18.0	10	6.6	-1.215	-

Table 95

Quantity of feed (in kg) given (month-wise) in the derelict ponds

Month	Pond 1 (0.03 ha)		Pond 2 (0.04 ha)	
	Dry fish	Rice bran	Dry fish	Rice bran
January	19,250	-	15,500	--
February	23,000	-	34,500	5,000
March	41,750	3,500	68,300	7,500
April	65,500	15,000	1,20,000	30,000
May	68,000	5,000	1,45,000	11,000
June	-	-	1,41,000	--
Total	2,17,500	23,500	5,24,300	53,500

Table 96

Growth of magur in ponds at Kalyani fish farm

Months	Size of fish			Size of fish		
	length (mm)		$\bar{x}$ weight (g)	length (mm)		$\bar{x}$ weight (g)
	range	$\bar{x}$		range	$\bar{x}$	
January	87-150	110	14.6	85-135	110	16.0
February	92-195	113	29.3	92-160	123	20.2
March	146-224	184	61.0	149-195	170	45.5
April	167-257	214	97.1	145-210	182	62.6
May	178-262	220	111.4	193-268	132	115.4

Table 97

Physico-chemical parameters of (ranges) water in the ponds

Pond area (ha)	pH	Dissolved oxygen ($mg\ l^{-1}$)	Free carbon dioxide ($mg\ l^{-1}$)	Total alkalinity ($mg\ l^{-1}$)	Phosphate phospharus ($mg\ l^{-1}$)	Nitrate nitrogen ($mg\ l^{-1}$)
0.03	8.2-8.6	4.6 - 7.4	1.0 - 5.0	72.0 - 120.0	0.05-0.06	0.05.0.20
0.04	8.2-8.6	5.2 -12.0	Nil - 1.0	72.0 - 80.0	0.05-1.00	0.08-2.00

Table 98

Growth of magur in 0.1 ha pond

Month	Size of fish	
	Length range (mm)	$\bar{x}$ weight (g)
February	90 - 120	12.5
March	110 - 147	25.0
April	120 - 160	135.0
May	140 - 220	54.3
June	180 - 220	65.0

Table 99

Water quality of the pond during intensive culture (1978-79)

Month	Temp. (°Celcius)	pH	Free carbon dioxide ($mg\ l^{-1}$)	Dissolved oxygen ($mg\ l^{-1}$)	Total alkalinity ($mg\ l^{-1}$)	Ammonia ($mg\ l^{-1}$)
December	24.0	8.4	14.0	20.0	8.0	trace
January	22.0	8.0	20.0	56.0	10.0	"
February	21.0	9.2	nil	80.0	11.0	"
March	28.0	9.6	nil	--	12.0	"
April	30.0	7.6	39.0	156.0	Trace	7.4
May	32.0	8.3	28.0	180.0	10.0	0.1
	34.0	8.6	nil	228.0	12.0	0.1
June	33.0	8.9	nil	---	10.2	0.8
	32.0	8.6	nil	300.0	4.6	0.8
August	32.0	8.1	14.0	320.0	6.6	12.0

Table 100

Month-wise growth pattern of magur

Month	Size of fish	
	Length range (mm)	$\bar{x}$ weight (g)
March	100 - 165	21.0
April	110 - 185	30.0
May	135 - 210	60.0
June	155 - 240	82.0

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Table 101

Water quality in the semi-intensive culture pond

Month (1979)	Temp. °Celsius	pH	Dissolved oxygen mg l^{-1}	Free carbon dioxide mg l^{-1}	Total alkalinity mg l^{-1}	Ammonia mg l^{-1}
April	30.0	9.0	8.4	---	84.0	trace
May	31.0	7.6	3.2	18.0	174.0	trace
June	35.0	8.6	6.6	---	--	0.6

Table 102

Length range and $\bar{x}$ weight of magur in semi-intensive culture pond

Month (1979)	Length range (mm)	$\bar{x}$ weight (g)
April	11.0 - 185	30.0
May	14.5 - 230	58.0
June	17.0 - 235	86.0
July	20.0 - 25.0	107.0

Table 103

Physico-chemical conditions of the pond water

pH	9.0 to 9.2
Dissolved oxygen (mg l^{-1})	6.4 to 11.2
Carbon dioxide (")	0.0 to 4.0
Total alkalinity (")	115.0 to 125.0

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06x87

Table 104

Growth pattern of singhi in a derelict pond

Month	length range (mm)	$\bar{x}$ weight (g)
April	100 - 135	12.1
May	130 - 145	14.7
June	110 - 170	15.4
July	...	..
August	130 - 175	38.0
September	190 - 230	40.0

Table 105

Data on semi-intensive and intensive culture of singhi in ponds

	Semi-intensive culture	Intensive culture
Area of the pond (ha)	0.04	0.03
N. of fingerlings stocked	2,400	13,000
Rate of stocking ha^{-1}	60,000	4,30,000
$\bar{x}$ weight (in g) of fingerlings	8.3	6.8
Period of rearing (months	7	9
Total fish harvested	2,345	10,950
$\bar{x}$ weight (g) of the harvested fish	28.0	20.0
Production (kg ha^{-1})	1,642	7,300

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Table 106

Physico-chemical characteristics of water before and after raking the bottom soil inside the enclosure in Dhakarda beel, Kalyani (water samples were collected at 0800 hours and gross primary production was measured between 0800 to 1200 hours).

Parameters	Physico-chemical values (Experiments I/II)					
	Initial value (before raking)	Values after raking				
		48 hours	96 hours	144 hours	192 hours	240 hours
Temperature (° Celsius)	27.5	28.0	29.5	30.8	28.5	28.5
pH	5.8/5.2	6.0/6.0	6.3/6.1	6.6/6.3	6.6/6.4	6.4/6.4
Carbondioxide (mg l^{-1})	14.8/ 13.2	3.2/ 3.39	2.52/ 3.36	1.28/ 2.97	1.12/ 2.77	0.744/ 2.04
Bicarbonate (mg l^{-1})	75.2/ 75.2	274.0/ 282.32	335.64/ 241.12	191.8/ 213.72	178.0/ 197.28	140.2/ 144.4
Dissolved Oxygen (mg l^{-1})	3.3/3.3	nil/nil	5.0/2.6	8.2/4.0	4.0/2.1	3.60/1.81
Organic carbon (mg l^{-1})	7.04/ 7.04	9.88/ 11.92	9.09/ 7.08	9.6/ 8.89	9.9/ 11.61	8.82/ 10.52
Calcium (Ca) (mg l^{-1})	12.0/ 12.0	16.2/ 16.0	12.8/ 12.9	12.4/ 12.6	12.4/ 12.6	12.4/ 12.6
Magnesium (Mg) (mg l^{-1})	4.8/4.8	7.4/7.4	7.9/7.8	8.4/8.3	7.7/8.0	6.2/7.8
Phosphorus (mg l^{-1})	0.01/ 0.01	0.42/ 0.40	0.36/ 0.32	0.156/ 0.148	0.02/ 0.02	0.001/ 0.001
Ammonium nitrogen (NH_4N) (mg l^{-1})	0.14/ 0.14	0.35/ 0.49	0.58/ 0.63	0.392/ 0.49	0.168/ 0.14	0.182/ 0.168
Nitrate nitrogen (No_3N) (mg l^{-1})	0.18/ 0.18	0.259/ 0.25	0.350/ 0.364	0.490/ 0.532	0.490/ 0.532	0.616/ 0.504
Silica (SiO_2) (mg l^{-1})	5.82/ 5.6	5.82/ 6.21	6.11/ 6.23	6.31/ 6.65	6.4/ 6.8	8.0/ 8.8
Gross primary production (mg C m^{-3} h^{-1})	315.5/ 315.5	nil/nil	1200.0/ 1030.0	1500.0/ 800.0	750.0/ 375.0	458.0/ 75.0

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Table 107

Water quality in the experimental cisterns

	Range in water quality			Total alkalinity ($CaCO_3$) (mg l^{-1})
	Temperature (° Celsius)	pH	Dissolved oxygen (mg l^{-1})	
Winter	17.5 - 22.5	7.4 - 7.6	4.0 - 4.5	360.2 - 380.6
Summer	26.5 - 29.6	7.4 - 7.6	4.0 - 4.5	360.2 - 380.6

Table 108

Experiments on the culture of magur in cement cisterns
(size : 1.8 m^2), Duration : 5 months

Seasons	Feed composition	$\bar{x}$ initial size		$\bar{x}$ final size		Net gain in weight month^{-1}
		length	weight (g)	length	weight	
Winter	Trash fish-meal + ground nut cake + rice bran (8:1:1)	174.0	44.7	182.0	49.3	4.6
	The above + yeast granules	157.0	38.2	159.6	38.2	nil
Summer	Trash fish + G.N. cake + yeast granules	134.4	157.7	132.4	24.97	92.0

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Table 109

Specific activities* of digestive enzymes in *C. batrachus*

Enzyme	Natural diet	Treatment	
		diet I	diet II
Amylase	1,490 ± 126.00	1,540 ± 102.00	1,480 ± 162.00
Cellulase	43 ± 3.90	11 ± 1.32	29 ± 3.55
Protease	1,440 ± 132.00	1,422 ± 112.001	1,664 ± 197.00
Lipase	380 ± 45.10	382 ± 44.95	391 ± 44.87

* $\bar{x}$ ± S.D. of 5 experiments

Table 110

Sub-cellular localization of protease* from intestine of *C. batrachus*

Sub-Cellular fractions	Specific activity of protease
Nuclear fractions	0.015 ± 0.0020
Mitochondrial fraction (10,000 x g)	0.154 ± 0.0100
Lysosomal fraction (20,000 x g)	0.268 ± 0.0099
Microsomal fraction (1,05,000 x g)	0.031 ± 0.0025
Soluble supernatant	0.075 ± 0.0030

* Values are $\bar{x}$ ± S.D. of 3 different experiments. Specific activity is expressed as O.D.-570 mg^{-1} protein h^{-1}.

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Table 111

Effect of dietary protein level on the proteolytic activity in the intestine of C. batrachus

Enzyme	Treatment - - 25 % protein diet	50 % protein diet	75 % protein diet
Total protease	0.45 ± 0.0324*	0.6900 ± 0.0260	0.770 ± 0.0651**
Typism	0.009 ± 0.0022*	0.1900 ± 0.0400	0.160 ± 0.0422**
Chymotrypsin	0.003 ± 0.0019**	0.004 ± 0.0015	0.003 ± 0.0018*

Values are $\bar{x}$ x S.D. of different experiments

* $\bar{x}$ value significantly different from that in 50 % protein diet treatment (P < 0.01)

** Not significantly different from that in 50 % protein diet treatment (P > 0.1)

Table 112

Purification of alkaline protease from intestine of C. batrachus (fish fed 50 % protein diet).

Fraction	Value (ml)	Sp.activity (△ D.570/ mg protein h⁻¹)	Total protein (mg)	Total enzyme activity (△ OD 570 h⁻¹)	Recovary	Purification (fold)
Crude extract (post mito chondrial)	20.0	10230	10260	180.6	100.0	1.0
30-70 % ammonium sulphate fraction	0.69	0.69	38.0	26.22	84.0	2.3
DEAE cellulose fraction (no.8)	17.7	17.7	1.35	24.0	77.0	60.0

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Table 113

Ingredient combination, proximate composition and energy values of experimental diets (protein level, 33 %).

Composition	Diets			
	A	B	C	B
Rice bran	-	32.6	32.6	32.6
Groundnut cake	-	32.6	32.6	32.6
Meatmeal	-	32.8	-	-
Fishmeal	-	-	32.8	32.8
Offal containing dried blood	-	-	-	32.8
Casein	30.0	-	-	-
Gelatin	5.0	-	-	-
Dextrin	35.0	-	-	-
Starch, potato	5.0	-	-	-
Cellulose	15.0	-	-	-
Groundnut oil	4.0	-	-	-
Liver oil (cod)	4.0	-	-	-
Vitamin-mineral mixture	2.0	2.0	2.0	2.0
Total	100.0	100.0	100.0	100.0
<u>Proximate composition</u>				
Moisture in pellets	7.9	8.5	7.6	8.1
<u>Composition, % of dry-matter</u>				
Protein (actual)	33.63	33.56	32.76	32.77
Fat	7.70	7.85	7.35	6.08
Nitrogen-free extract (N.F.B)	38.20	28.74	21.40	31.30
Crude fibre (C.F.)	15.20	15.83	14.89	11.67
Ash	5.27	14.02	23.60	18.18
Total Carbohydrate	53.40	44.57	36.29	32.97
Organic matter	94.73	85.98	76.40	81.82
<u>Energy values</u>				
Gross energy (Kcal/100 g^{-1})	417.42	383.17	342.35	317.68
P/E (mg protein/$Kcal^{-1}$)	80.57	80.59	95.69	103.15
% Protein energy[2]	32.23	35.03	38.28	41.46
% lipid carbohydrate energy	67.77	64.97	61.72	58.54

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Table 114

Biomass gain (period : 120 days) and specific growth rates of magur magut

Diet number	Initial biomass (g)	final biomass (g)	Biomass gain (g)	specific growth rate 1/
Diet A	100	207	107	89.17
Diet B	105	246	141	117.50
Diet C	115	230	115	95.83
Diet D	110	187	77	64.17

1/ Specific growth rate = $\frac{\text{final wt. - initial wt.}}{\text{no. of days}} \times 100$

Table 115

Feed consumption, feed efficiency (FE) and protein efficiency ratio (P.E.R) in magur fed with different experimental diets

Diet number	Rate of feed distribution (%)	Total dry feed consumption (%)	Feed efficiency (PE)	Total protein consumption (%)	Protein efficiency ratio (P E R)
Diet A	4	480	4.48	161.42	0.66
Diet B	4	504	3.57	169.14	0.83
Diet C	4	552	4.80	180.84	0.64
Diet D	4	528	6.85	170.02	0.45

F.E = $\frac{\text{dry wt. feed consumption}}{\text{wet wt. gain}}$; P.E.R = $\frac{\text{wet wt. gain}}{\text{dry wt. protein consumption}}$

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Table 116

$\bar{x}$ size and condition factor of experimental fish

Diet number	$\bar{x}$ Initial size weight (g)	length (mm)	condition factor 1/	Final size ($\bar{x}$) weight (g)	length (m)	condition factor
A	16.67	13,56	0.668	34.50	17.28	0.668
B	17.50	13.70	0.670	41.00	14.96	1.220
C	19.17	14.28	0.658	30.58	15.59	1.010
D	18.33	12.56	0.925	31.08	13,79	1.185

1/ Condition factor = $\frac{\text{weight (g)}}{\text{length (mm)}^3} \times 100$

Table 117

Mean size of C. batrachus under different doses of methyl testosterone over a period of 107 days (hormone feeding discontinued after 63 days).

dose of methyl testosterone (mg kg^{-1} ped)	$\bar{x}$ size of fish: initial length (mm)	initial weight (g)	final length (mm)	final weight (g)
0.0	103.8	10.80	126.8	16.20
1.0	112.6	10.60	140.9	18.05
2.5	110.4	10.70	138.6	18.25
5.0	109.6	10.75	130.4	15.10
10.0	110.8	10.65	122.5	13.85

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Table 118

Weight gain, food conversion, condition factor and protein efficiency ratio (PER) of C. batrachus fed methyl testosterone with supplemented diet for 107 days (hormone administration discontinued after 63 days).

Dose of methyl testosterons (mg kg^{-1} feed)	weight gain (g)	Weight gain over initial wt. (%)	Conversion ratio	Protein efficiency ratio (PER)
0.0	5.40	50.00	10.85	0.26
1.0	7.45	70.20	7.95	0.35
2.5	7.55	70.56	7.85	0.35
5.0	4.35	40.47	12.76	0.22
10.0	3.20	30.05	17.07	0.16

Table 119

Effect of dietary administration of methyl testosterone over a period of 107 days on the incorporation of 1-leucine-^{14}C (U) into liver protein (hormone feeding discontinued after 63 days).

Dose (mg kg^{-1} feed)	Incorporation (cpm 100 mg^{-1} fresh tissue)	
	TCA insoluble	TCA soluble
0.0	270.0	35.0
1.0	1006.0	103.2
2.5	303.4	77.2
5.0	351.0	91.0
10.0	150.0	76.0

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5x87

Table 120

Effect of different dietary proteins on growth and conversion efficiency of C. batrachus

	Halver's standard diet	Fishmeal diet	Meatmeal diet	silkworm pupae diet	oilcake diet
Conversion ratio	4.36	5.19	10.98	5.31	39.67
PER	0.82	0.61	0.38	0.59	0.17
Specific growth rate*	1.7	1.2	0.6	1.0	0.1

* Expressed as growth per day as percentage of body weight (α) according to the equation

$$W_t = W_o \left(1 + \frac{\alpha}{100}\right) t$$

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Table 121

Effects of different dietory proteins on certain physiological parameters of *C. batrachus*

	Halver's diet	Fish meal diet	Meat meal diet	Silkworm pupae diet	Ground nut cake diet
Intestinal protease activity (ΔOD 570 mg^{-1} protein h^{-1})	12.0 ± 0.03	12.52 ± 0.30	10.14 ± 0.61	12.89 ± 0.60	8.02 ± 0.15[a]
Amino acid (1-lycine-U^{14}C) incorporation (mm mg^{-1}) liver tissue)	375.53 ± 2.79	146.30 ± 2.58	86.30 ± 1.86[b]	166.24 ± 3.83	13.78 ± 1.36[b]
Serum protein (g 100 ml^{-1})	4.01 ± 0.04	4.04 ± 0.0011	4.12 ± 0.0374	3.80 ± 0.2160	4.01 ± 0.0838[c]
Serum Ca : p ratio	0.079 ± 0.0008	0.075 ± 0.0041	0.058 ± 0.0015	0.071 ± 0.0009	0.053 ± 0.0015[d]
Haemoglobin content (g 100 ml^{-1})	9.80 ± 0.04	0.70 ± 0.04	9.30 ± 0.25	9.20 ± 0.36	9.26 ± 0.20[c]
RBC count ($\times$ 10^{6} cells mm^{-3})	1.53 ± 0.07	1.74 ± 0.07	1.43 ± 0.06	1.39 ± 0.08	1.27 ± 0.06[c]

Values are expressed as $\bar{x}$ ± S.E.

a = Differ significantly from other means in the same row ($p < 0.1$)

b = Differ significantly from other means in the same row ($P < 0.01$)

c = $\bar{x}$ in the same row are not significantly different

d = $\bar{x}$ in the same row differ significantly ($p < 0.05$)

Table 122

Summary of haematological data on the catfish, C. batrachus exposed to malathion

Experimental group	Erythrocyte count (10^6 cells mm^{-3})	Total leucocyte count (No. of cells mm^{-3})	Haemoglobin (g . 100 ml^{-1} blood)	Haematocrit (%)	Erythrocyte sedimentation rate (mm h^{-1})
Control	2.14 ± 0.25	400 ± 160	13.4 ±0.2	26.5±1.5	4.0 ± 0.5
With malathion	1.37 ± 0.80*	4800 ± 200	12.6± 0.6	21.0±1.5	4.0 ± 0.5

Results are expressed as $\bar{x}$ ± S.D. of six separate determinations* $P < 0.05$

Table 123

Effect of malathion on the composition of different white blood cells of the catfish C. batrachus (Linn.)

Experiment group	Neutrophil	Eosinophil	Lymphocyte	Nonocyte
Control	7.0 + 0.5	5.4 ± 1.07	62.4 ± 4.67	25.2 ± 2.18
with Malathion	9.2 ± 1.08**	19.0 ± 1.39**	52.8 ± 3.72	18.5 ± 2.08

Results are $\bar{x}$ ± S.D. of sixteen separate observations
** $P < 0.001$: * $P < 0.05$

Table 124

Changes in certain serum parameters of C. batrachus following exposure to malathion

Parameters	Treatments	
	control	with malathion
Total protein (mg ml^{-1})	45.8 ± 0.55	45.0 ± 0.80
Total chlesterol (mg 100 ml^{-1})	428.0 ± 28.8	470.0 + 40.0
Free amino acids (μg ml^{-1})	775.0 ± 39.5	968.8 ± 41.8*
Glucose (mg 100 ml^{-1})	62.6 ± 2.9	89.6 ± 3.5*

Values are $\bar{x}$ ± S.D. of six seperate determinations

* $P < 0.05$

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Table 125

Level of certain biochemicals constituents in liver of C. batrachus exposed to malation

Parameters	Control	Experimental
Protein (mg g^{-1} wet tissue)	162.6 ± 08.5	158.0 ± 09.0
DNA (mg g^{-1} wet tissue)	4.83 ± 0.97	4.45 ± 1.5
RNA (mg g^{-1} wet tissue)	9.21 ± 1.10	8.30 ± 0.88
Glycogen (mg g^{-1} wet tissue)	38.1 ± 2.6	20.7 ± 2.8*
Total lipid (mg g^{-1} wet tissue)	74.0 ± 6.1	76.7 ± 5.5
Phospholipid (mg g^{-1} wet tissue)	34.0 ± 0.9	50.2 ± 2.8*
Stalic acid (mg g^{-1} wet tissue)	380.5 + 22.8	415.0 + 25.0

Values are $\bar{x}$ ± S.D. of six determinations :
* P ´0.05

Table 126

Incorporation of l-Lysine-U-^{14}C into proteins of liver from normal and malathion treated C. batrachus : effect of increased dietary protein administration.

System	Dietary protein level (%)	Incorporation : DPM mg^{-1} protein
Control	22.0	1331.25 ± 52.75
Malathion exposed		557.50 ± 45.00 **
Control	38.0	1546.25 ± 115.00
Malathion exposed		781.25 ± 95.00 **

Values are $\bar{x}$ ± S.D.

** Difference significant at P ´0.001

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Table 127

Mg^{2+} -ATPase and Na^{1+} -K^{1+} -Mg^{2+} -ATPase activity in the mitochondrial fraction from liver and gills of <u>C. batrachus</u> exposed to malathion

System		Enzyme activity (μ mol.Pi liberated. mg^{-1} protein h^{-1})	
		Mg^{++} -ATPase	Na^{1+} -K^{1+} -Mg^{2+} -ATPase
Liver	Control	9.20 ± 1.15	12.52 ± 1.25
	With malathion	5.00 ± 0.78[a]	7.82 ± 1.11[a]
Gills	Control	15.58 ± 2.00	17.27 ± 1.84
	With malathion	10.24 ± 1.24[b]	11.02 ± 1.29[b]

Values are $\bar{x}$ ± S.D. of six determinations, P values : a $<$ 0.01, b $<$ 0.05

Table 128

Effect of malathion treatment of the lysosomal enzyme activities in gills and liver of <u>C. batrachus</u>

Enzyme	Gills		Liver	
	Control	with malathion	Control	with malathion
Acid phosphatase	21[illegible].62 ± 4.18 (229.16 ± 3.69)	147.46 ± 2.88** (151.40 ± 3.41)	187.55 ± 5.40 (219.10 ± 5.36)	143.60±2.95[a]) (157.23±4.00)
β-glucuronidase	38.59 ± 1.22 (40.35 ± 2.70)	51.17 ± 1.58[a] (53.74 ± 2.12)	47.00 ± 2.20 (49.60 ± 2.65)	56.20±1.89[a] (60.96±2.92)

Enzyme activity : μg p-nitrophenol liberated mg $protein^{-1}$ h^{-1}

Values are $\bar{x}$ ± S.D. of six determinations.

Values in parentheses indicate the activity of enzyme after 0.1 % surfactant (Triton x 100) treatment.

P values : a $<$ 0.01

ink
04x87=

Table 129

Esterases from different organs of C. batrachus following exposure to malathion

System	Control		With malathion	
	PNPA	PNPP	PNPA	PNPP
liver	0.854 ± 0.072	1.024 ± 0.087	0.577 ± 0.041*	0.610 ± 0.037*
Gills	0.092 ± 0.042	0.086 ± 0.037	0.852 ± 0.033*	0.072 ± 0.024
Serum	0.044 ± 0.017	0.048 ± 0.020	0.041 ± 0.015	0.046 ± 0.019

Values are $\bar{x}$ ± S.D. of six determinations

* $P < 0.05$

PNPA : p-nitrophenyl acetate hydrolysis

PNPP : p-nitrophenyl propionate hydrolysis

Table 130

Effect of malathion exposure on microsomal drug metabolising enzyme activities of liver and gills of C. batrachus (values are $\bar{x}$ ± S.D)

Treatment	O-demethylase*		N-demethylase**		Cytochrome P-450***	
	Gills	Liver	Gills	Liver	Gills	Liver
Control	5.84 ± 0.67	3.55 ± 0.85	3.66 ± 0.80	6.61 ± 1.05	1.98 ± 0.28	2.27±0.55
With malathion	7.68 ± 1.72#	6.87 ± 0.71	4.26 ± 0.92	9.85 ± 1.21##	3.14 ± 0.78	5.15±1.20##

P values : # <0.05 : ## <0.001

* n moles p-nitrophenol liberated mg^{-1} protein h^{-1}

** n moles HCHO released mg^{-1} protein h^{-1}

*** n moles mg^{-1} protein

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Table 131

Total lipid content, composition and distribution of different prospholipids in the liver tissue of *C. batrachus*

Composition of phospholipids (% total phospholipid)	Control	With malathion
Unidentified phospholipid at the base of TLC plate	0.66 ± 0.15	0.74 ± 0.12
Sphingomyslin	1.90 ± 0.22	1.48 ± 0.30
Lysophosphatidyl choline	10.00 ± 1.05	9.70 ± 0.90
Phosphatidyl choline	46.10 ± 1.16	43.00 ± 1.08
Phosphatidyl ethanolamine	34.00 ± 1.25	38.50 ± 1.30
Cardiolipin	5.40 ± 0.90	6.00 ± 0.81

Results are $\bar{x} \pm$ S.D. of six separate determinations

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Table 132

Fatty acid composition of total lipids of *C. batrachus*

Peak No.	Nomenclature	Height of the peak (cm)	Width at half height (cm)	Total area (cm^2)	Attenuation	Corrected area (cm^2)
1	12 : 0	0.6	0.1	0.06	64×10^2	0.06
2	14 : 0	0.2	0.1	0.02	64×10^2	0.02
3	15 : 0	1.3	0.1	0.13	64×10^2	0.13
4	16 : 0	0.6	0.2	0.12	64×10^2	0.12
5	16 : 1	14.5	0.2	2.90	64×10^2	2.90
6	18 : 0	4.5	0.3	1.38	64×10^2	1.35
7	18 : 1 w 6	11.6	0.3	3.48	64×10^2	3.48
8	18 : 2 w 6	1.7	0.4	0.68	64×10^2	0.68
9	18 : 3 w 3	0.8	0.4	0.32	64×10^2	0.32
10	20 : 2 w 6	0.2	0.4	0.08	32×10^2	0.16
11	20 : 3 w 6	0.3	0.3	0.09	32×10^2	0.18
12	20 : 4 w 6	3.7	0.7	2.59	32×10^2	5.18
13	20 : 5 w 3	1.5	1.0	1.50	16×10^2	6.00
14	22 : 4 w 6	1.2	1.5	1.80	16×10^2	7.20
15	22 : 5 w 6	0.40	1.4	0.56	16×10^2	2.24
16	22 : 5 w 3	0.25	1.7	0.43	16×10^2	1.70
17	22 : 6 w 3	2.2	1.8	3.96	16×10^2	15.84

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Table 133

Fatty acid composition of total lipids of *C. batrachus* following exposure to 0.5 mg l^{-1} malathion

Peak No.	Nomenclature	Height of the peak (cm)	Width at half height (cm)	Total area (cm^2)	Attenuation	Corrected area (cm^2)
1	12 : 0	0.5	0.1	0.05	64×10^2	0.05
2	14 : 0	0.8	0.2	0.16	64×10^2	0.16
3	15 : 0	9.7	0.3	2.91	64×10^2	2.91
4	16 : 0	7.2	0.4	2.88	64×10^2	2.88
5	16 : 1	20.00	0.4	6.00	64×10^2	8.00
6	18 : 0	11.00	0.6	6.60	64×10^2	6.60
7	18 : 1 w 6	12.80	0.5	6.40	64×10^2	6.40
8	18 : 2 w 6	4.7	0.7	3.29	64×10^2	3.29
9	18 : 3 w 3	3.8	0.5	1.90	32×10^2	3.80
10	20 : 2 w 6	1.2	0.8	0.95	32×10^2	1.92
11	20 : 3 w 6	0.7	0.5	0.35	32×10^2	0.70
12	20 : 4 w 6	8.5	0.9	7.65	32×10^2	7.65
13	20 : 5 w 3	2.0	0.9	1.80	32×10^2	3.60
14	22 : 4 w 6	3.5	1.7	5.95	32×10^2	11.90
15	22 : 5 w 6	0.7	1.5	1.05	32×10^2	2.10
16	22 : 5 w 3	0.5	1.5	0.75	32×10^2	1.50
17	22 : 6 w 3	3.8	1.8	6.84	32×10^2	13.68

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4x07

Table 134

Level of serum constituents in C. batrachus exposed to 0.5 mg l^{-1} Carbofuran for 30 days

Values are $\bar{x} \pm$ S.E. of 6 determinations

Serum constituent	Control	Carbofuran
Calcium (mg 100 ml^{-1})	3.086 ± 0.240	3.06 ± 0.230[a]
Phosphorus (mg 100 ml^{-1})	45.16 ± 0.328	48.52 ± 4.58
Albumin (g 100 ml^{-1})	0.595 ± 0.116	0.560 ± 0.070
Protein (g 100 ml^{-1})	3.62 ± 0.170	3.56 ± 0.170

a = significantly different from control, $p < 0.01$

Table 135

Effect of 0.5 ppm carbofuran exposure for a period of 30 days on the Activity of brain Acetylcholinesterase in C. batrachus

Values are $\bar{x} \pm$ S.E. of 6 determination

System	Acetylcholinesterase activity (µmol acetylcholine mg protein^{-1} h^{-1})
Control	465.35 ± 7.51
Carbofuran	380.3 ±15.1[a]
Carbofuran withdrawn for 15 days	462.45 ± 4.07

a = Significantly different fron control, $P < 0.01$

Table 136

Levels of ammonia in Serum of C. batrachus and in ambient water under normal and carbofuran treatment (0.5 mg l^{-1}) for 30 days.

Values are $\bar{x} \pm$ S.E. of 5 determinations

Carbofuran (mg l^{-1})	Ammonia in serum (g ml^{-1})	Ammonia level in ambient water (mg fish^{-1} h^{-1})
0.0	38.0 ± 2.40	3.0 ± 0.16
0.5	60.0 ± 4.26	1.58 ± 0.14[a]

a = Significantly different from control, $p < 0.01$

ink
4x87

Table 137

In vitro effects of 0.5 ppm carbofuran exposure for 30 days on biochemical charges in the tissues of C. batrachus

(each value is $\bar{x} \pm$ S.E. of 6 determinations)

Biochemical parameters/	Tissues	Control	Under carbofuran (mg l^{-1} for 30 days)
Mg^{2+} -AT Pase*		0.864 ± 0.019	0.536 ± 0.064[a]
Ma^{+}, K^{+} -AT Pase*	Gills	0.716 ± 0.011	0.398 ± 0.020[a]
Mg^{2+} - AT Pase*	--	0.910 ± 0.0009	0.566 ± 0.039[a]
Na^{+}, K^{+} - AT Pase*	Intestine	0.681 ± 0.040	0.483 ± 0.005[b]
Glucose 6-Phosphatase*	Liver	9.46 ± 1.86	15.1 ± 1.85[a]
Glycogen**	Liver	39.56 ± 1.86	27.08 ± 0.66[a]
Glucose***	Serum	81.05 ± 2.81	89.76 ± 3.60[b]

1 * = μg inorganic phosphate liberated mg^{-1} protein hr^{-1}
** = mg g^{-1} tissue
*** = mg 100 ml^{-1} serum
ap = < 0.001
bp = < 0.01

Table 138

Activities of alkaline phosphatage and acid phosphatase in liver and serum of C. batrachus exposed to 0.5 mg l^{-1} carbofuran for 30 days

Each value is $\bar{x} \pm$ S.E. of 6 determinations

Enzymes		Control	With carbofuran
Acid Phosphatase / μg p-nitrophenol released mg protein^{-1} h^{-1}	Liver	2.75 ± 0.135	2.65 ± 0.21
	Serum	1.40 ± 0.340	3.09 ± 0.39[a]
Alkaline phosphatase (μg p-nitrophenol released mg protein^{-1} h^{-1}	Liver	0.333 ± 0.020	0.832 ± 0.05
	Serum	0.290 ± 0.036	0.346 ± 0.046[b]

ap = < 0.001

bp = < 0.05

ink
4x87

Table 139

Activities of glutamate oxalacetate transaminase and flutamate pyruvate transaminase in liver and serum of C. batrachus exposed to 0.5 mg l^{-1} carbofuran for 30 days

(Each value is $\bar{x} \pm$ S.E. of 6 determination)

Enzyme		Control	With carbofuran
glutamate oxalacetate transaminase (μ mol pyruate released mg protein h^{-1})	Serum	0.250 ± 0.100	0.325 ± 0.130[a]
	Liver	0.033 ± 0.030	0.838 ± 0.034[b]
glutamate pyruvate transaminase (μ mol pyruvate released mg protein h^{-1})	Serum	0.033 ± 0.005	0.075 ± 0.025[a]
	Liver	0.493 ± 0.011	0.516 ± 0.014[b]

ap 0.01
bp 0.001

Table 140

Enzymatic activities in intestine and liver of H. fossilis fed with NPN supplemented diet

Treatment group	Intestinal urease (n.g. ammonia)	intestinal alkaline phosphates (μg p-nitrophenol)	Liver arginase (n.mol. urea)	Liver aspertate amino transferase (n. mol pyruvate)	Liver alanine amine transferase (n. mol. pyruvate)
Diet - 1	233.11±6.31	40.10±0.44	227.0±50.0	136.0+13.0	408.0±12.0
Diet - 2	362.22±7.58	37.72±0.12	196.0±30.0	193.0±7.0	436.0±13.30
Significance test)	P < 0.001	P > 0.01	P > 0.01	P > 0.01	P > 0.01

RT/ink
24x87

Table 141

Effect of dietary NPN administration on blood urea and protein free amino acid level in *H. fossilis*.

Treatment group	Serum urea ($\mu g.\ ml^{-1}$)	Serum total protein* ($mg\ \ ml^{-1}$)
Diet - 1	165.0 ± 14.1	42.5 ± 0.53
Diet - 2	158.63± 0.80	43.0 ± 0.85
Significance test	P > 0.01	P > 0.01

* Amino acid profile (μmol ml^{-1} serum) as determined by Automatic Amono acid Analyser (standard diet (Diet - 1)/NPN supplemented diet; Threonine: 0.07/0.05; Isoleucine:0.07/0.06; le cine: 0.14/0.12; lysine: 0.33/0.34; arginine: 0.16/0.19: methionine: trace/trace; trytophane trace/trace; valine: 0.07/0.11; phenylalanine: 0.26/0.27; histidine: 0.45/0.36).

Table 142

Body muscle composition of *H. fossilis* fed with NPN supplemented dist.

Treatment group	Dry matter	Composition of muscle tissue (%) Dry matter			
		Protein	Total carbo-hydrate	Fat	Ash
Dist - 1	29.0	68.62	22.11	2.93	6.34
Dist - 2	28.0	66.96	22.26	3.21	7.57

Table 143

Enzymatic activities in intestine and liver of *C. batrachus* fed with NPN supplemented diet

Treatment group	Intestinal urease (mg ammonia)	Tissue enzyme activities (mg proteins h^{-1})			
		intestinal alkaline phosphatase (ug nitrophenol)	liver arginase (n mol urea)	liver aspartate amino transferase (n mol. pyruvate)	liver alkaline amino transferase (n mol pyruvate)
Diet - 1	98.08 ± 10.05	30.59 ± 0.12	248.0 ± 21.0	132.0 ± 12.0	402.0 ± 15.0
Diet - 2	190.74 ± 3.30	32.87 ± 0.12	207.0 ± 10.0	87.0 ± 8.0	364.0 ± 16.8
Significance test	$P > 0.001$	$P > 0.01$	$P > 0.01$	$P > 0.01$	$P > 0.01$

Table 144

Effect of dietary NPS administration on blood urea and protein free amino acid level in *C. batrachus*

Treatment group	Serum urea (μg ml^{-1})	Serum total protein* (mg ml^{-1})
Diet 1	158.36 ± 0.90	42.1 ± 0.24
Diet 2	161.70 ± 1.25	44.6 ± 0.25
Significance test	$P > 0.01$	$P > 0.01$

* Amino acid profile (in mol. ml^{-1} serum) as determined by automatic amino acid analyser (standard diet/NPN supplemented diet ; threonine : 0.86/ 0.39; isoleucine:0.53/ 0.34; leucine: 1.16/0.95; lysine:1.41/1.18; arginine : 0.97/0.92; methionine:traces; [illegible] : tryptophan : traces; valine : 0.07/0.11; phenylalamine : 0.26/ 0.27; histidine : 0.45/ 0.36).

RTink
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Table 146

Glucose metabolism in C. batrachus and H. fossilis fed with non-protein nitrogen supplemented diet.

Species	Dietary treatment	Growth (%)	Blood glucose (mg ml^{-1})	Liver glucose 6 phosphotase activity (µmol. P mg$^{\cdot}$ protein^{-1} h^{-1})
C. batrachus	Reference diet	79.39	36.0 ± 2.0	157.0 ± 8.60
	NPN diet	57.38	50.0 ± 2.0	534.0 ± 40.0*
H. fossilis	Reference diet	19.51	37.0 ± 1.0	454.0 ± 54.0
	NPN diet	29.76	51.0 ± 2.0	590.0 ± 69.0**

* P < 0.001 : ** P < 0001

ink
4x87

Table 145

Body muscle composition of C. batrachus fed with NPN supplemented diet

Treatment group	Dry matter	Composition of muscle tissue % dry matter			
		Protein	Total carbohydrate	Fat	Ash
Diet - 1	26.0	67.54	15.26	6.62	10.56
Diet - 2	28.0	64.29	20.21	6.36	10.14

ink
4x87

Table 147

Harvesting of magur (pond area : 0.1 ha; duration : 5 months) and singhi (pond area : 0.04 ha; duration : 6 months) under intensive culture.

Species	Period of stocking	month	No.	$\bar{x}$ weight (g)	Total weight (kg)	Fish removed for breeding & other experiments			Quantity of fish harvested (kg)	Total production (kg)	production kg ha^{-1}	Survival (%)
						date	No.	Total weight (kg)				
Magur	16.02.79 to 02.04.79	February	18	10	0.80	14.08.79	50	3.00	451.20	785.64	7,800 in 5 months	40 %
		March	50	32	1.60	20.08.79	30	2.19				
		April	550	34	19.14	29.08.79	50	2.50				
		May	400	43.9	17.56	05.09.79	20	0.50				
		June	4490	50	224.50	10.09.79	20	1.00				
		July	500	49.7	24.85	17.09.79	20	1.00				
		August	600	50.0	30.00							
			6,598		318.45		220	15.99				
Singhi	16.02.79 to 28.02.79	-	1,267		6.4	-	-	-	109.20	195.60	4,890 in 6 months	94.8 %

ink
4x87

Table 148

Growth of *A. testudineus* fed on different compounded diets

Diets	Biomass fish^{-1}			growth (%)	Survival (%)	Total dry wt. feed (g fish^{-1})	Feed conversion efficiency
	Initial	Final	Biomass gain (g)				
Diet A	8.251	10.008	1.757	21.3	80	6.50	3:7:1
Diet B	8.251	10.479	2.228	27.0	90	7.129	3:2:1
Control (cow mannure)	8.251	9.414	1.163	14.1	90	4.593	3:95:1

ink
4x87

Table 149

Experiment on paddy cum air breathing fish culture (kharif, 1982)

Stocking rate m^{-2} ±	$\bar{x}$ weight (g)	Production of fish kg ha^{-1} in 30 days		Paddy yield kg ha^{-1} in 60 days		Straw yield kg ha^{-1} in 60 days		Control kg ha^{-1} in 60 days	
		without feed	with feed	without feed	with feed	without feed	with feed	paddy	straw
1	30	199.4	375.0	1,039.20	1,077.97	3,920.57	4047.61	1,794.64	4,345.23

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4x07

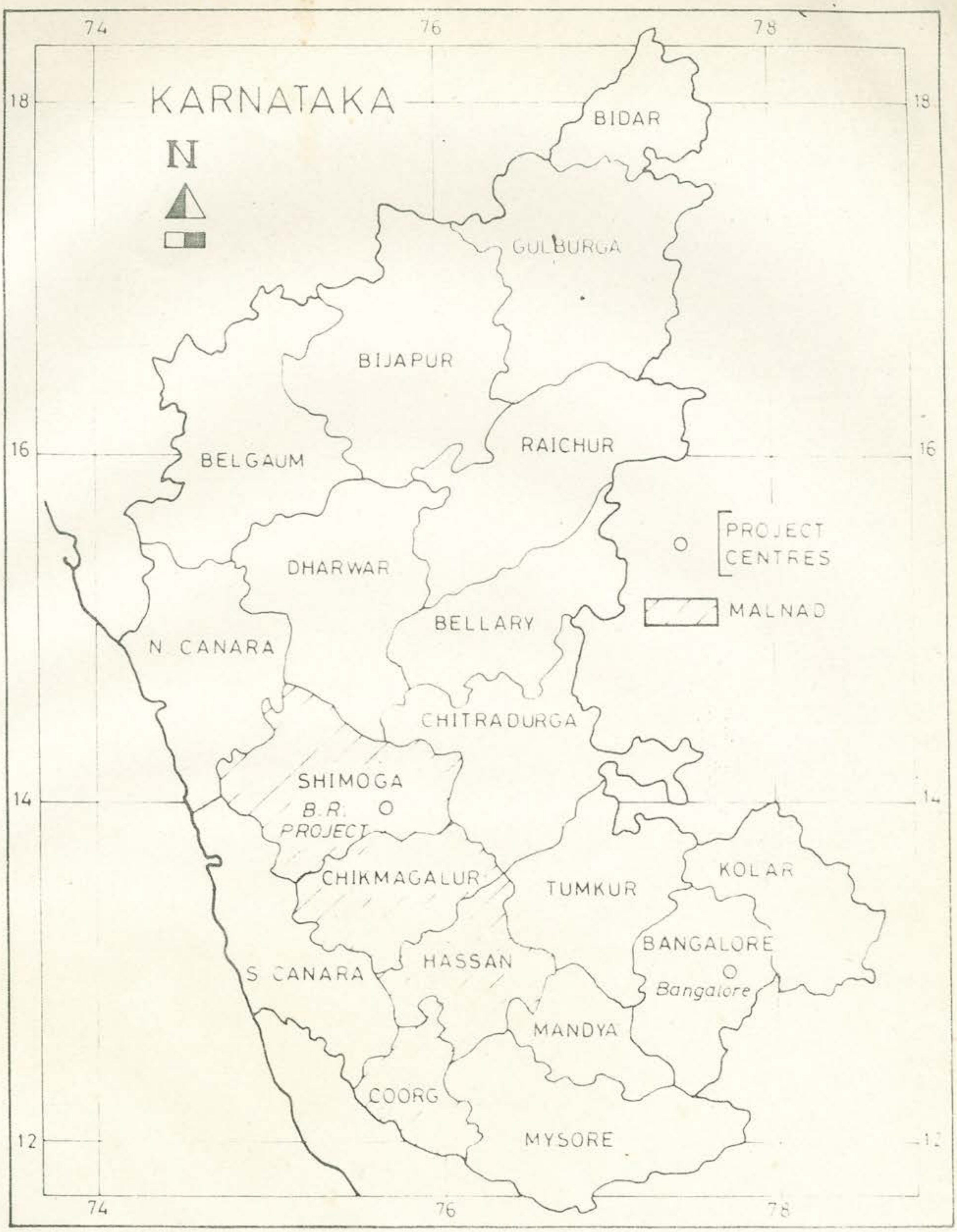


FIG. 1. MAP OF KARNATAKA SHOWING THE DISTRICTS AND THE LOCATIONS OF THE RESEARCH CENTRE.

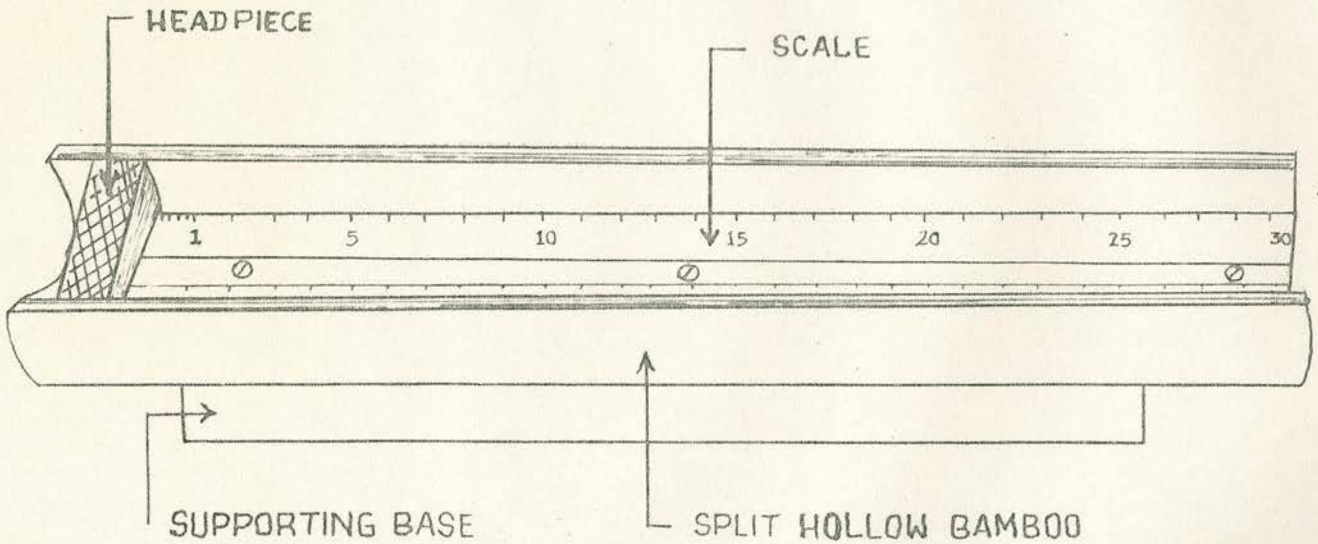


FIG. 2. THREE DIMENSIONAL VIEW OF A MEASURING BOARD

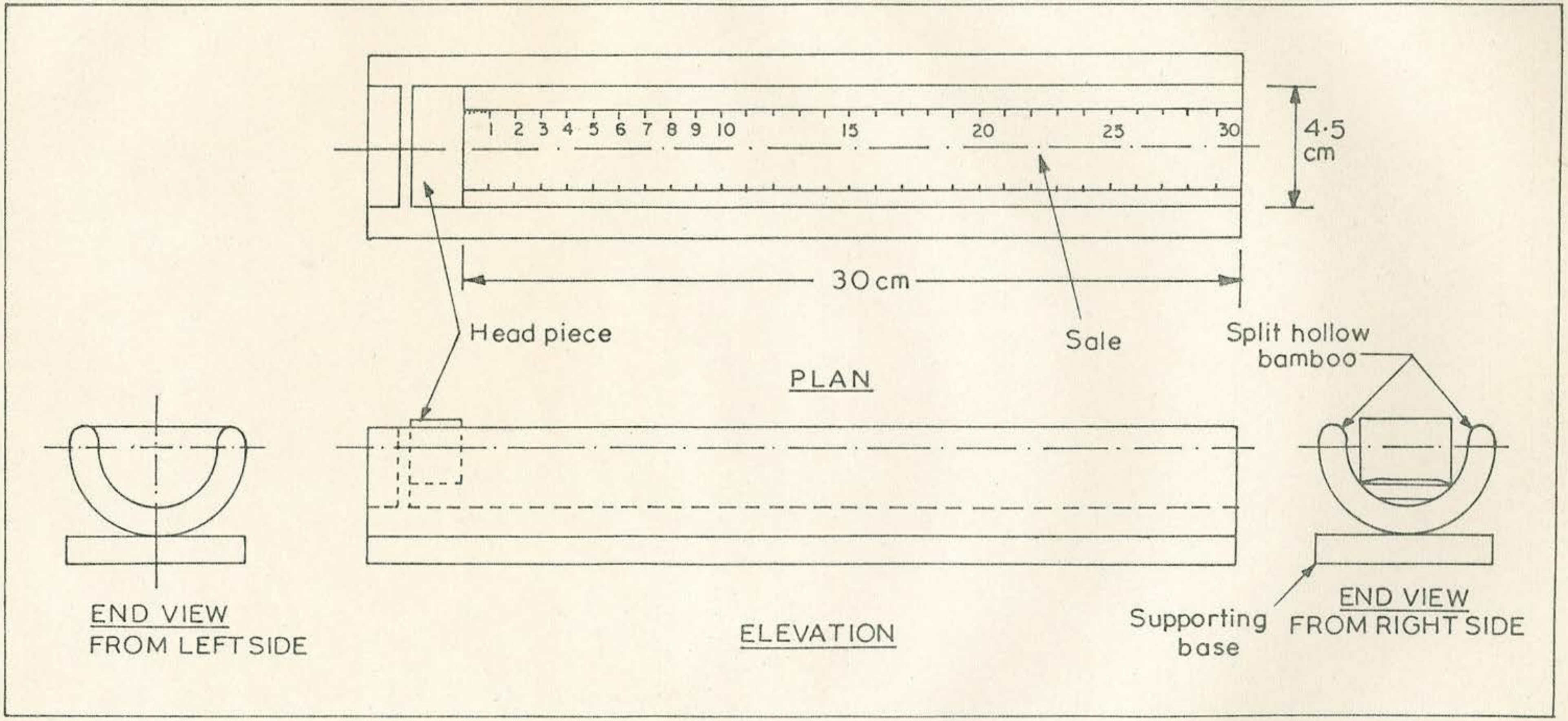


Fig. 3. Measuring board for air breathing fishes

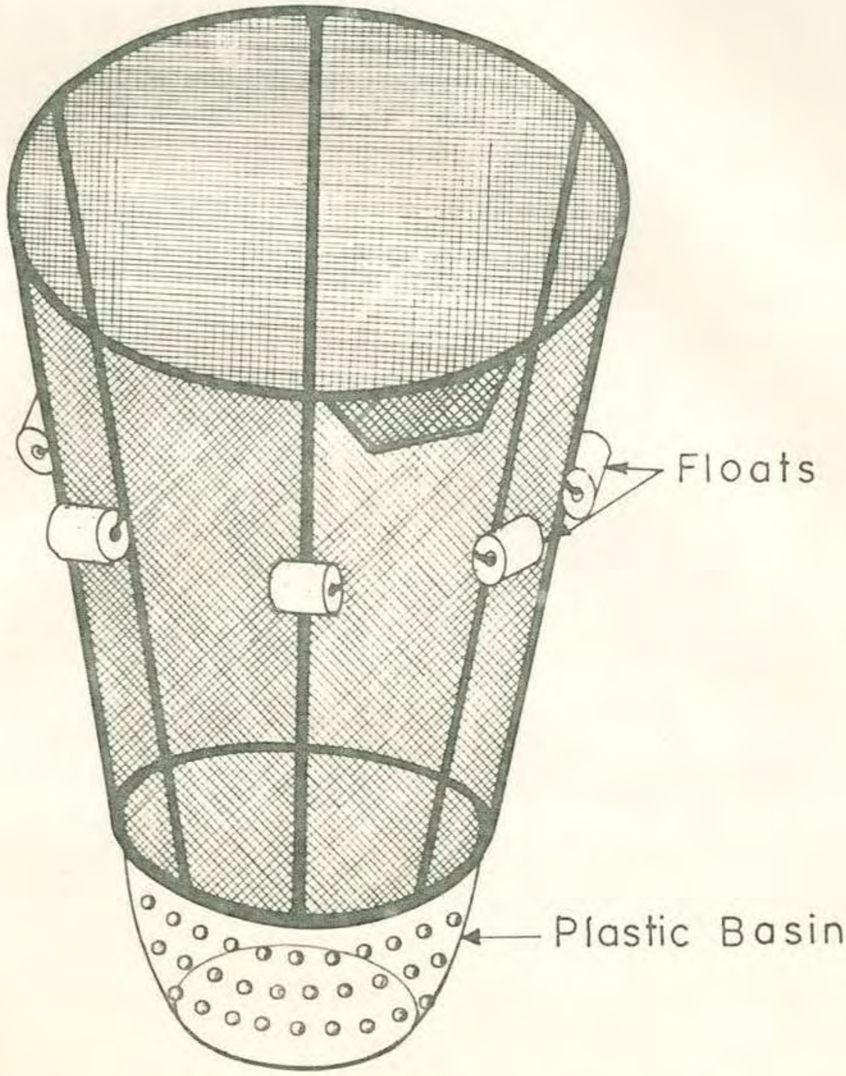
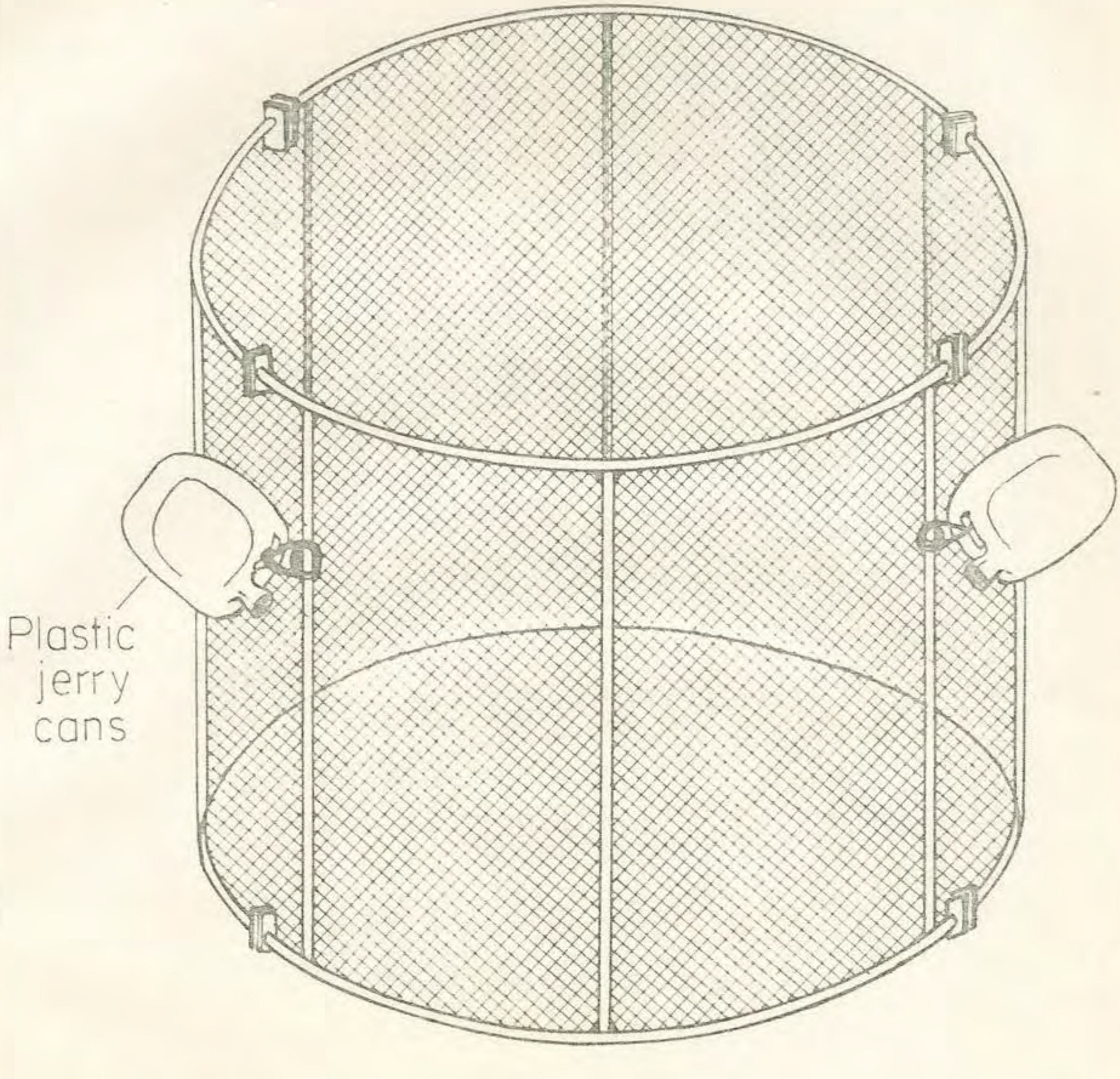


Fig. 4. Basket cage for experimental rearing of fishes.



height =1·5 m
dia. =3·5 m
radius =1·74 m
area $= 10 m^2$
arcs = 4 nos
Float size = 48 x 14 cm
Pipe dia = 2 cm

FIG.5. CIRCULAR NET CAGE FOR FISH CULTURE

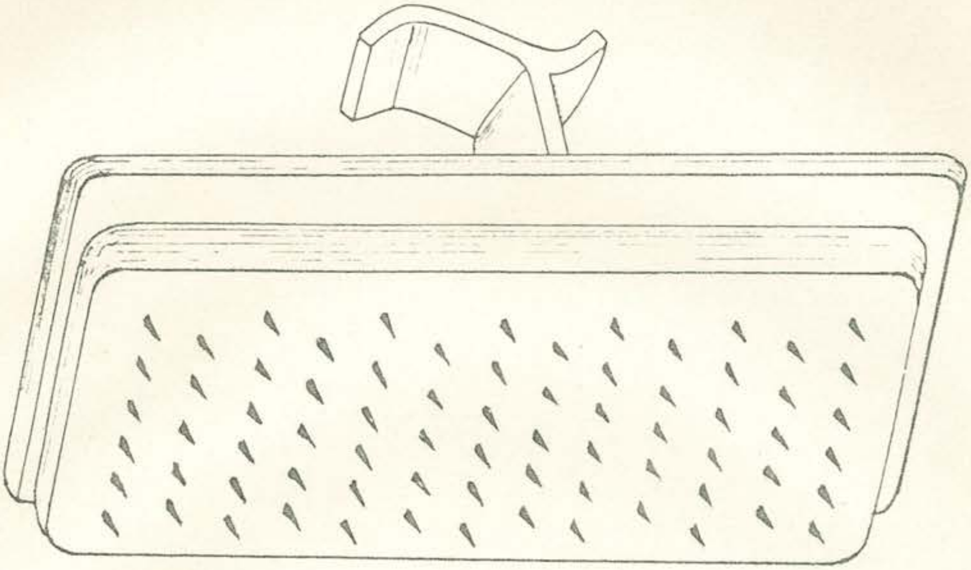


FIG. 6 FISH SCALER

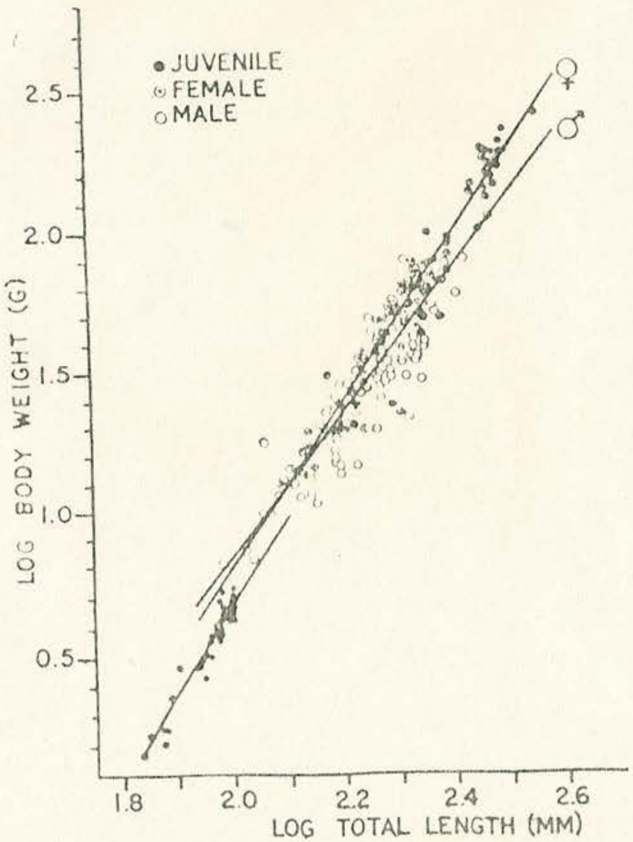


Fig 7. Logarithmic relationships between length and weight in juveniles, females and males of H. fossilis

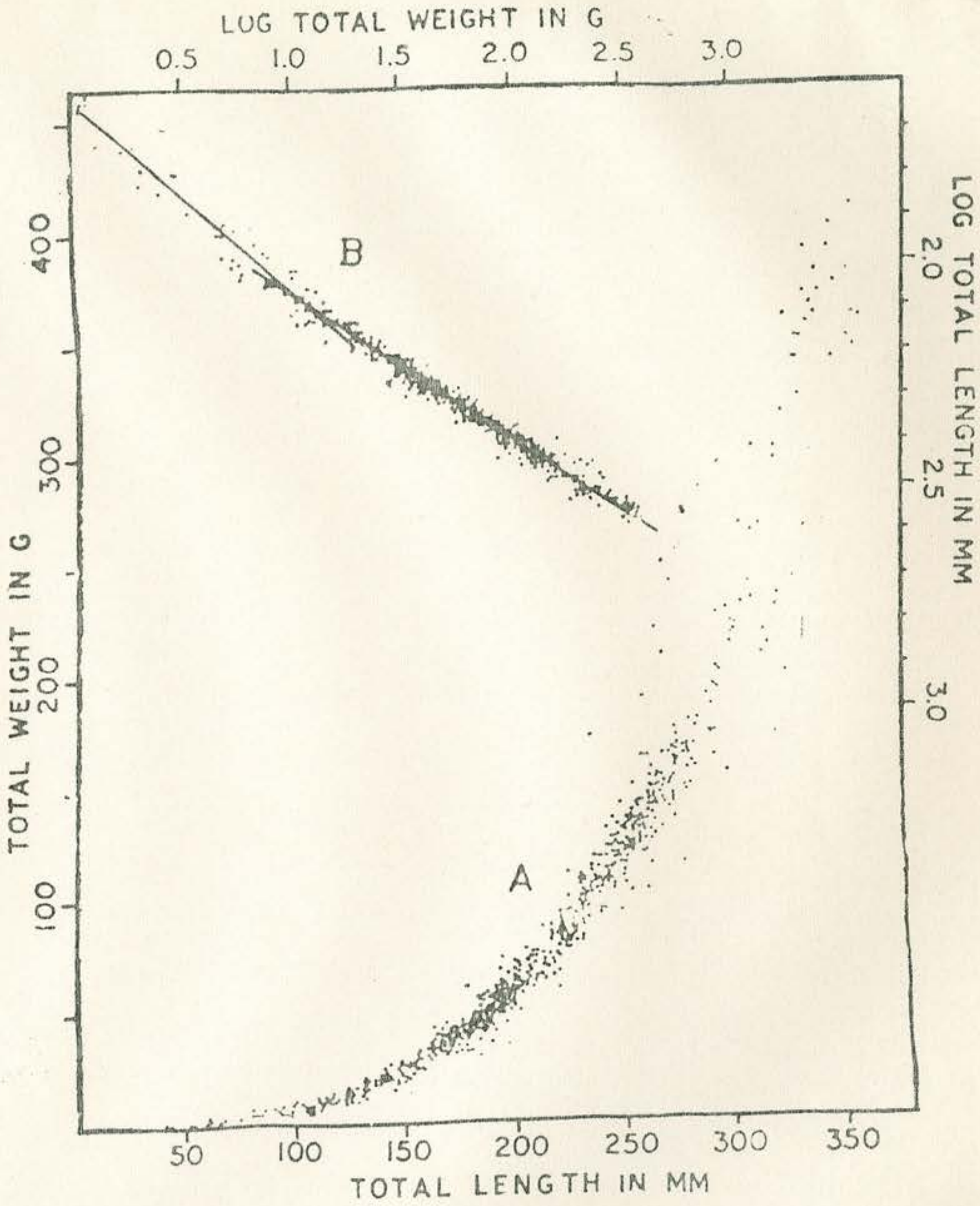
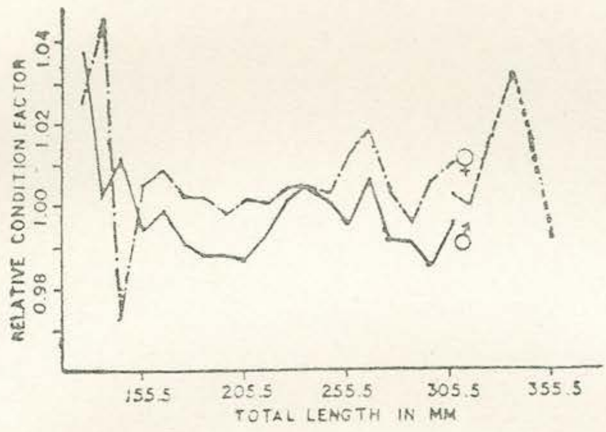


Fig 8. Length-weight relationship of C. batrachus
(A) scatter diagram of absolute values,
(B) log-log transformation.



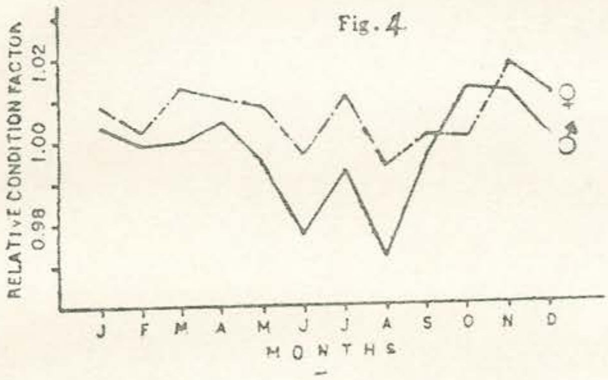


Fig. 9 Relative condition of C. batrachus at different lengths

Fig.10 Relative condition of C. batrachus during different months.

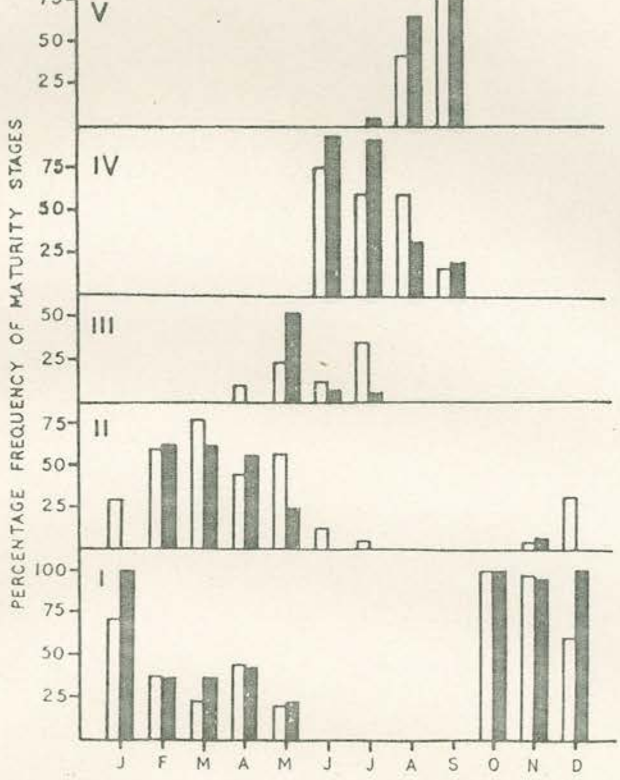


Fig. 11 Monthly percentage of gonads of _C. batrachus_ in each of stage of maturity. Shaded bars represent female and unshaded ones males.

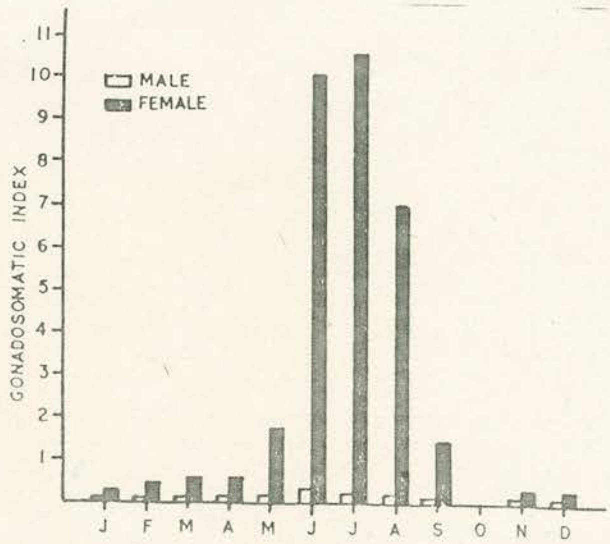


Fig. 12 Monthly variations in gonado-somatic index of _C. batrachus_

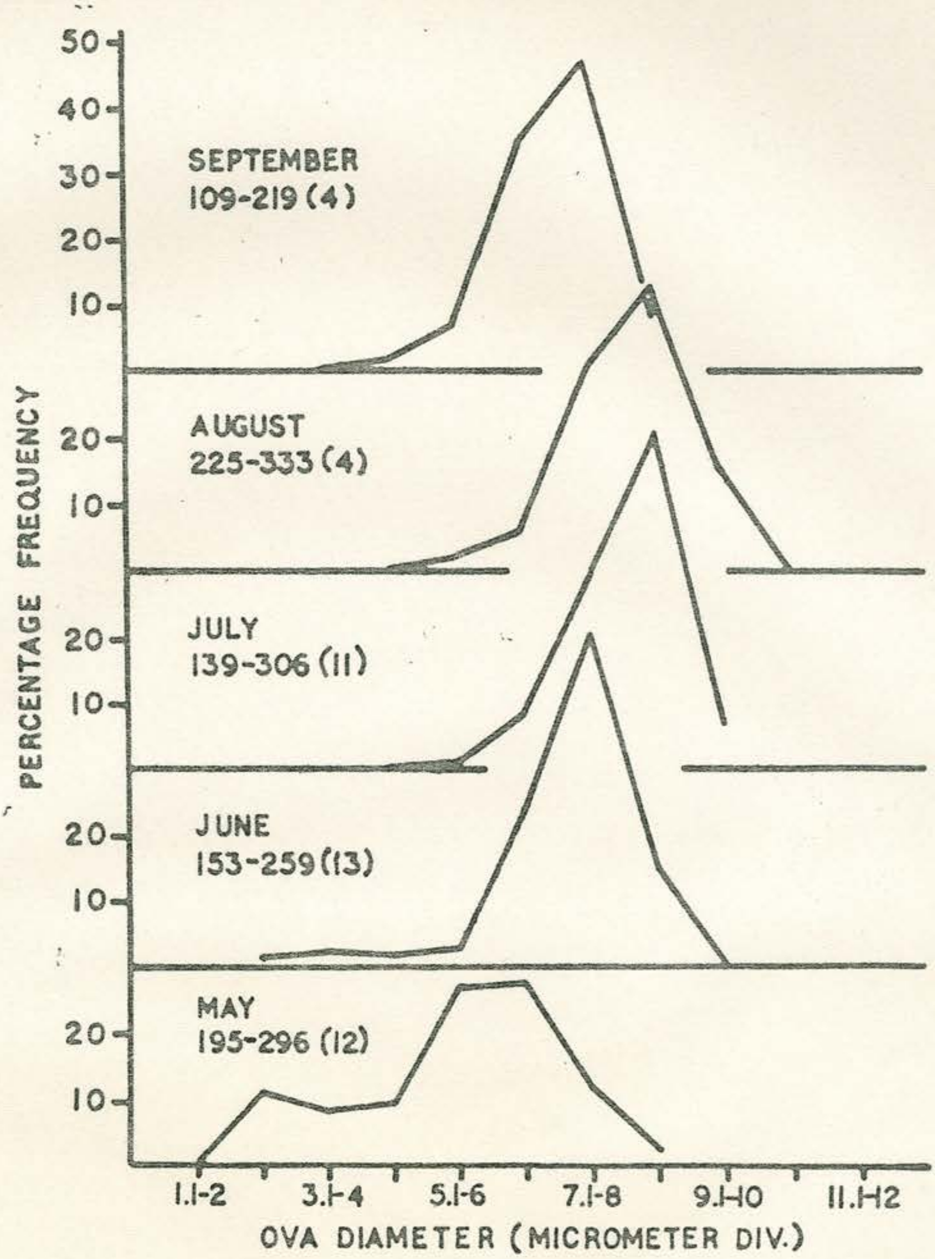


Fig. 13 Monthly size frequency distribution of ova in C. batrachus. Figures noted below months indicate the size range of the fish in mm and those noted within parenthesis denote the number of fish examined.

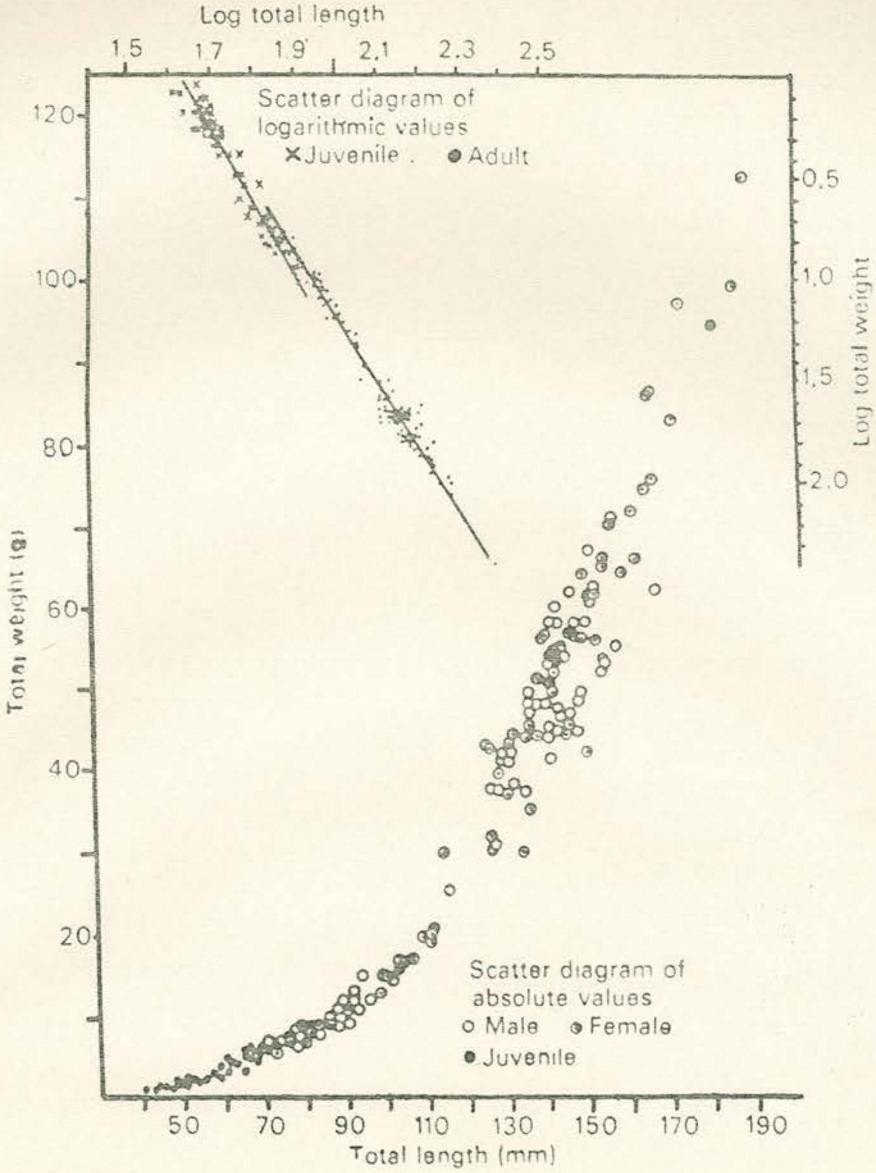


Fig. 14 Length-weight relationship of _A_. _testudineus_

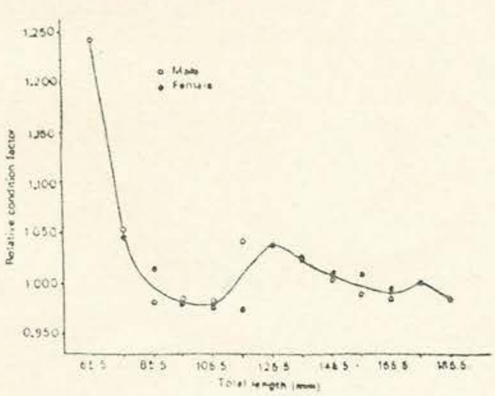


Fig. 15 Mean values of relative condition at different lengths in _A_. _testudineus_

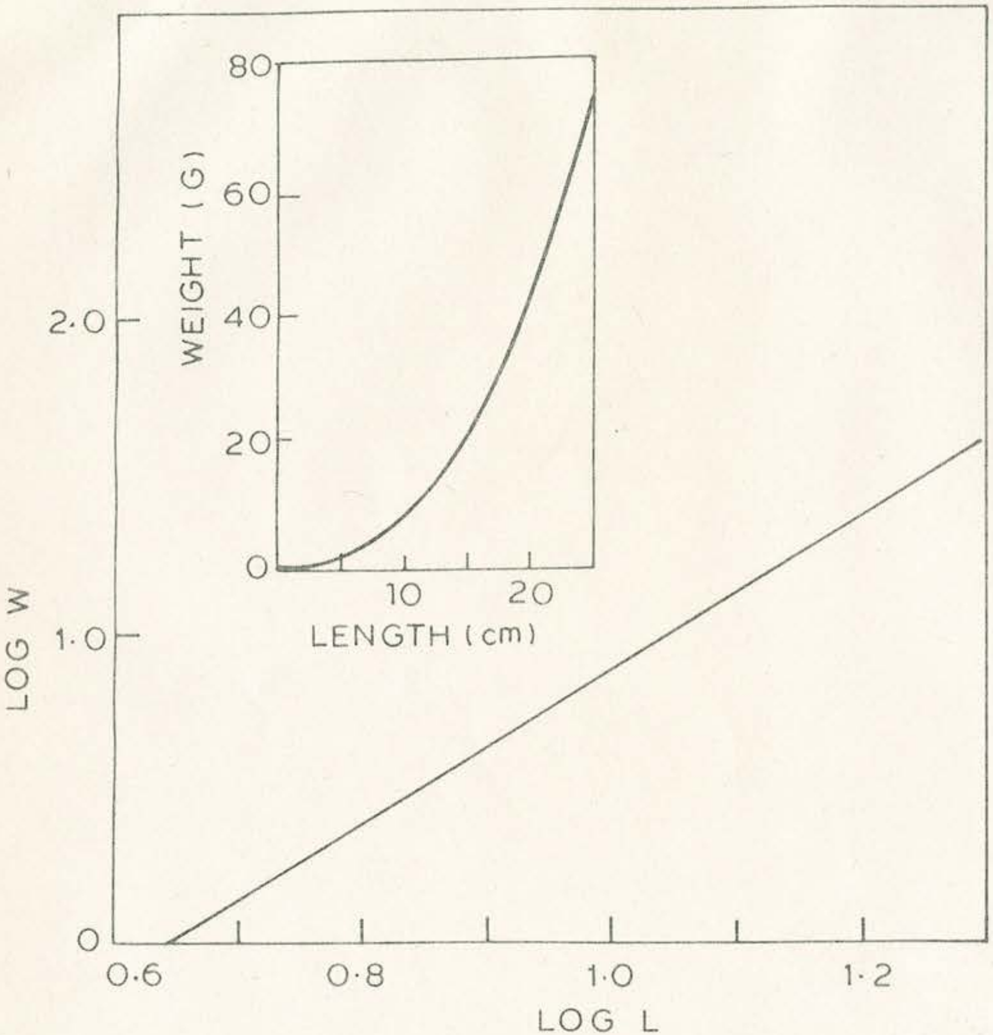


Fig. 16. Length weight relationship of *H. fossilis* .

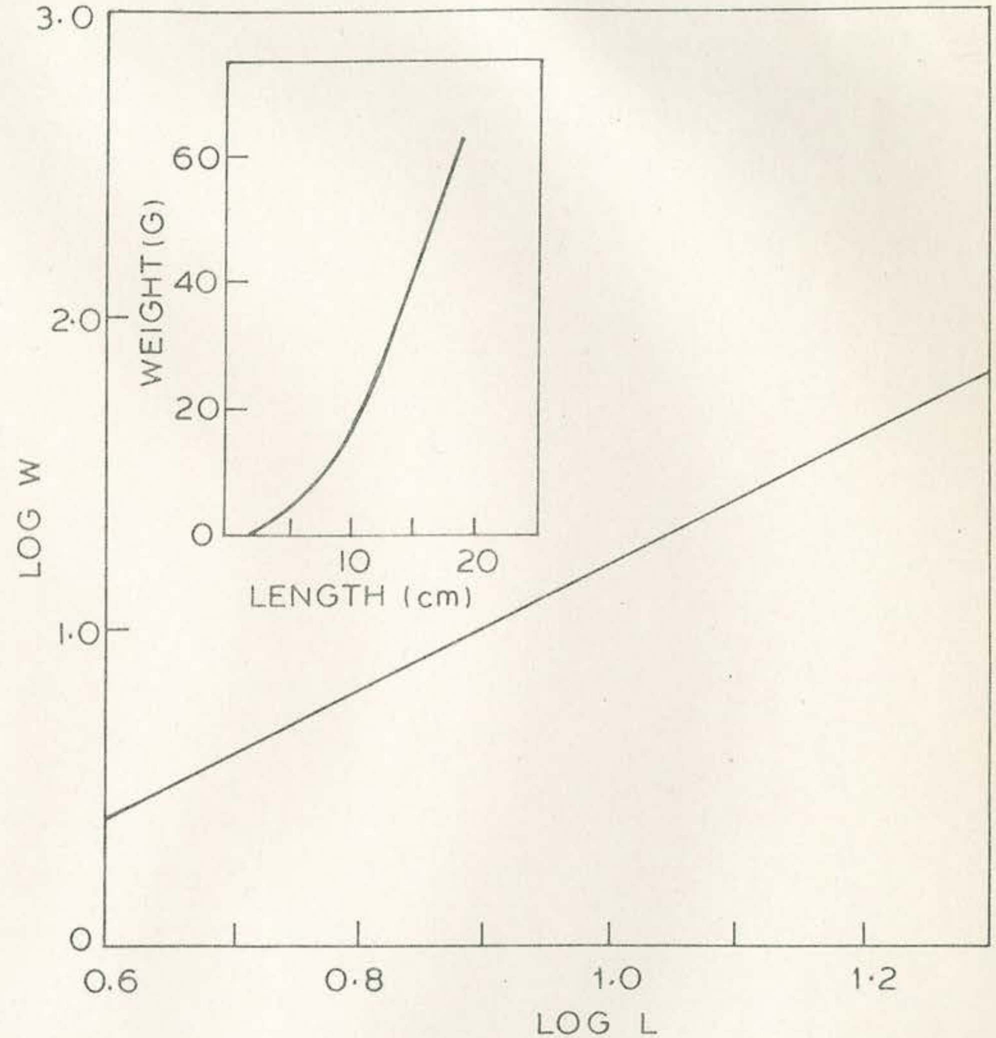


Fig. 17. Length weight relationship of *A. testudineus* .

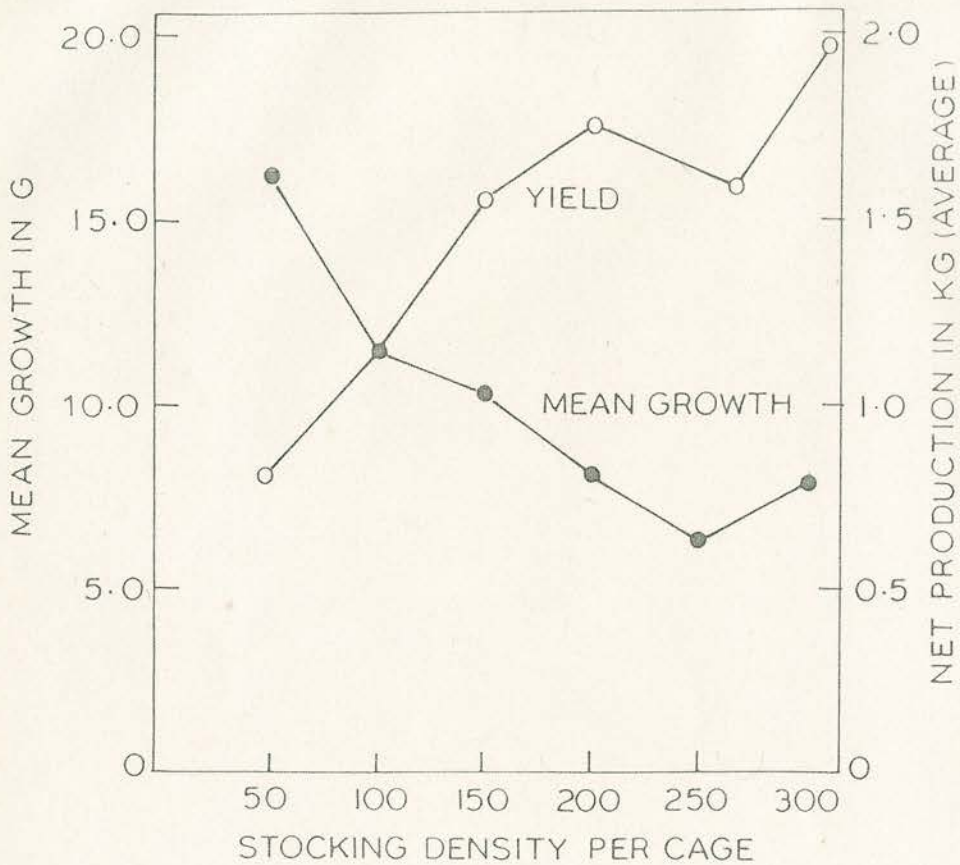


Fig. 18. Growth and production of *H. fossilis* at different stocking densities.

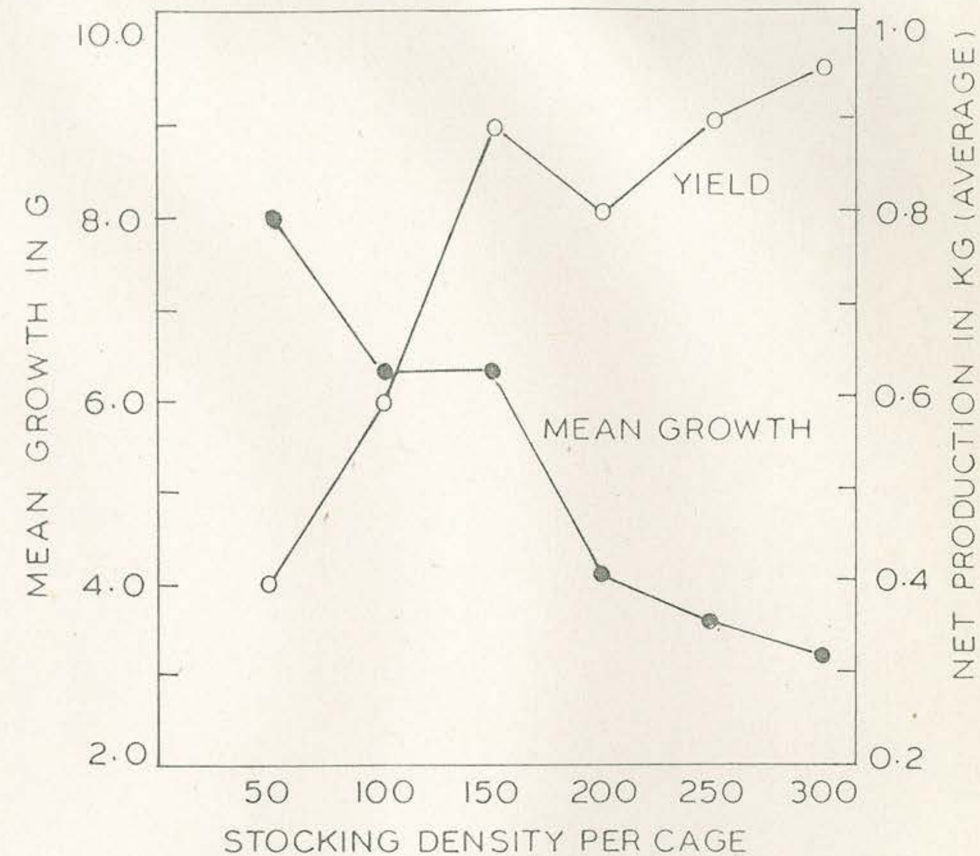


Fig. 19. Growth and production of *A. testudineus* at different stocking densities.

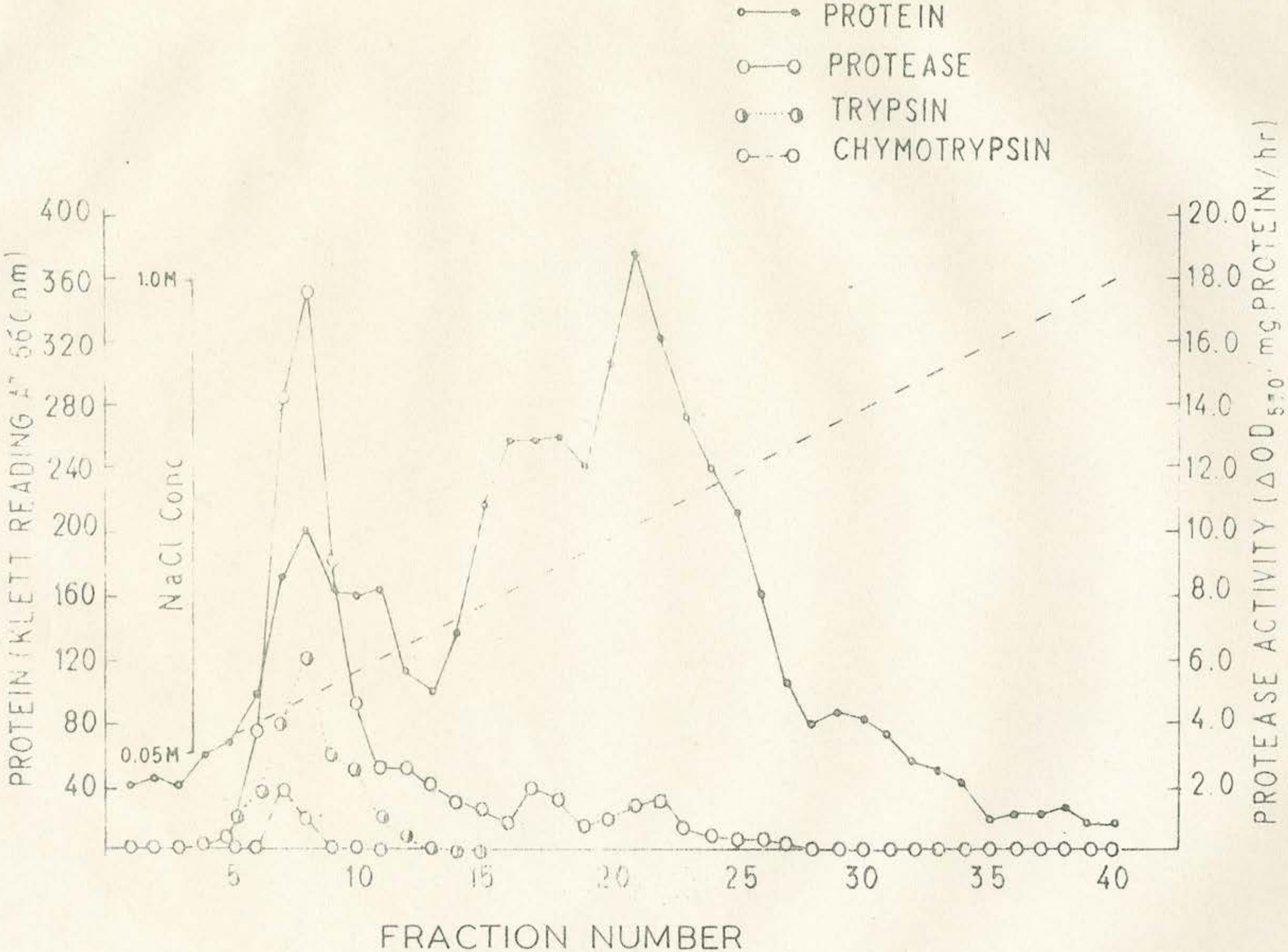


FIG. 20. DEAE-CELLULOSE CHROMATOGRAPHY OF ALKALINE PROTEASE FROM THE INTESTINE OF MAGUR.

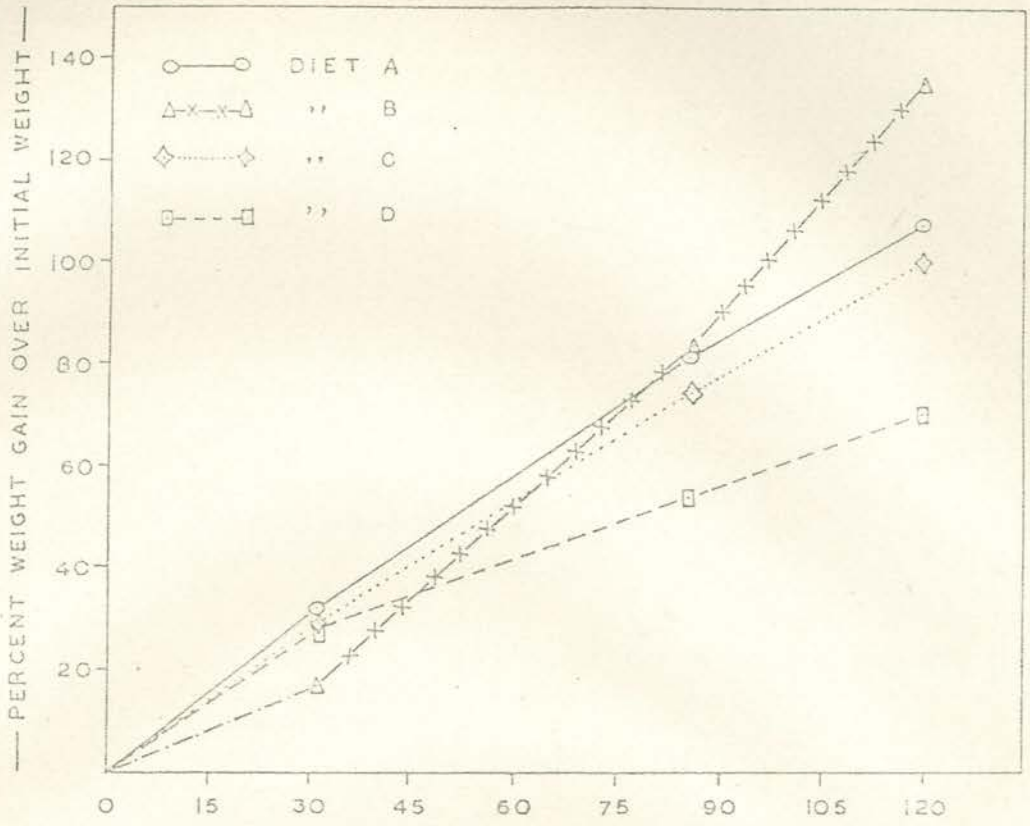


FIG. 21. GROWTH PATTERN OF C. batrachus FED WITH DIFFERENT EXPERIMENTAL DIETS.

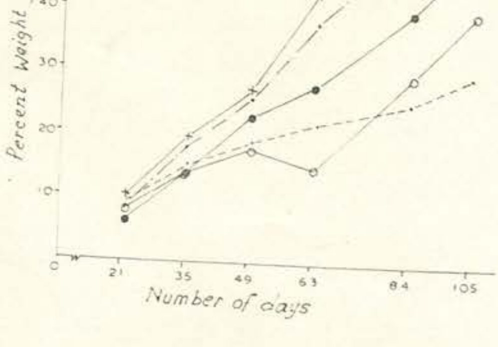


FIG. 22 Weight gain of the catfish, Clarias batrachus fed on varied levels of dietary methyl testosterone (MT).

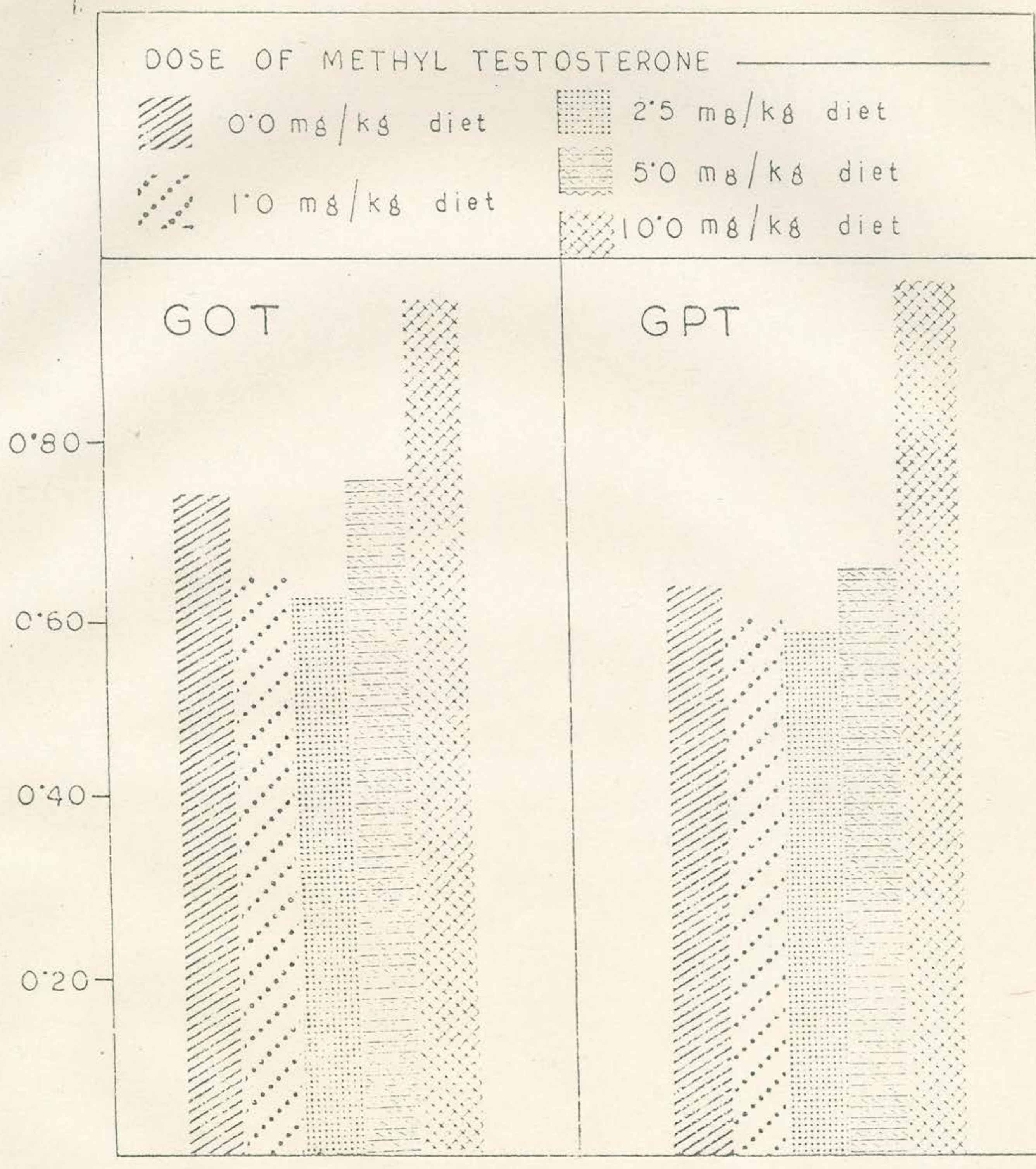


FIG. 23. HISTOGRAM SHOWING EFFECTS OF DIETARY METHY TESTOSTERONE ON THE ACTIVITIES OF GLUTAMATE OXALACETATE TRANSAMINASE (GOT) AND GLUTAMAT PYRUVATE TRANSAMINASE (GPT) IN LIVER TISSUE THE CATFISH C. batrachus

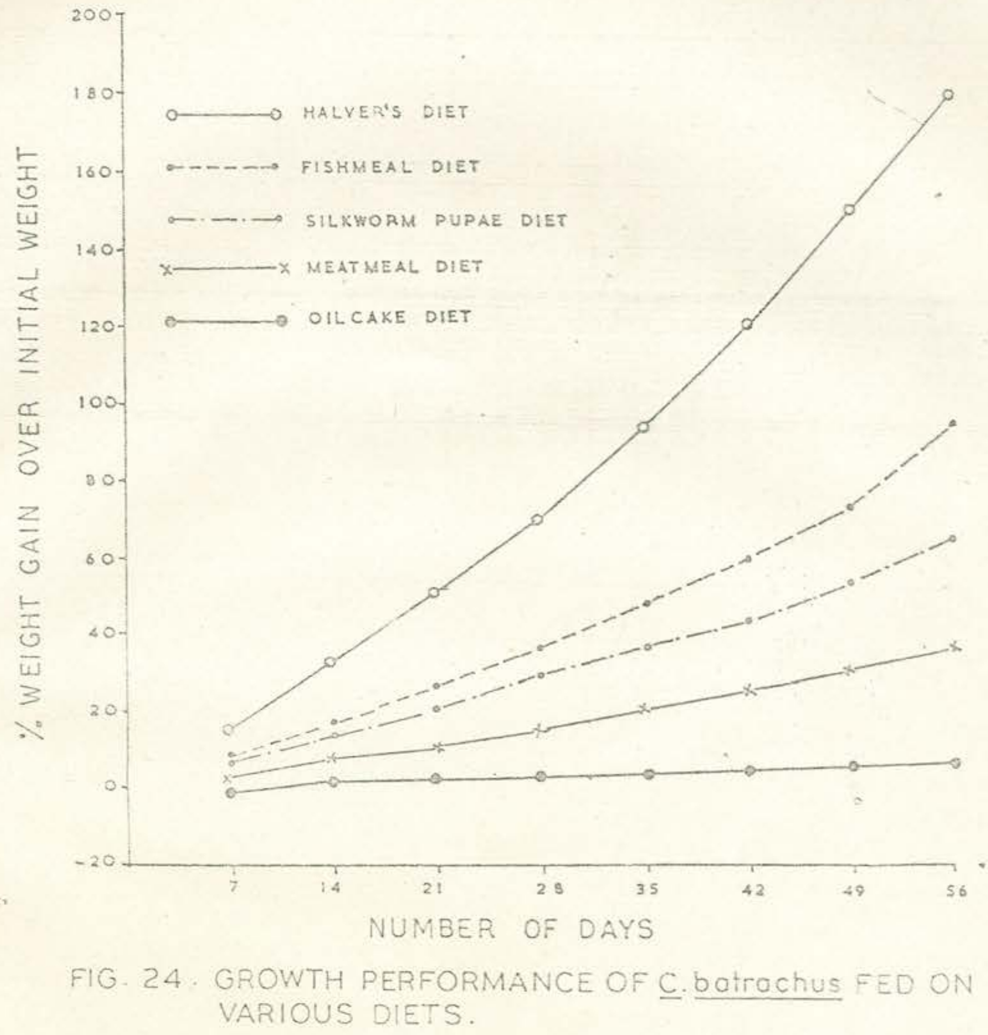
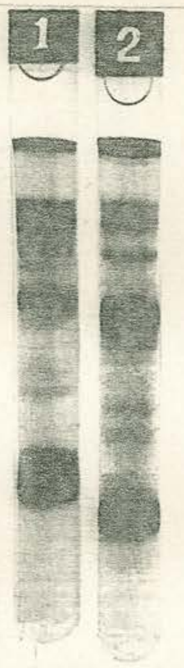
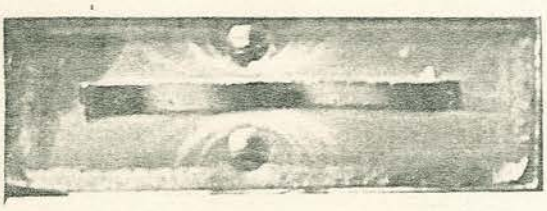


FIG. 24. GROWTH PERFORMANCE OF C. batrachus FED ON VARIOUS DIETS.



25 A. Comparative electrophoretic separation of serum protein constituents in C. batrachus: (1) control and (2) exposed to 1.0 mg l^{-1} malathion



25 B. Immunoelectrophoretic separation of serum protein constituents of C. batrachus.

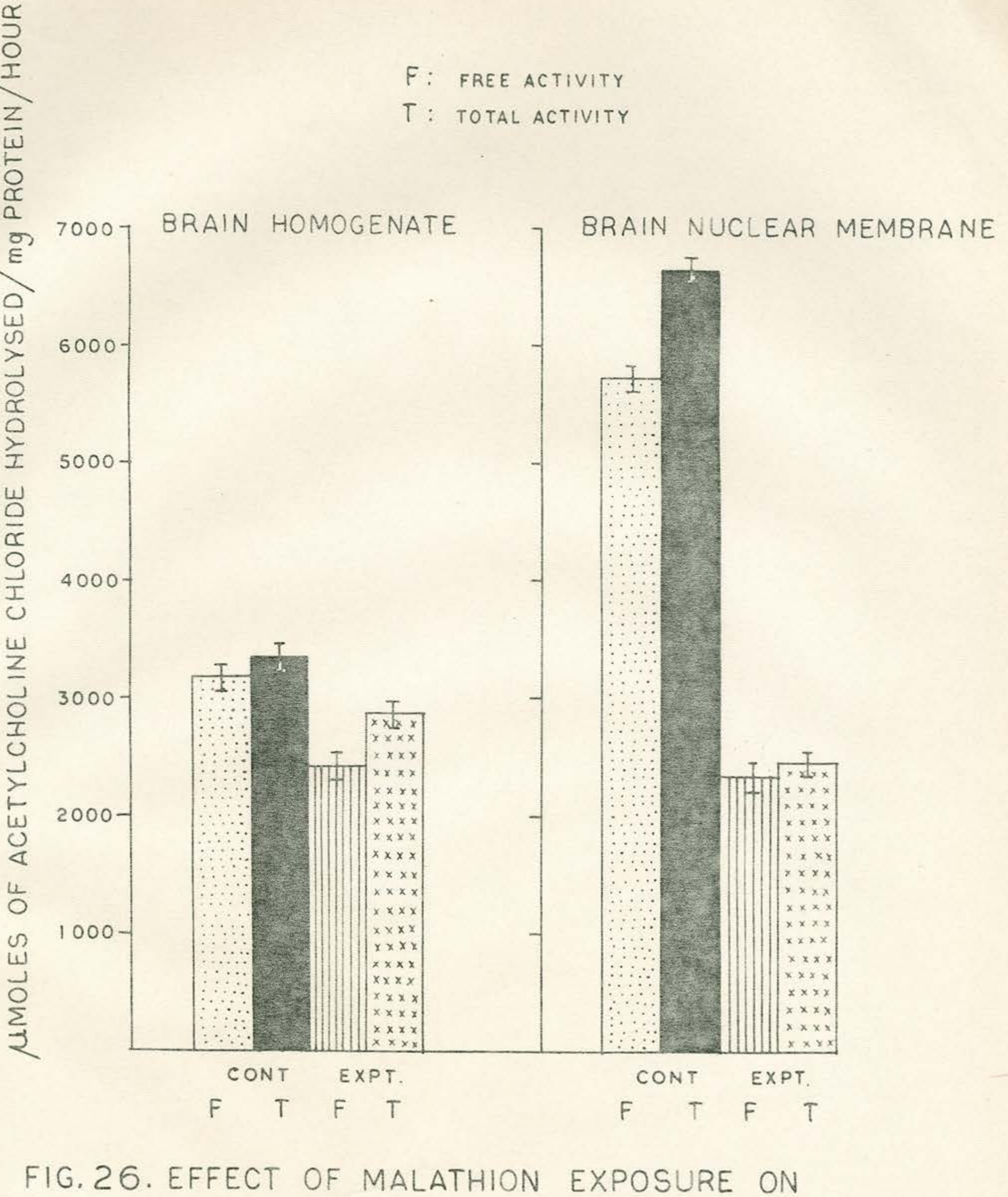


FIG. 26. EFFECT OF MALATHION EXPOSURE ON ACETYLCHOLINESTERASE ACTIVITY IN BRAIN HOMOGENATE AND NUCLEAR MEMBRANE FRACTION OF *C. batrachus*

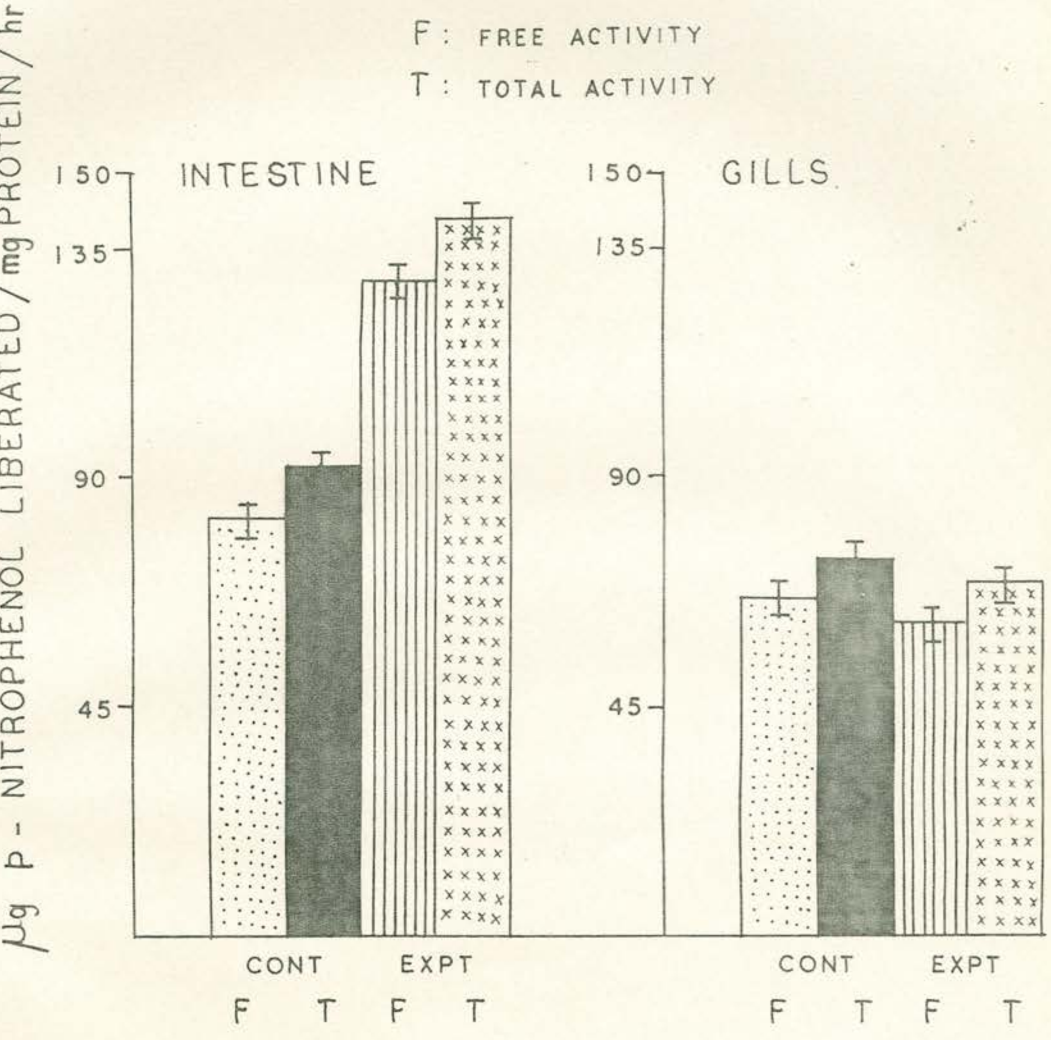


FIG. 27. ALKALINE PHOSPHATASE ACTIVITY IN *C. batrachus* UNDER NORMAL AND MALATHION TREATED CONDITIONS

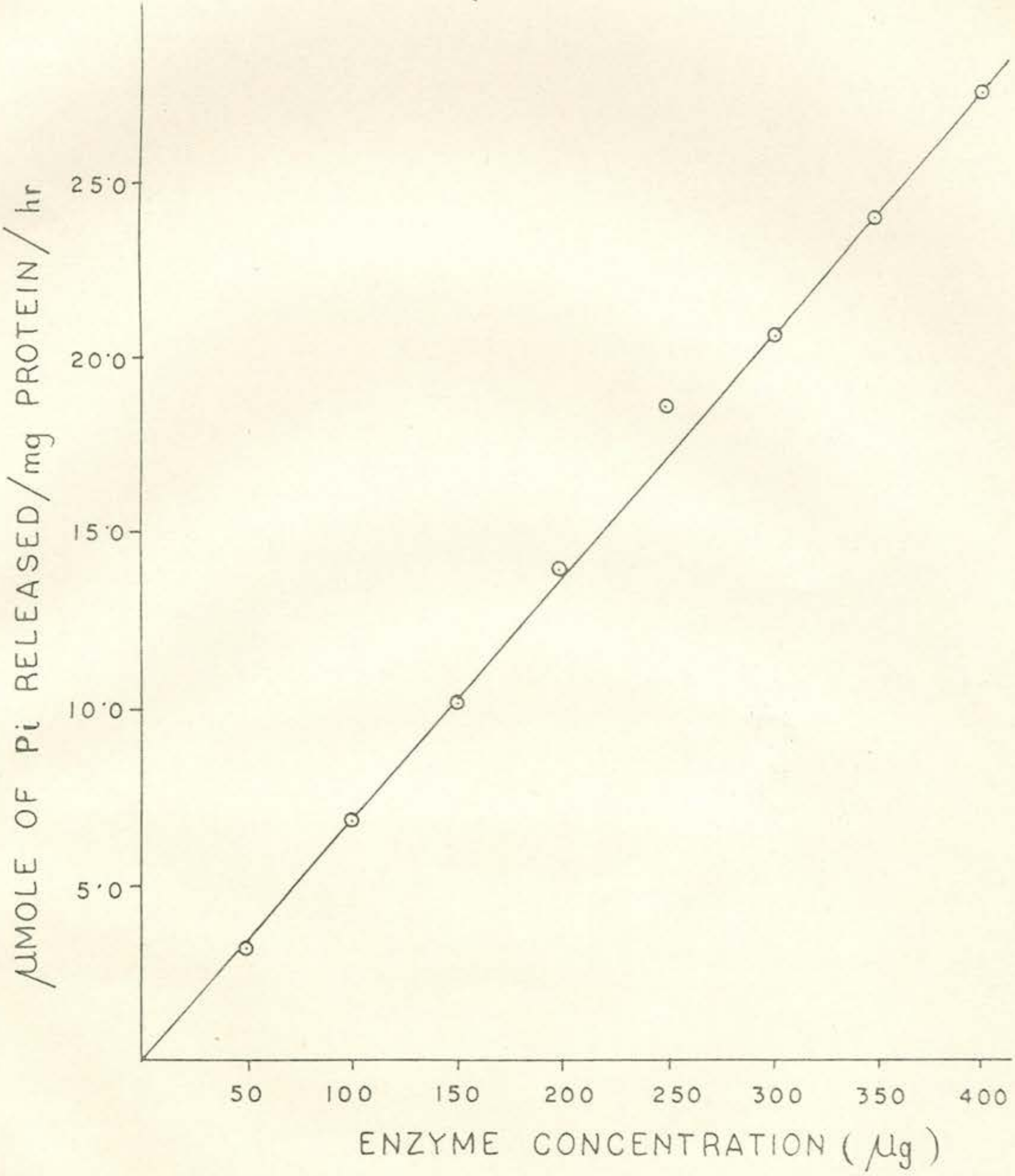


FIG. 28. EFFECT OF ENZYME CONCENTRATION ON Na^{+}–K^{+}–Mg^{2+}– ATPase ACTIVITY IN *C. batrachus*

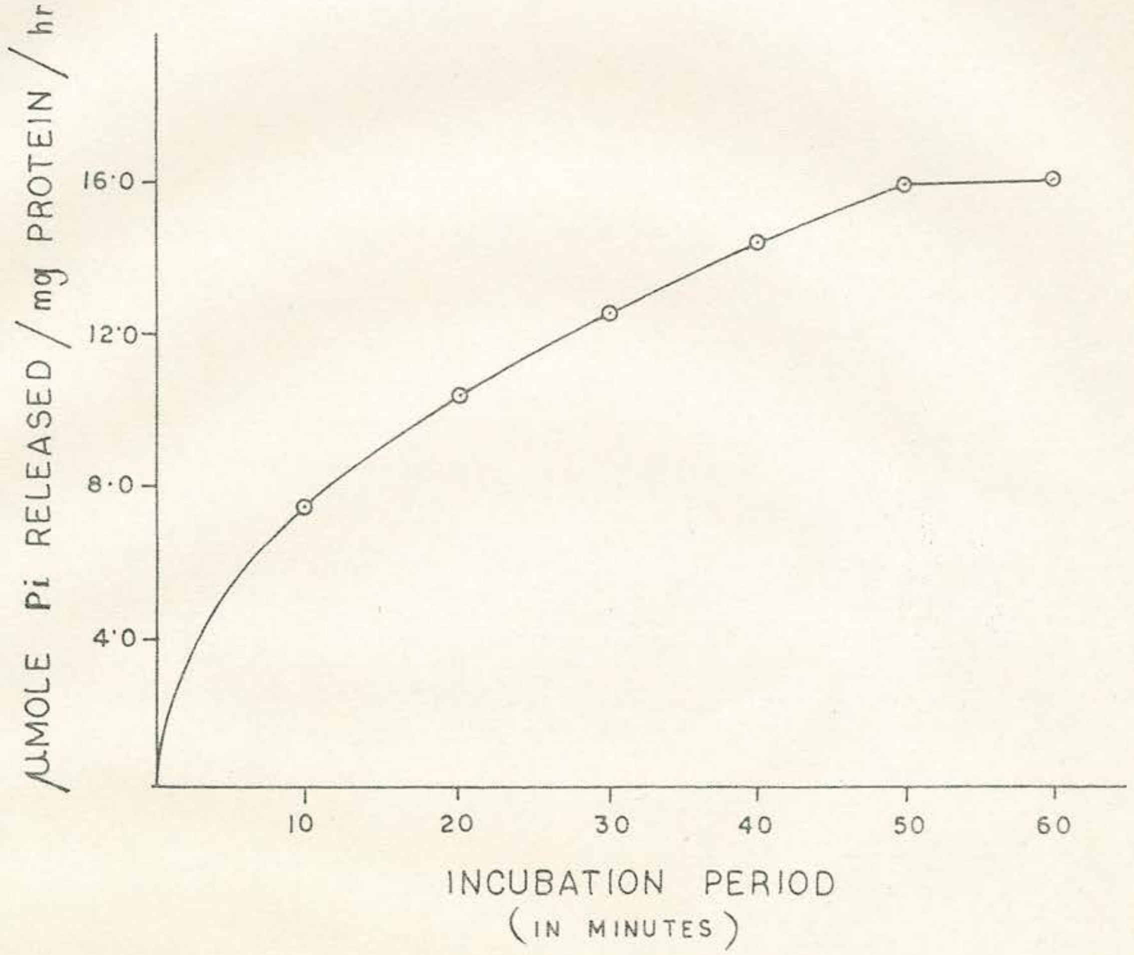


FIG. 29. TIME COURSE STUDY OF HEPATIC Na^+-K^+-Mg^{2+}-ATPase ACTIVITY OF *C. batrachus*

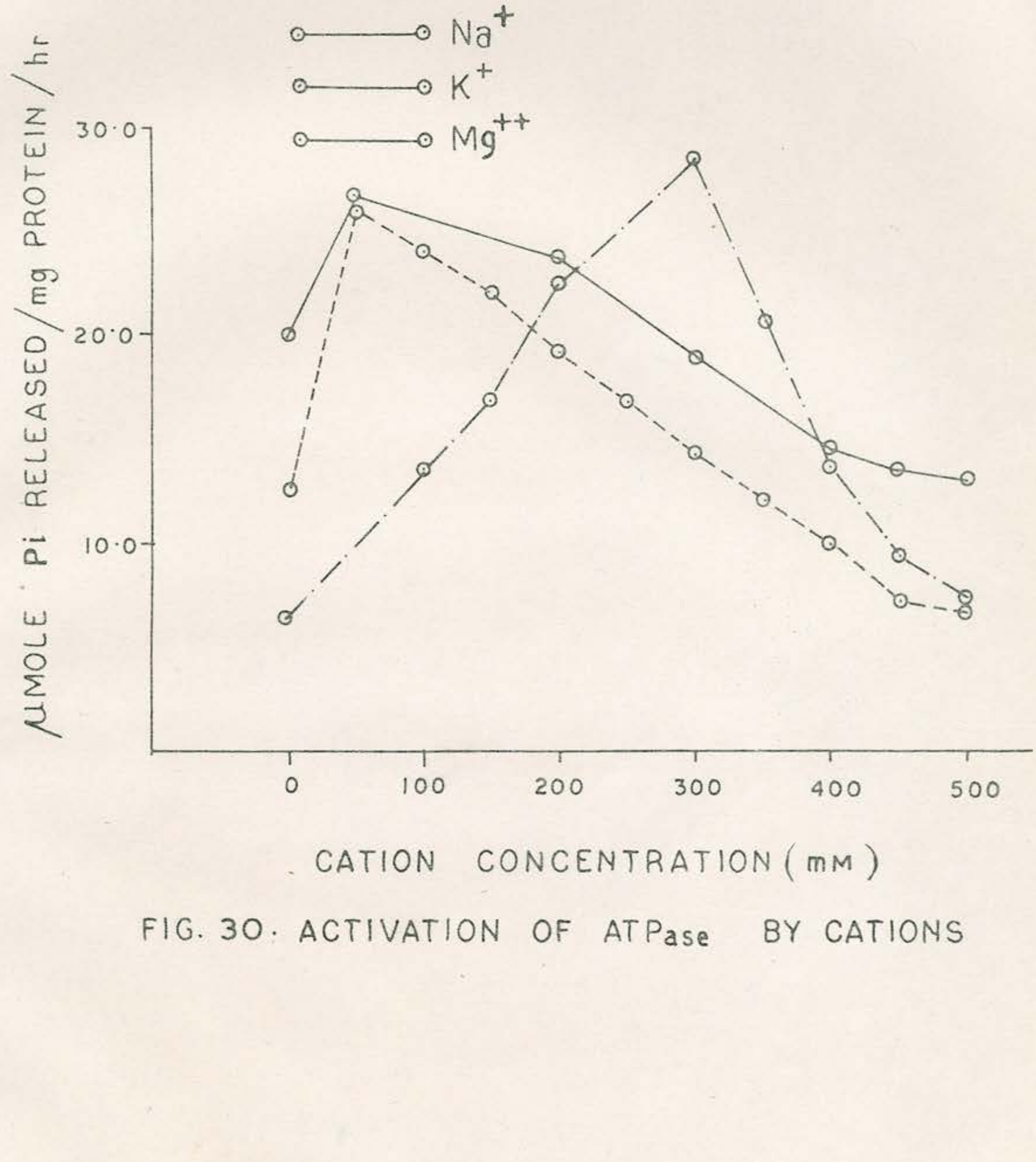


FIG. 30. ACTIVATION OF ATPase BY CATIONS

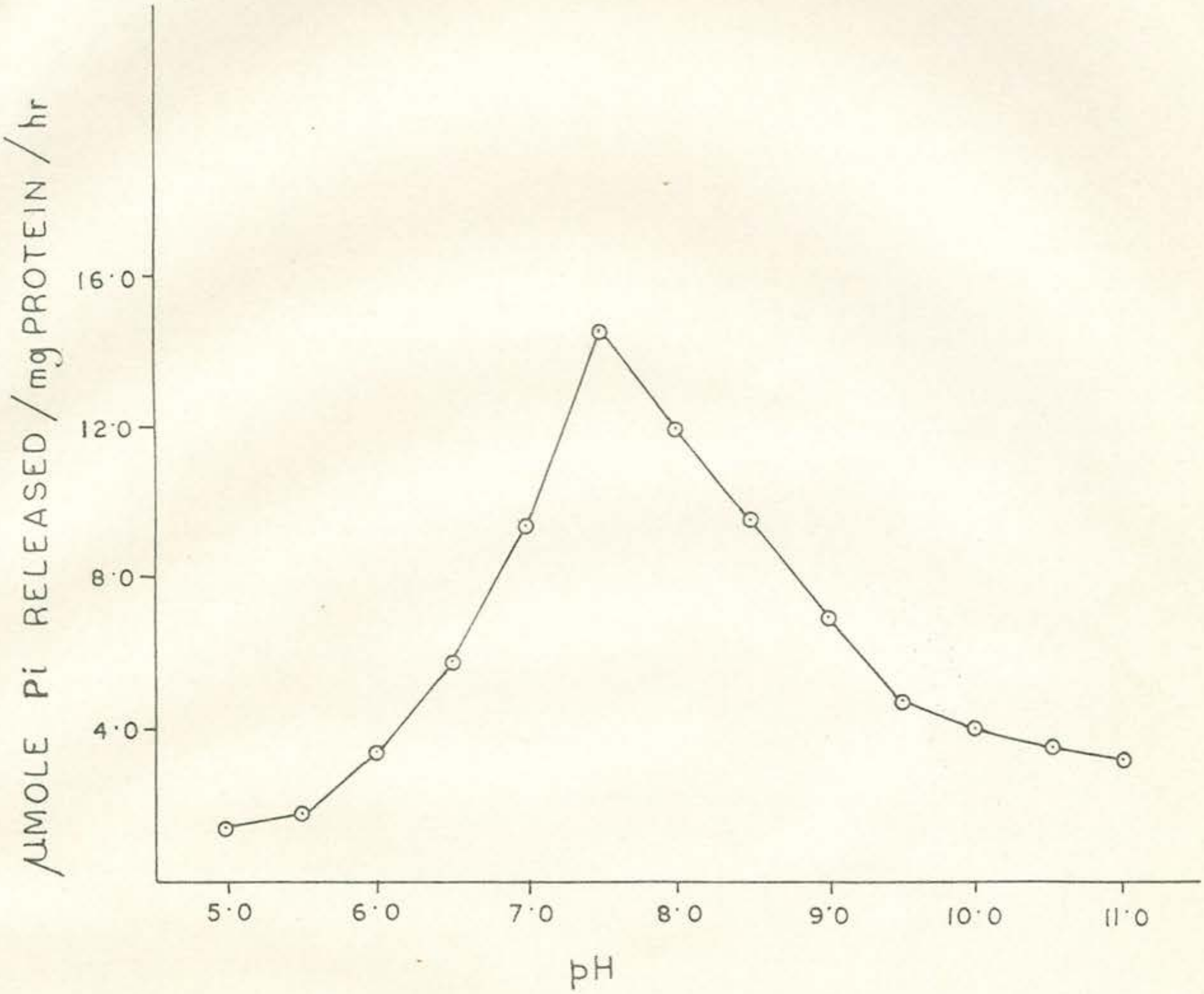


FIG. 31. EFFECT OF pH ON Na^{+}–K^{+}–Mg^{2+}–ATPase ACTIVITY IN *C. batrachus*

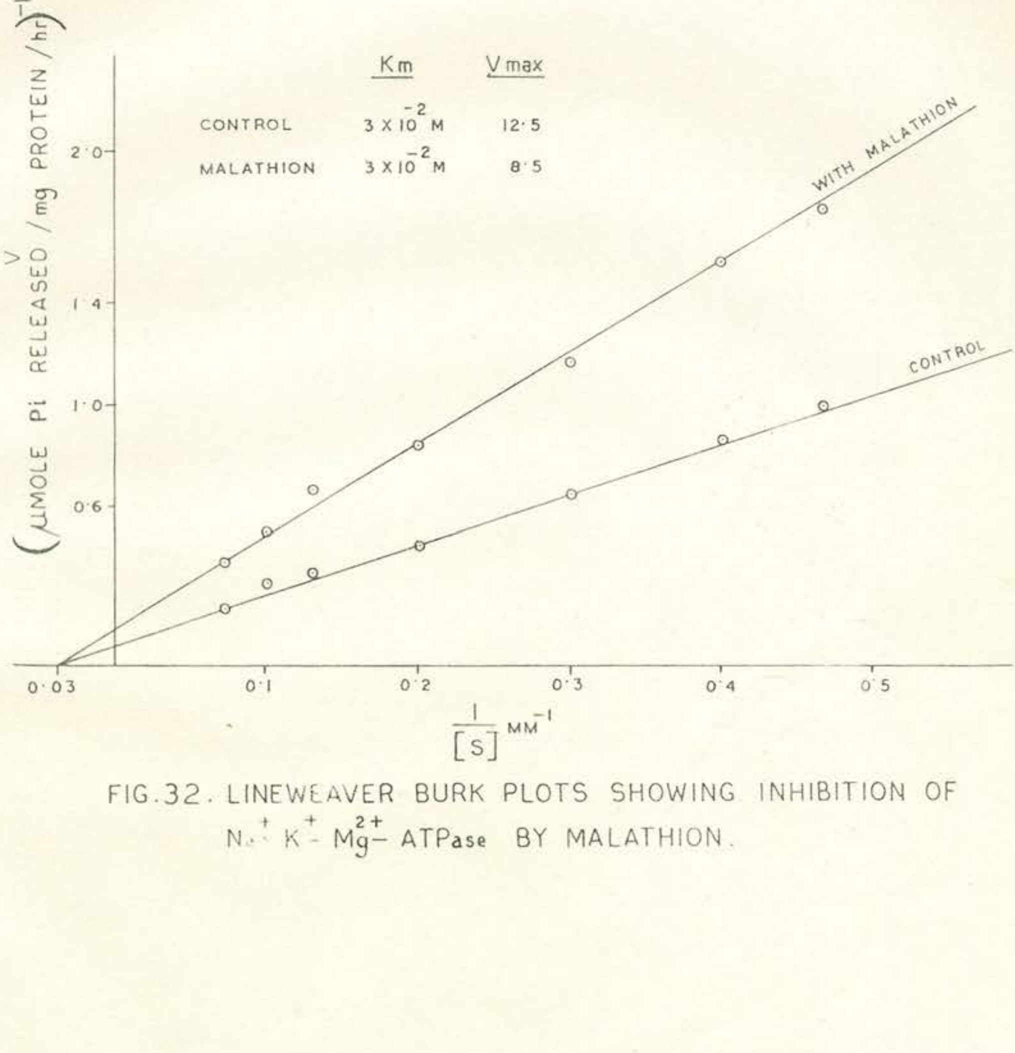


FIG.32. LINEWEAVER BURK PLOTS SHOWING INHIBITION OF Na^{+} K^{+} - Mg^{2+} – ATPase BY MALATHION.

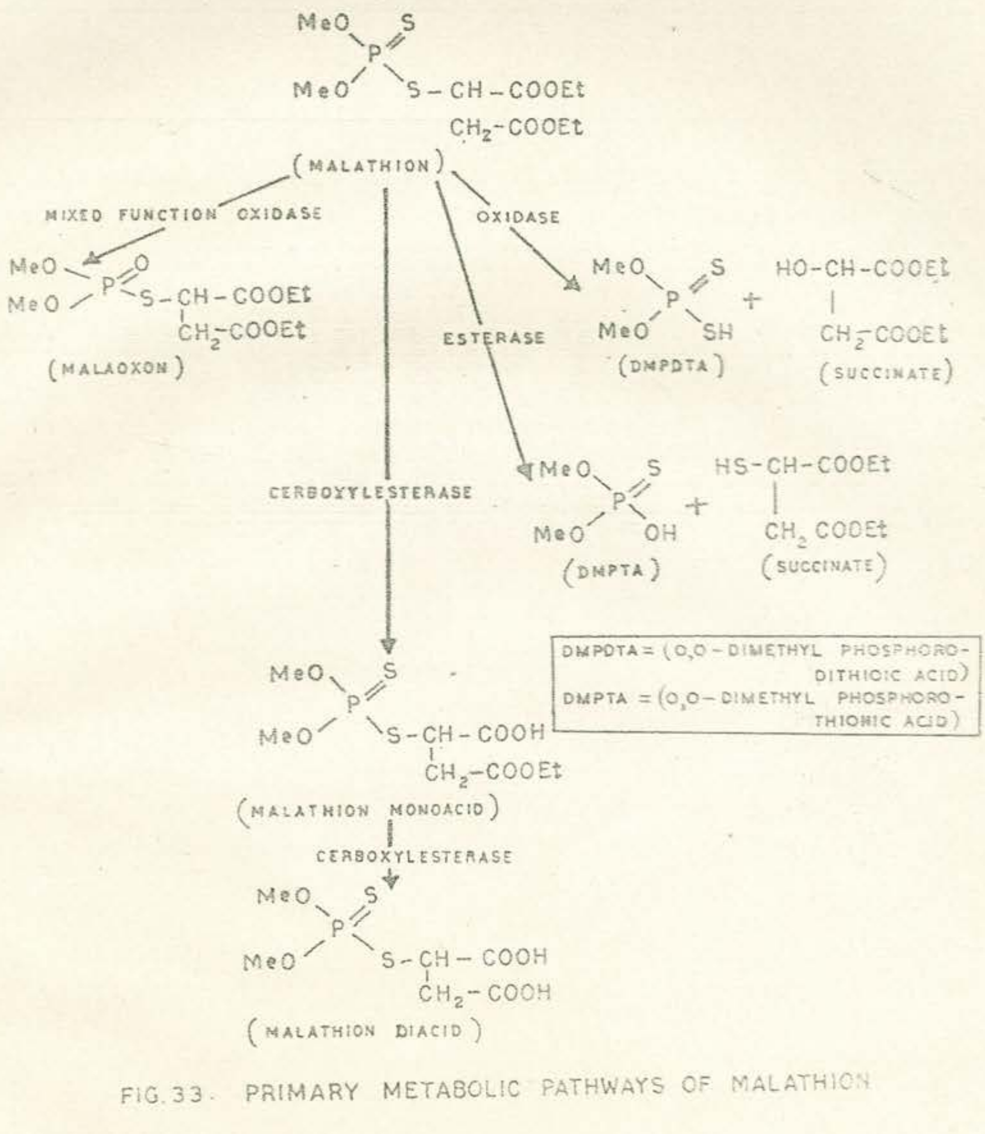


FIG. 33. PRIMARY METABOLIC PATHWAYS OF MALATHION

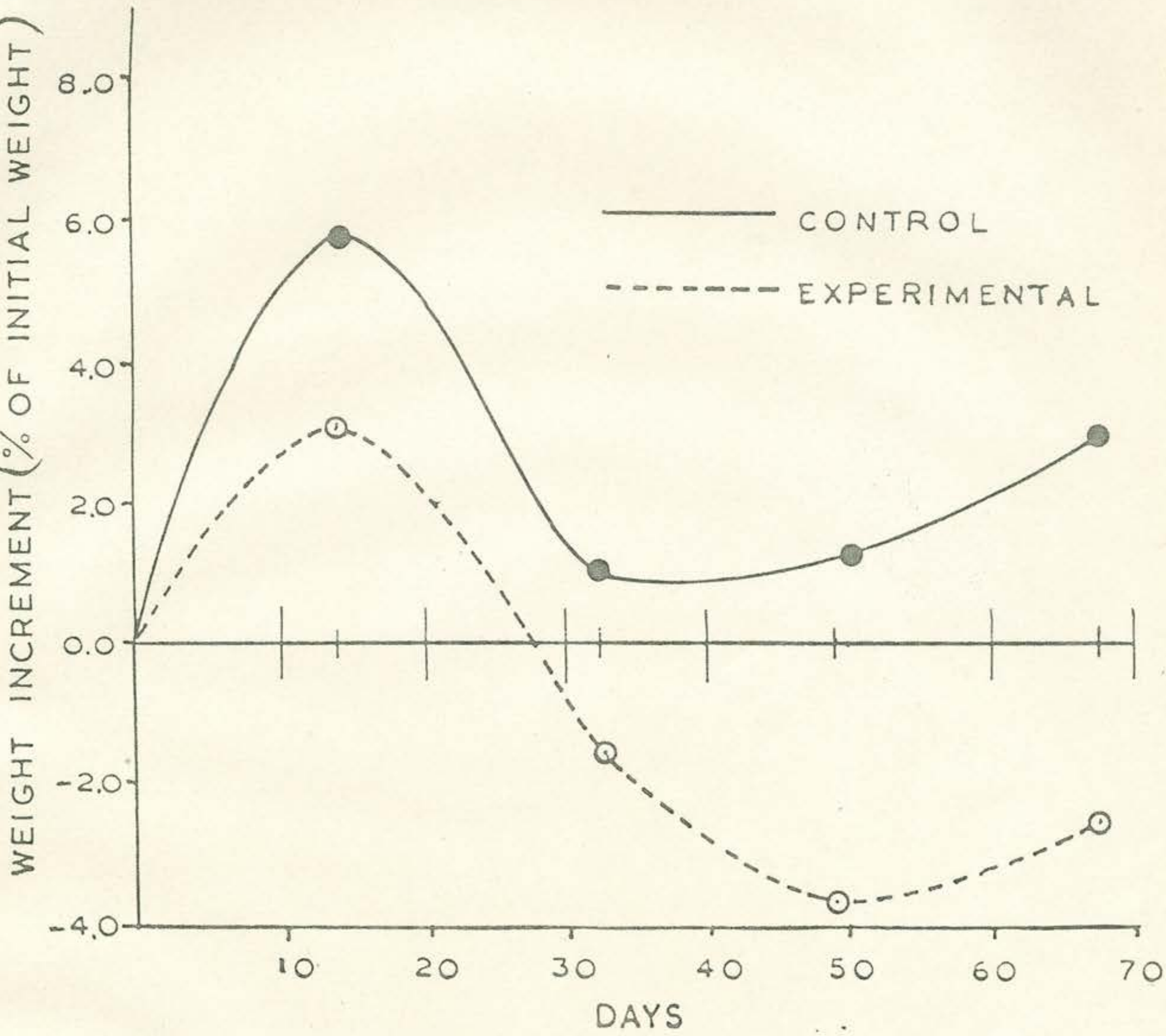


Fig. 34 Effect of 0.5 ppm Carbofuran treatment (experimental) on the growth performance of C.batrachus

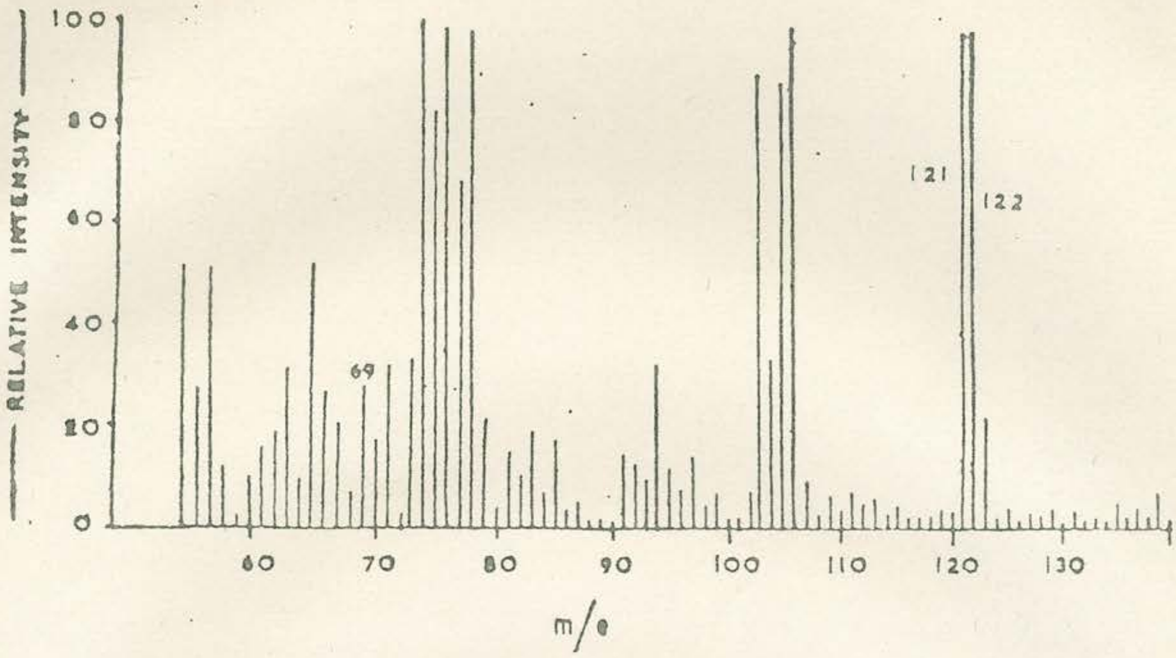


Fig. 35 Mass spectrum of benzamide prepared from liver protein of
C. batrachus

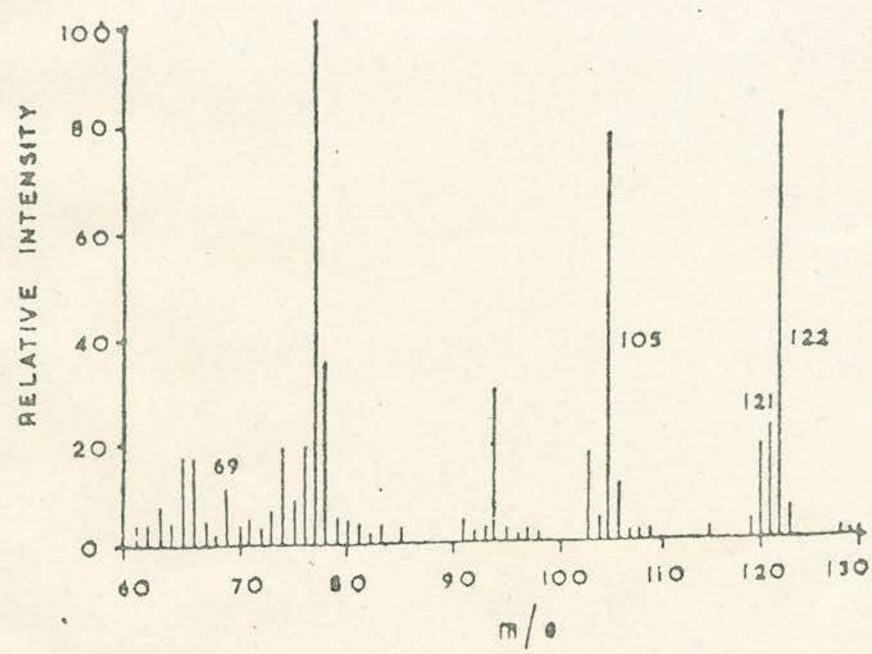


Fig. 36 Mass spectrum of benzamide prepared from liver protein o
H. fossilis

Plate 1. The progressive fish farmer's farm, Bangalore

Plate 2. Seining for air breathing fishes

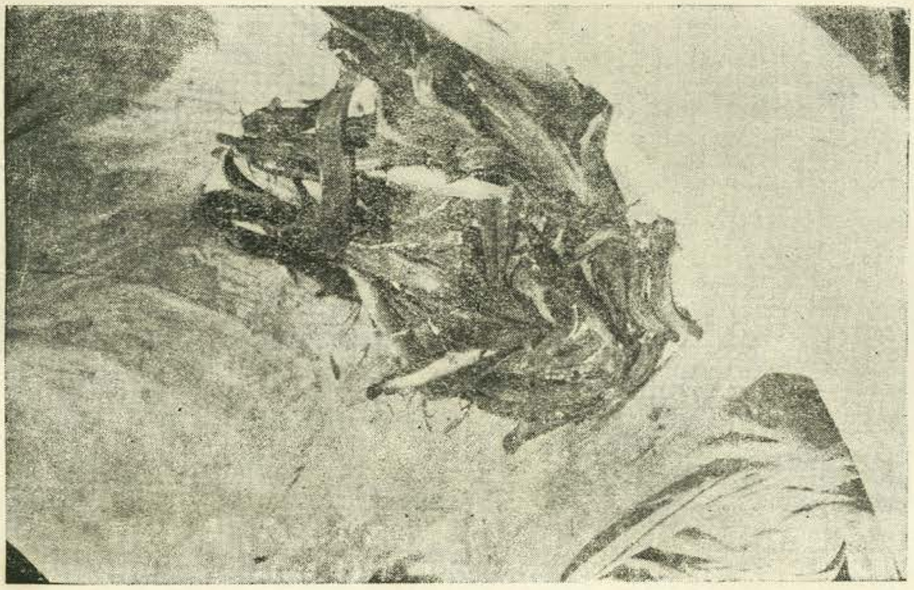


Plate 3. A haul of air breathing fishes

Plate 4. Collection of marginal plankton in a derelict tank

Plate 5. Collection of plankton from the tank bottom, using a Kemmerer sampler

Plate 6. Collection of bottom soil samples for macrofauna, using Ekman dredge

Plate 7. Sieving bottom soil samples for benthic macrofauna

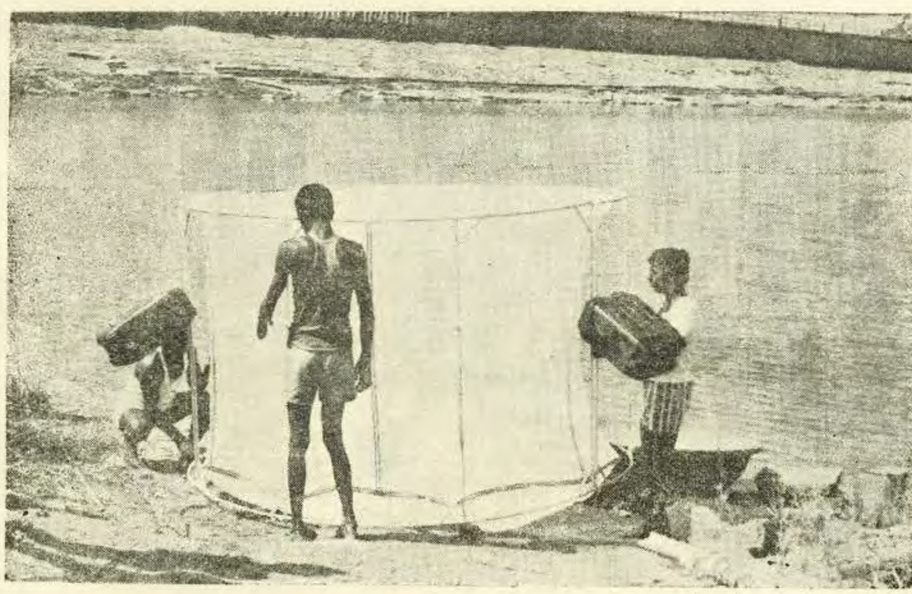


Plate 8. A circular net cage being made ready for installation

Plate 9. Circular cage being lifted for sampling of the murrel stock

Plate 10. The stock of the circular cage being examined

Plate 11. The stock of cage being sampled

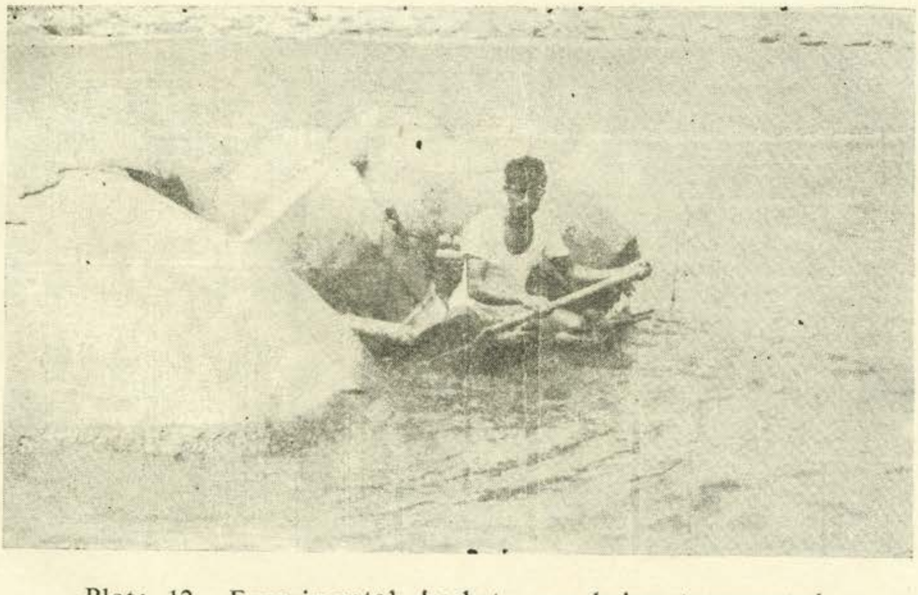


Plate 12. Experimental basket cage being transported

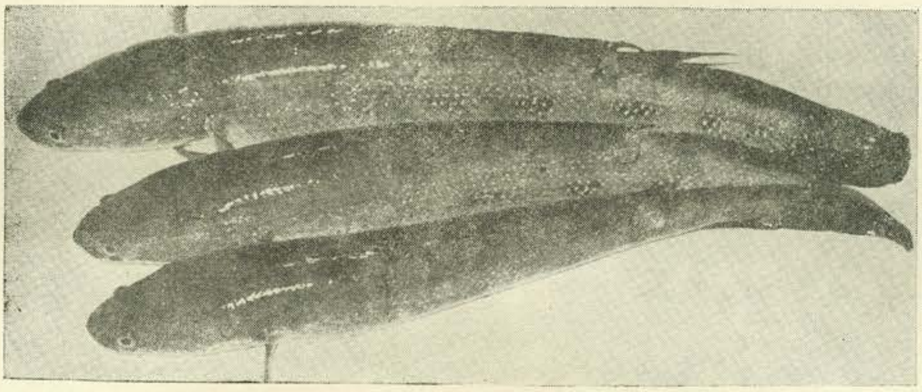


Plate 13. Tagged murrel *Channa marulius* recovered after 13 months (size : 454 to 504 mm)

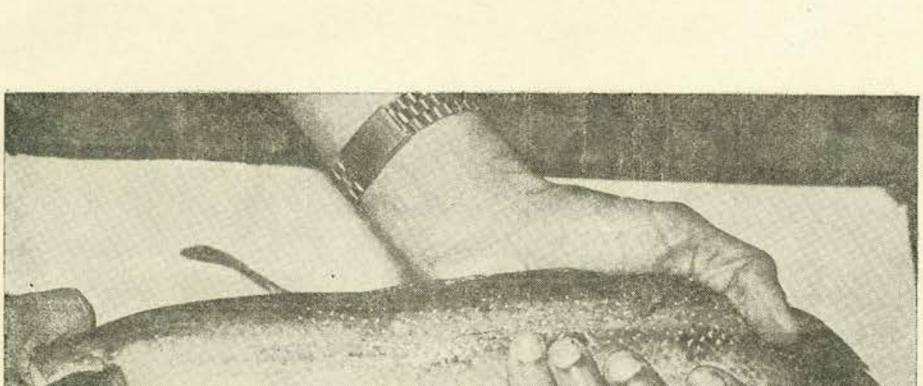


Plate 14. Recovered tagged *Channa marulius* - closer view

Plate 15. Female *Channa marulius* being injected with pituitary hormones for breeding