143

BEHAVIOURAL BIOLOGY OF THE FISH *BARBUS PUTITORA* (MAHSEER)

by

FAZLI SUBHAN

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CONTENTS

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ABSTRACT

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The present investigations were aimed initially at the primary productivity of the Ramli stream used for supplying running water to experimental ponds employed to study the breeding biology and behaviour of the fish Barbus putitora (Mahseer). These investigations are important as Mahseer is economically important fish but very difficult to breed. It is of utmost importance to know a-biotic and biotic factors operating and controlling a particular fauna.

Present investigations show that a temperature of 13°-36°C and dissolved oxygen (2.7 - 7.9 ppl) are important controlling factors in the breeding of this fish. Besides, planktonic fauna predated upon by the fish has been described, such as Cyclops magnus, Disptomus sp., Moina brachitata, Chydorus ovalis. Other a-biotic factors like pH and phosphate contents are described for reference.

Feeding behaviour is dependent on the selective responses of the fish towards the effective stimuli. The fish responds to the reportoire of visual stimuli such as size, shape, colour and frequency of movement.

The orientation is influenced by dorsal light reaction and is operated by tropotaxis, telotaxis and menotaxis. The investigations on fish food show that 35% protein in the diet are best suited for adequate growth and economic breeding of this fish.

Studies on the behavioural energetics show that protean behaviour is used by the fish as a postural device for energy conservation.

Induced spawning was successfully experimented in the fish *B. putitora*.

CHAPTER ONE

INTRODUCTION

Fresh water fishes of Pakistan have a significant economic importance due to their nutritive value especially animal proteins. Taxonomic status of most of the fresh water fishes has been established and catalogued (Ahmed, 1961). Attempts have also been made by the Fisheries Department to update fresh water fisheries management programe for the proliferation, survival, feed, breeding and economic use of some of these fishes. It need be emphasized here that for successful breeding and propagation of fishes, controlled mechanism involved are to be related to the ecological complexes in which these fishes thrive. Carpenter (1928), Needham and Lloyd (1930), Wards and Whipple (1956), Marcuzzi, Giorgio and Lorezoni (1971) worked on life of inland water including Phytoplanktons and Zooplanktons. Studies have also been made by Chapman (1931), Reid (1961), Hutchinson (19[illegible]7). Mortimer (1971) and Shapiro (1958-1970), investigated the chemical exchange between sediments water. In this regard little work has been done in Pakistan (Baqai and Zubairi, 1974; Azra and Iqbal, 1975). Another important factor operating on the fish biology is fish feed and food preference and the fish growth in relation to feed and ecological factors such as dissolved oxygen, temperature, phosphates, nitrates and chlorides.

No work has been done in eco-behaviour of fishes in Pakistan. Among the workers outside the country Baerands et al (1950, 1955) have done research on the ethology and behaviour of Lebistes reticulatus. Similarly, Baggerman et al. (1956) has made studies on Chlidonias. Clark et al. (1954) and Morris (1954) have made extensive studies on reproductive behaviour of three-spined Stickleback, Xiphophonis fishes and river bull head fishes respectively. Among the most recent work, Moody (1975) has experimented on the perceptional capabilities of Barbus. Helgolander (1975) have described the migratory patterns in fishes. Barlow et al. (1975) has given a comparitive account of the feeding behaviour, spacing and aggresive behaviour patterns in colour morphs of the Midis cichlid. Little work is reported on the food habits and feed of carps (Menon, 1955; Hussain, 1955; Vas, 1957; Alikunhi, 1958; Arshad, 1965; Desai, 1968; Ahmad, 1969; Sukmaran, 1969; Hephar, 1969; Szunmiec, 1969; Khandker, 1970; Javed, 1970; and Chinkichis et al., 1976).

Protean displays as a form of allaesthetic behaviour was first described by Chance and Rusell (1959) and confirmed by Driver and Humpries (1970) who also suggested that such behaviour is based on irregularity principle. Account of zig-zagging displays of prey animals, single erratic response during escape behaviour, aggression and courtship have been discussed by several workers (Armstrong, 1949, 1954; Baerends, 1950; Beukema, 1968; Bullock, 1958; Hinde, 1954; Iqbal, 1972; Raport, 1962; Simmon, 1955; Spooner, 1931; Tinbergen, 1951, 1962, 1967; Welty, 1934). No theoretical or experimental evidence is available on the occurance of protean behaviour in other aspects of behaviour patterns. Present work draws attention to the experimental evidence of energy conservation through protean displays.

Spawning and its effects have been described by Aronson (1944) in case of Tilapia microcephala. Parental care has been reported by Iersel (1953) in case of three spined stickle back. Indepth investigations to breed the carps artificially are also scanty. The only meaningful reports are experimental breeding are by Hussain (1965), Wledek (1968), Choudhuri (1968, 1969), Jafri (1973, 1977), Doha and Dewan (1967) and Qazi (1965).

The present investigation were aimed at describing environmental factors such as dissolved oxygen, organic phosphates, pH and temperature, which play an important role in controlling survival, growth and successful breeding of the fish Barbus putitora (Mahseer). The investigation also describe food formulation, food preference, feeding behaviour and protean behaviour of the fish. Lastly investigations briefly describe experimentation with induced breeding of the fish Barbus putitora.

CHAPTER TWO

MATERIALS AND METHODS

PRIMARY PRODUCTIVITY OF THE STREAM AND EXPERIMENTAL PONDS

Water samples were collected from two stations selected at the stream and were then compared with samples collected from the experimental ponds, supplied with stream water through ½" and 2" diameter pipes. Day and night samples were taken from the ponds. Samples were collected simultaneously upstream, downstream and from the ponds. Ponds were of two different dimensions 45' x 25' and 6' high, 35' x 15' and 5' high, water could either flow independently of each pond or could be run from pond 1 to pond 2.

Oxygen analysis was done by Wrinkler's method. Estimation of inorganic phosphates was done by Fiske & Subbarow's method. Analysis was done over a period of six months. Approximate variables of dissolved oxygen and temperature were also monitered using four aquariums 5' x 3' and 4' high placed alongside the ponds and by supplying oxygen with air pump. Controlled temperature water was supplied through a water bath connected to aquarium with nylon tubing (Fig. 1).

Fig. 1

T.C.W.B.	=	Temperature Control Water Bath
A.P.	=	Air Pump
G.W.W.P.	=	Glass Wire Water Pipe
A.R.	=	Air Releaser
3W.V.	=	3 Way Valve
S.	=	Stream
A.	=	Aquarium
W.R.	=	Water Releaser
T.	=	Table
O.D.V.	=	Oil Dust Filter

Fishes were collected from Hassan Abdal Fish Farm, Barakoh stream, Chattar Bagh and outlet stream of Rawal Dam. Fishes were brought in fish containers.

LENGTH: Fishes were measured from tip of the shout to the tip of the gill and from tip of the gill to the tip of the tail fin and then from the tip of the tail fin to the tail fin end.

WEIGHT: A container was half filled with water and weighed as (a), then the fish was put into it and again weighed as (b). The actual weight (w), was worked out as b - a = w.

Each fish was tagged before release and bi-monthly length-weight measurements were taken to observe growth-food relationship. Similarly, bi-monthly increase in weight was noted for each fish. The fish food was prepared as given in Table 1.

Plankton fauna on which the fish were observed to predate was noted and identified.

Observations on Protean behaviour were made at the inlet stream of Rawal Dam. Observation on the maturity of male and female fish were made by (a) squeezing out spermatoza and ova from the fish, (b) by disecting the fish and then scanning the testis and ovary under a binocular microscope. Induced spawning was affected by injecting pituitary Hormones in the male and female fish as given below.

The pituitary glands of the several fishes were taken out by disecting the fishes. It was then homoganized and centrifuged and the extract was placed in small test tubes in deep freeze at -10°C.

The fishes of known weight and length were given injections of pituitary to affect spawning behaviour in August. Experiments on induced breeding were carried out in the aquariuns.

Table 1

Formulation of feed containing different levels of protein

Ingradients	0% protein	25% protein	30% protein	35 % protein
Casein	0.00 gms	25.00gms	30.00gms	35.00 gms
Starch	20.00 "	10.00 "	15.00 "	10.00 "
Cellulose	30.00 "	25.00 "	18.00 "	19.00 "
Minerals	4.00 "	2.00 "	2.00 "	2.00 "
Vitamins	2.00 "	4.00 "	4.00 "	4.00 "
Oil	24.00 "	19.00 "	16.00 "	15.00 "
Glucose	20.00 "	15.00 "	15.00 "	15.00 "
	100.00 "	100.00 "	100.00 "	100.00 "
	385 calories	371 calories	384 calories	375 calories

CHAPTER THREE

SECTION A

LIMNOLOGICAL STUDIES

pH: Hydrogen ion concentration ranged between 7.2 to 8.6, round theyear, which is slightly alkaline in nature.

PHOSPHATE: Inorganic phosphates were maximum 0.03 to 0.04 mg/ml in June-July, while in winter, the concentration was low being 0.003 - 0.001 mg/ml.

OXYGEN: Dissolved oxygen was minimum in June, ranging between 4.5 - 4.7/ppl and was maximum in January ranging between 6.8 - 7.9/ppl. When water flow into the ponds was controlled and brought to a minimum, the dissolved oxygen content went down to a minimum and toxicity caused 100% mortality to the fish.

Experimental observations on isolated oxygen contents were made, using a¢quaria placed alongside the ponds (Fig. 1). Results indicated that a low concentration of oxygen (2.7/ppl) caused mortality to fish.

TEMPERATURE: Minimum temperature ranged between 13°-15°C in January and maximum ranged between 20°-36°C in June and July. Experiments on temperature effects were conducted in the aquaria (Fig. 1). The results show that temperature is also an important factor in the breeding and survival of the fish and that temperature ranging between 16°-34°C is favourable for the fish.

PLANKTON FAUNA: Zooplanktons such as Cyclops magnus, Diaptous sp., Moina brachitata, Chydorus ovalis were usually predated upon by the fish Barbus putitora.

CONCLUSIONS AND DISCUSSION

Limnological studies indicate that dissolved oxygen is a critical factor in the survival and successful breeding of the fish Barbus putitora (Mahseer) and that the fish may only be breed and propagated in ponds, lakes or streams having a safe range of dissolved oxygen level as indicated in the results. Similarly, temperature seems to be a critical factor for the survival and breeding of this fish.

SECTION B

FOOD RELATIONSHIPS

Four dietary experiments were conducted on the fish, along with a control group. Each group was of four fishes, each fish was measured, weighed, tagged and then released into the experimental aquariums. Results are shown in Tables 2-10. For comparison of weight relationship and length relationship see graphs 1-4. The results indicate that 35% protein in the diet are best suited for adequate growth of the fish.

FEEDING BEHAVIOUR

Stimuli

Four experiments were conducted to study the stimuli-orientation mechanism opperating in the feeding behaviour of the fish B. putitora. The experiments were conducted in four separate aquariums maintained at a temperature of 25°-27°C. A group of ten fishes was tested for responses against stimuli by hanging the objects with strings and then presenting them to the fish from a distance of 5"-6" in water as shown in Tables 11-20.

The results indicate that the fish respond to the effective stimuli and that the responses are based on the selective responses toward the effective stimulus. The results show that to aroused by orientation in the fish, the effective stimulus must be within certain limits of size, i.e. approximately 1" in length or less, should be oblong in shape, must show movement and preferably be bright coloured.

ORIENTATION: The experiments were conducted in 4 aquariums maintained at a temperature of 25°-27°C. One of the experiments was conducted in a dark room and the light was thrown from different sides or angles with pencil table lamp. The effective stimuli were presented to identify different types of taxis-orientation mechanisms.

The presentation of stimuli from different directions and angles indicated that all the fishes responded positively even when stimuli were moved erratically, showing that tropotaxis and telotaxis mechanisms are opperating and that on the perception of a weak erratic stimulus, posterior omatidia were responding. In the second experiment conducted in the dark room, the effective stimulus of an object was presented in $\mp$ $\mp$ $\mp$ affector manner and light was thrown from different directions or angles as shown in Fig. 2. The results show that the fish orient under the influence of dorsal light reaction towards the stimulus and are operated by menotaxis.

CONCLUSIONS AND DISCUSSION

Present investigations show that the feeding behaviour of the fish B. putitora (Mahseer) is operated by selective responses towards the effective stimuli. Such behaviour of three spined stickle back by Tin Burgen (1961) and referred as sign stimuli by Russell (1943). This behaviour is contrary to the gestalt psychology and depends on hetrogenous summation followed by reinforcement mechanism. Present investigations also show that the orientation of B. putitora operates under the configration of tropotaxis, telotaxis which has not been investigated in the fishes. But dorsal light reaction has been reported in case of fish Crenilabrus sp. (Van Holst, 1953).

Four dietary experiment were conducted on the fish along with a control group. Dietary feed contained 0%, 25%, 30%, 35% protein. Results are shown in Tables 2-10.

For comparison see graphs 1-4 showing weight-length relationship. These results indicate that 35% protein are most adequate for economic breeding and propogation of the fish B. putitors (Mahseer).

Fig. 2

Dorsal light reaction of the fish *B. putitora* towards light stimulus.

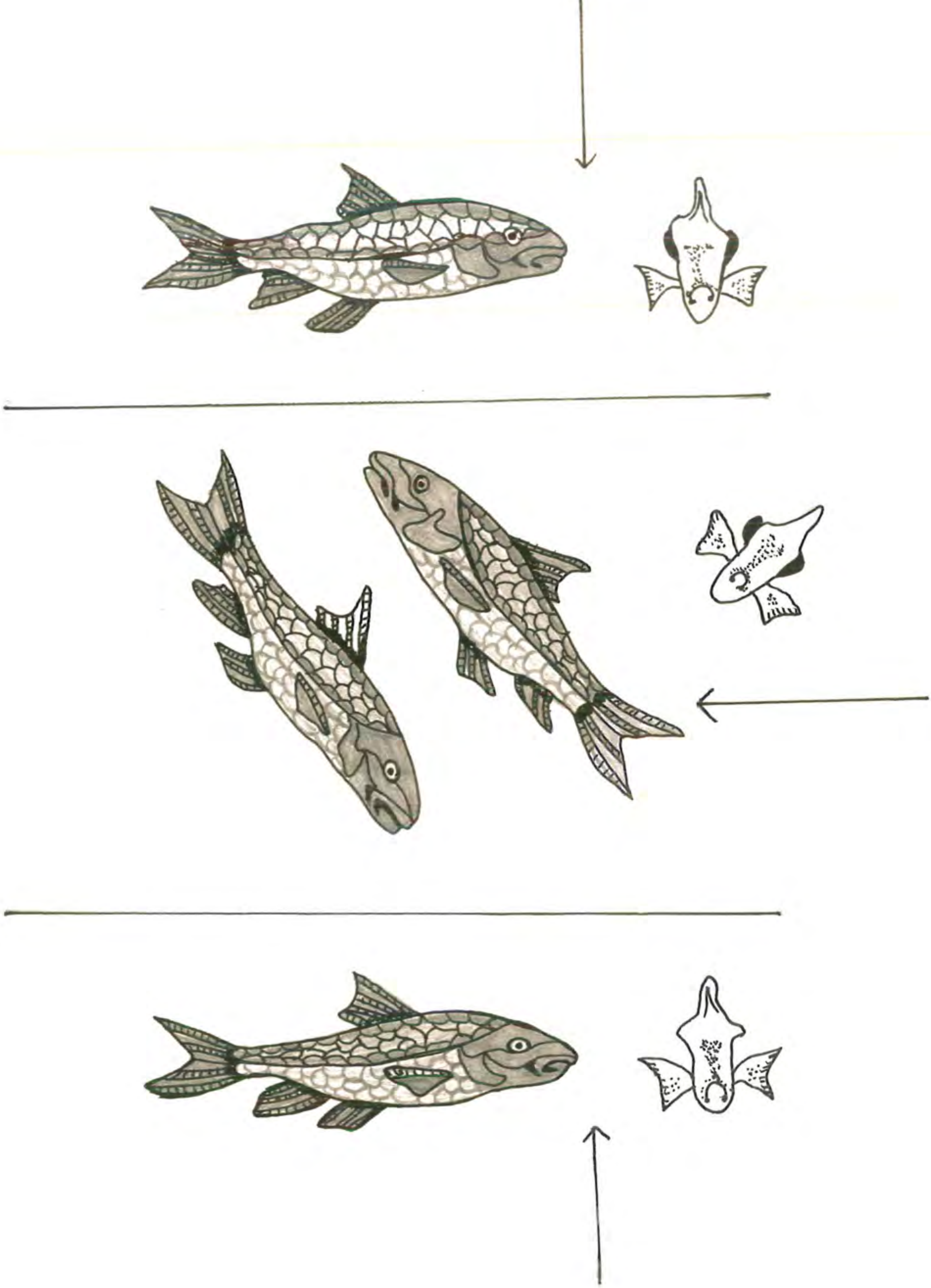


Table 2

Initial weight and length of *Barbus putitora* (Mehseer) before treating with any specific diet

Number of fishes *B. putitora*	Total weight of the fishes *B. putitora* (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fishes (mm)	Total increase in weight of the fishes (gms) W
1	4.00	10	50	15	75	x	x
2	4.00	10	50	15	75	x	x
3	4.00	10	50	15	75	x	x
4	4.00	10	50	15	75	x	x

Table 3 (Group A)

Total weight-length increase of fish *Barbus putitora* (Mehseer) after feeding for 15 days on 0% protein diet at 25°-27°C of water temperature.

Number of fishes *B. putitora*	Total weight of the fishes *B. putitora* (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fishes (mm)	Total increase in weight of the fishes (gms) W
1	4.8	10	54	15	79	4	0.8
2	4.8	10	54	15	79	4	0.8
3	4.8	10	54	15	79	4	0.8
4	4.8	10	54	15	79	4	0.8

Table 4 (Group A)

Total weight-length increase of fish *Barbus putitora* after feeding for thirty days on 0% protein diet at 25°-27°C of water temperature

Number of fishes *B. putitora*	Total weight of the fish *B. putitora* (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fish (mm)	Total increase in weight of the fish (gms) W
1	5.7	16	58	20	94	19	1.7
2	5.7	16	58	20	94	19	1.7
3	5.7	16	58	20	94	19	1.7
4	5.7	16	58	20	94	19	1.7

Table 5 (Group B)

Total weight-length increase of fish Barbus putitora after feeding for fifteen days on 25% protein at 25°-27°C of wather temperature.

Number of fishes B. putitora	Total weight of the fish B. putitora (gms)W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fish (mm)	Total increase in weight of the fish (gms)W
1	6.00	16	58	20	94	19	2.00
2	6.00	16	58	20	94	19	2.00
3	6.00	16	58	20	94	19	2.00
4	6.00	16	58	20	94	19	2.00

Table 6 (Group B)

Total weight-length increase of fish *Barbus putitora* after feeding for thirty days on 25% protein at 25°-27°C of water temperature

Number of fish's *B. putitora*	Total weight of the fish *B. putitora* (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fish (mm)	Total increase in weight of the fish (gms) W
1	8.4	18	60	21	99	24	4.4
2	8.4	18	60	21	99	24	4.4
3	8.4	18	60	21	99	24	4.4
4	8.4	18	60	21	99	24	4.4

Table 7 (Group C)

Total weight-length increase of fish *Barbus putitora* after feeding for fifteen days on 30% protein at 25°-27°C of water temperature

Number of fishes *B. putitora*	Total weight of the fishes *B. putitora* (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fishes (mm)	Total increase in weight of the fishes (gms) W
1	7.1	18	60	21	99	24	3.1
2	7.1	18	60	21	99	24	3.1
3	7.1	18	60	21	99	24	3.1
4	7.1	18	60	21	99	24	3.1

Table 8 (Group C)

Total weight-length increase of fish *Barbus putitora* after feeding for thirty days on 30% protein at 25°-27°C of water temperature

Number of fishes *B. putitora*	Total weight of the fishes *B. putitora* (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fishes (mm)	Total increase in weight of the fishes (gms) W
1	10.5	20	71	22	113	38	6.5
2	10.5	20	71	22	113	38	6.5
3	10.5	20	71	22	113	38	6.5
4	10.5	20	71	22	113	38	6.5

Table 9 (Group D)

Total weight-length increase of fish Barbus putitora after feeding fifteen days on 35% protein at 25°-27°C of water temperature

Number of fishes B. putitora	Total weight of the fish B. putitora (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fishes (mm)	Total increase in weight of the fishes (gms) W
1	12.2	21	73	22	116	41	8.2
2	12.2	21	73	22	116	41	8.2
3	12.2	21	73	22	116	41	8.2
4	12.2	21	73	22	116	41	8.2

Table 10 (Group D)

Total weight-length increase of fish Barbus putitora after feeding for thirty days on 35% protein at 25°-27°C of water temperature.

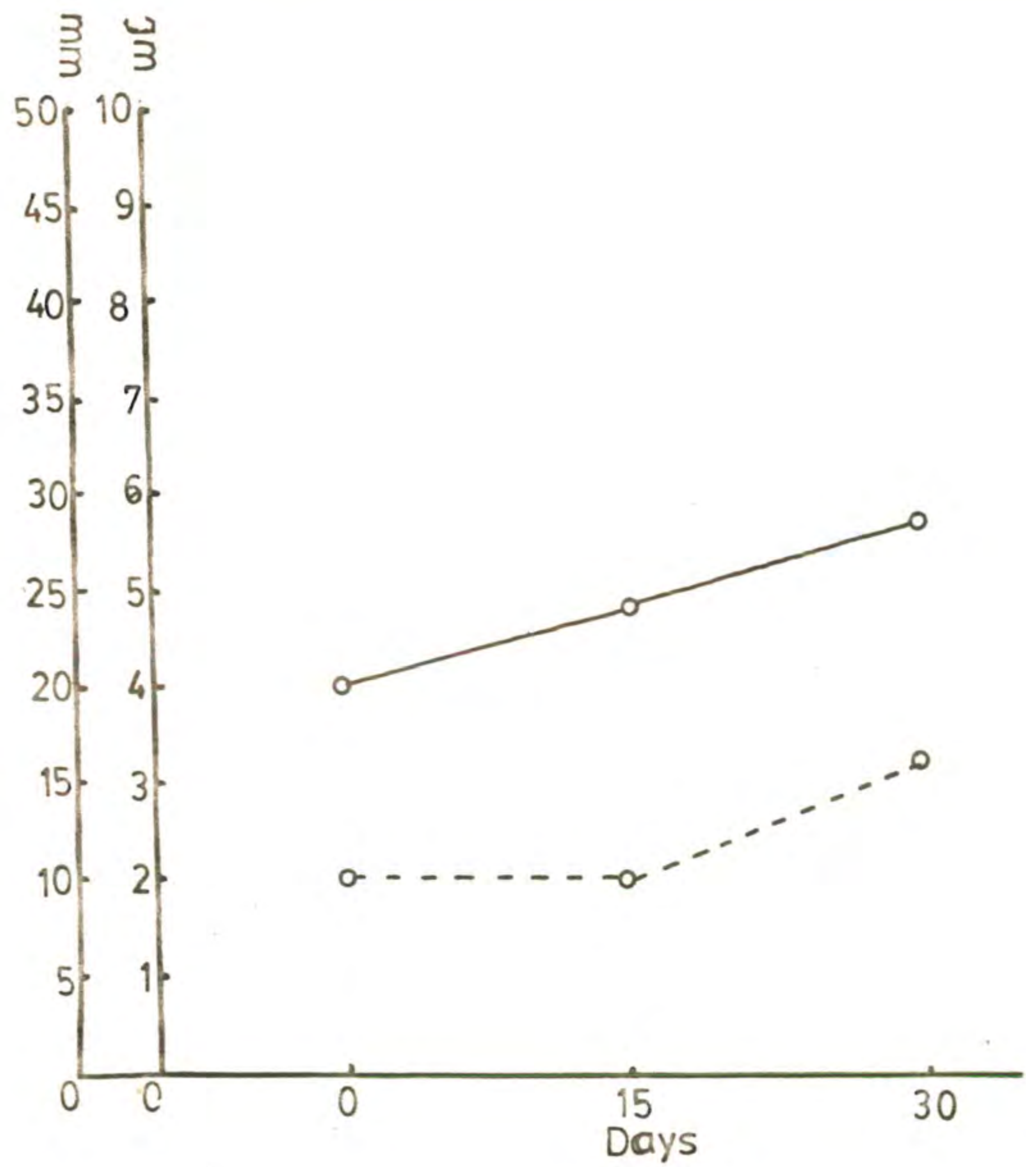
Number of fishes B. putitora	Total weight of the fishes B. putitora (gms) W	Length from mouth to the end of gill cover (mm)	Length from end of gill cover upto end of body (mm)	Length of tail fin (mm)	Total length from mouth upto tail end (mm)	Total increase in length of the fishes (mm)	Total increase in weight of the fishes (gms) W
1	25.2	28	90	29	147	72	21.2
2	25.2	28	90	29	147	72	21.2
3	25.2	28	90	29	147	72	21.2
4	25.2	28	90	29	147	72	21.2

Graph No. 1.

Weight-length relationship of the fish (Barbus putitora) Feed on 0% protein

Wt ————————

Length.---------



mm
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5
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10
9
8
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6
5
4
3
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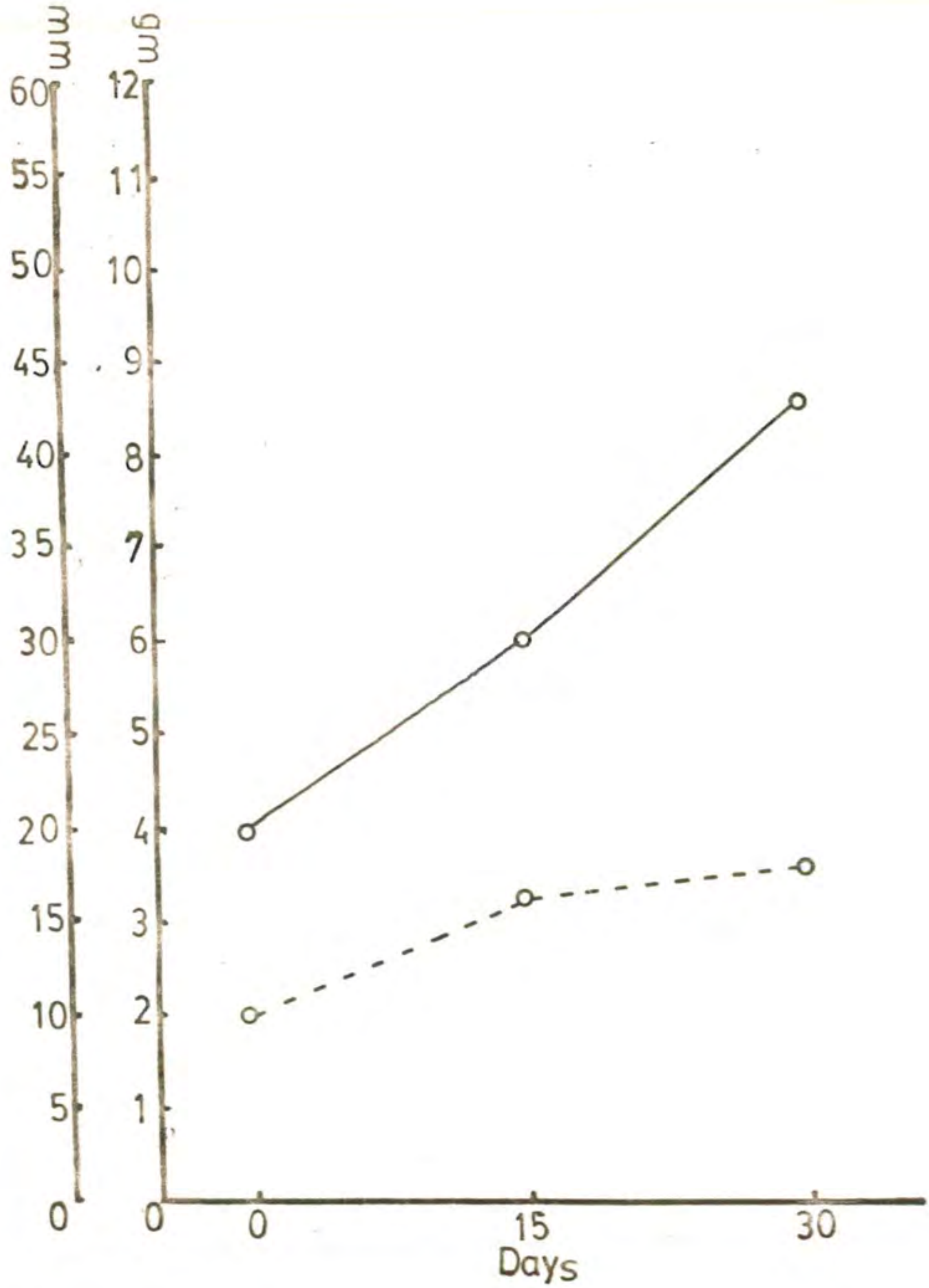
0
15
30
Days

Graph No. 2.

Weight-length relationship of the fish *Barbus putitora* (Mahseer) fed on 25% protein.

Wt. ————————

Length.-----------


mm
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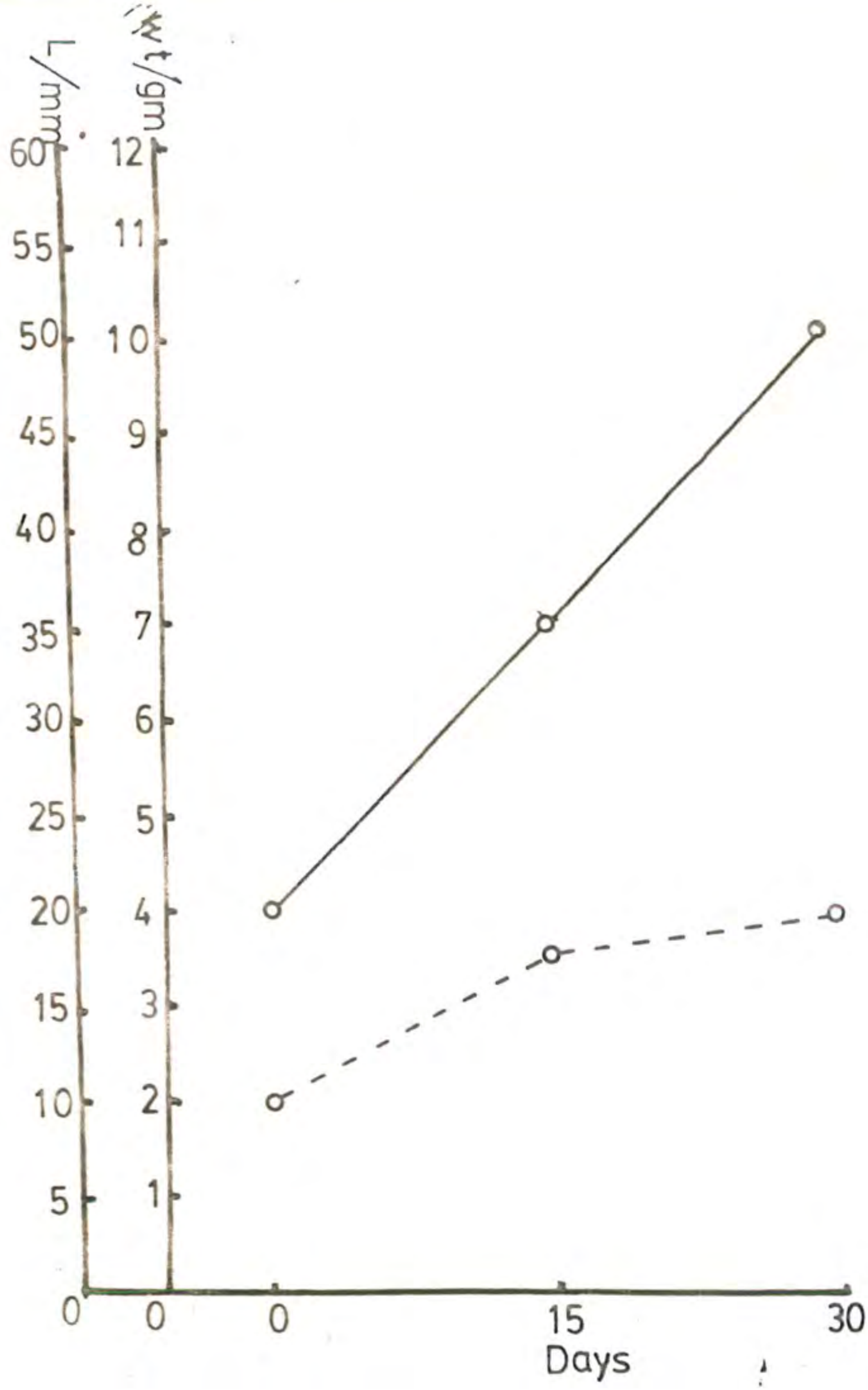
5
4
3
2
1
0
0
15
30
Days

Graph No. 3.

Weight-length relationship of the fish *Barbus putitora* (Mahseer) fed on 30% protein.

Wt. ——————

Length -----------



L/mm
Wt/gm
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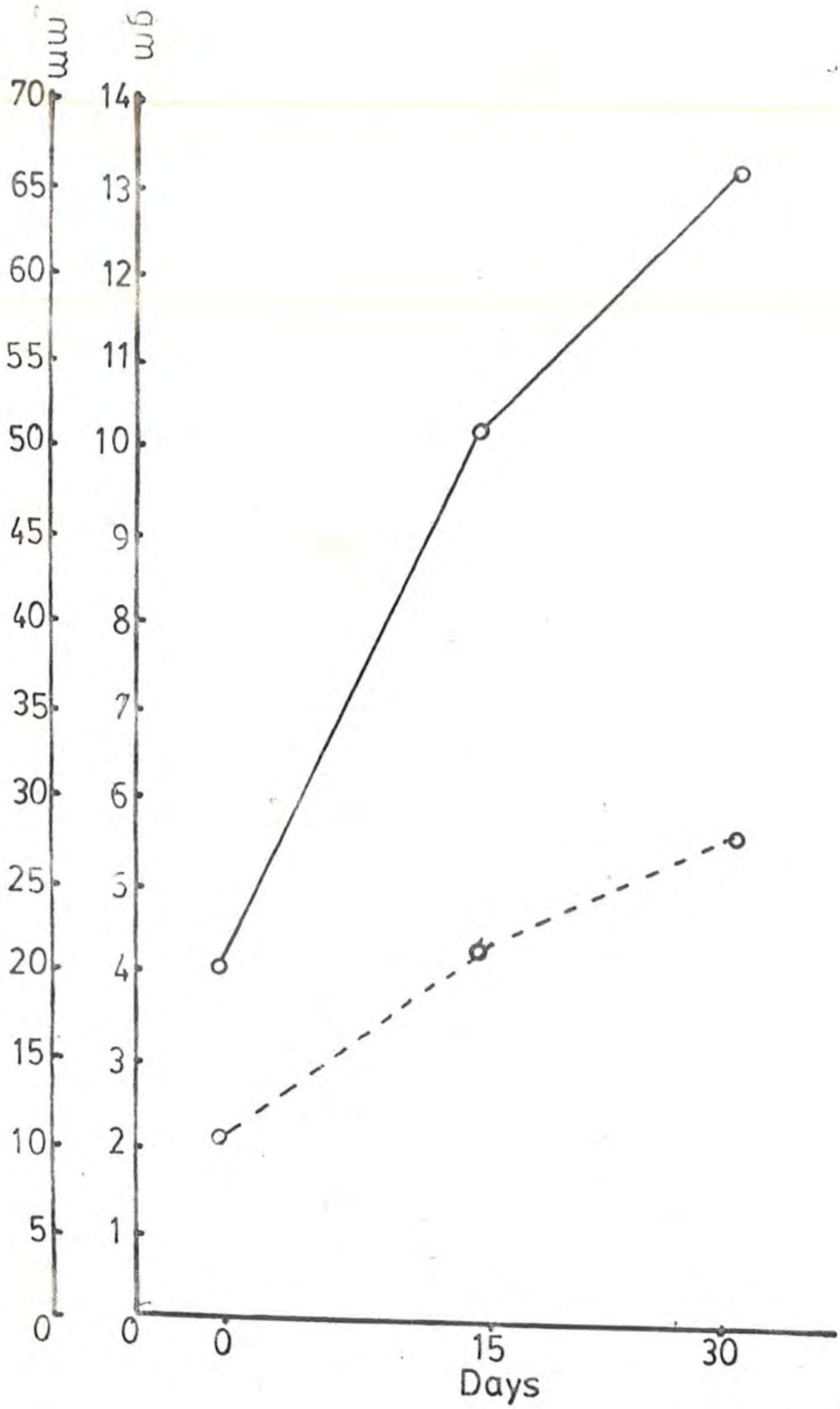
55
50
45
40
35
30
25
20
15
10
5
0
12
11
10
9
8
7
6
5
4
3
2
1
0
0
15
30
Days

Graph No. 4.

Weight-length relationship of the fish *Barbus putitora* (Mahseer) fed on 35% protein

Wt. ————————

Length -----------



mm
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10
9
8
7
6
5
4
3
2
1
0
0
15
30
Days

Table 11

Selective response of fish B. putitora (sample i) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 12

Selective response of fish B. *putitora* (sample ii) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

\- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 13

Selective response of fish B. *putitora* (sample iii towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 14

Selective response of fish B. *putitora* (sample iv) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 15

Selective response of fish B. *putitora* (sample v) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 16

Selective response of fish B. putitora (sample vi) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 17

Selective response of fish B. *putitora* (sample vii) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 18

Selective response of fish B. putitora (sample viii) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 19

Selective response of fish B. *putitora* (sample ix) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

\- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

Table 20

Selective response of fish B. *putitora* (sample x) towards effective stimuli

Stimulus	Size	Shape	Colour	Mobile	Stationary	Response of fish
1.	3"	Rectangular	L.Brown	No	Yes	-
	3"	Rectangular	D.Brown	No	Yes	-
	3"	Rectangular	L.Brown	Yes	No	Avoidance
	3"	Rectangular	D.Brown	Yes	No	"
2.	2"	Rectangular	L.Brown	No	Yes	-
	2"	Rectangular	D.Brown	No	Yes	-
	2"	Rectangular	L.Brown	Yes	No	-
	2"	Rectangular	D.Brown	Yes	No	-
3.	1"	Oblong	L.Brown	No	Yes	-
	1"	Oblong	D.Brown	No	Yes	-
	1"	Oblong	L.Brown	Yes	No	++
	1"	Oblong	D.Brown	Yes	No	+++

\- Negative response

++ Approach and pecking at the food model (stimulus)

+++ Increase in frequency of approach and pecking response.

CHAPTER FOUR

PROTEAN BEHAVIOUR

The fish B. putitora shows two types of diurinal movements 1. Short-length movements in water. These do not exceed more than 60 yards upstream and down-stream lures. 2. Long-length movements during which the fish and their school travel upstream in the morning (6.00 - 6.30 a.m.) travelling several hundred yards and then travel back to the lake at approximately 11.30 a.m. to 12.00 noon.

PROTEAN MOVEMENTS

The fish B. putitora shows single erratic movements by zig-zagging or leeping in the stream. This protean behaviour is shown during down stream and up stream journey, fish do not travel parallel to water flow out show protean behaviour by zig-zagging so that when they travel down stream, the water flow is at 120° to the right or left of the front region of the fish. Similarly, while travelling up stream, the water flow hits the tail at 60°. This zig-zagging protean behaviour is used as a postural device by the fish to offer least resistance in water and at the same time, movements at angle to water flow facilitate swift journey using least possible energy. Whereas, when showing movement-pause the fish always orientate parallel to water flow

CONCLUSIONS AND DISCUSSION

The fish Barbus putitora uses protean behaviour as a means of energy conservation during up-stream and down-stream for energy.

Occurance of protean behaviour in prey organisms has been reviewed and discussed by Humphries and Driver (1967) and Humphries and Driver (1970). No evidence is available on the eco-behavioural aspects of protean displays involved in other behavioural pattern except courtship display, Iqbal, personal observation).

Present studies indicate that protean displays are used as postural device for energy conservation. Such postural erratic devices are comparable to sudden jet blasts employed for propulsion.

CHAPTER FIVE

INDUCED BREEDING

Five males weighing 1½ kg and 5 females weighing 1½ kg were used in the induced spawning experiment. The preserved pituitary (male and female) of the fishes was homogenized and diluted with a drop of water and centrifuged. Intermuscular injection of the female pituitary was then given to the female fish at a rate of 3 mg/kg of the body weight. After four hours an other injection was given at a ratio of 5 mg/kg. The female was then freed into the hapa net. The net was spread in the middle of aquarium water, so that it did not touch the bottom.

Same process of injectioning male pituitary was simultaneously given to the two males, which were also released into the same net. After some time the female showed splashing movements in water. After seven and half hours the female secreted the spawn and the male discharged milt over the eggs.

Hatching of the eggs occurred after fourteen hours of fertilization. Two nets were used during hatching one was large and the other one small. The larger hapa contained the smaller one inside it. When the eggs hatched the larvae came out of the meshes of smaller one and went to the larger net, through which the fingerlings could not pass down.

After the completion of this procedure, all the fingerilings were transferred to the pond. The cage was not poured at once in the pond because the abrupt change of temperature may effect fingerlings. The cage was gradually poured so that fingerlings could aclamatize with the temperature.

CHAPTER SIX

GENERAL DISCUSSION

In the last two decades unlimited number of limnological studies have been conducted on the fresh water and marine ecosystem. During recent time, commercial fisheries has become one of the most important fields of economic upsurge. In order to successfully propogate and economically breed the economic fishes, it is necessary to study the a-biotic factors and their influence on fish survival, breeding the population dynamics. Such studies are few in number (Frey, 1949; Bayless, 1963; Davis et al., 1969; Davis and Darrell, 1971). Since Mann (1969) emphasized the need for studies on dynamics of aquatic eco-system, a number of studies of variety of fresh water eco-system have been undertaken in different parts of the world. Projects such as those on Vorderer Finstertaler Sec in Austria (Pechlaner et al., 1973), Lake Marion (Efford, 1969, 1972) and Charhake (Rigler, 1972; Schindler et al., 1972) in Netherlands, Lake Gcorge (Greenwood and Lund, 1973) in Uganda, Loach hauen (Morgan and Mchusky, 1974) and the river Thames (Mann et al., 1972; Berrie, 1972a) in Great Britain and many projects in the USSR (see Winberg, 1972a) trophic levels and their results enable us to begin a "whole ecosystem" approach to the understanding of the dynamics of a production which man may harvest. In this chapter we shall discuss three examples of this approach. In Pakistan such studies have never been under taken nor does any body understand limno-eco-behavioural dynamics for propogation of commercial fisheries. Present studies were an effort to explain the reportoire of these fundamentals to propogate the fish Mahseer, B. putitora, for commercial fisheries. Present studies indicate that among the a-biotic factors of an oxygen level of 4.5 - 4.7/ppl, temperature ranging from 13°-36°C and pH of 7.2 - 8.6 are adequate for survival, successful propogation and economic breeding of these fishes. Besides, these studies also indicate the level of phosphates present in water and identify the planktonic fauna predated upon by the fish. The importance of oxygen level and particular temperature have been emphasized for respiration and blooms of planktonic fauna, survival of vertebrate life, and for allochthonous energy input (Bindless, 1974; Ganf, 1974; Gwahaba, 1975; Brett and Higgs, 1970).

The significance of gregarious feeding behaviour has been postulated by Brown and Orians (1970), Cody

(1971), Pianka (1974) and Thompson et al., (1974). But direct evidence on feeding behaviour of fishes in relation to stimuli-orientation is not available. Beri, et al., (1974) reported the role of visual stimuli in the feeding behaviour of stripped mullet, *Mugil cephalus*. Orientation of the fish *Crenilabrus* towards the visual stimuli under the dorsal light reaction was described by Von Holst (1935). Present studies experimentally isolate different stimuli such as effective stimuli perceptually operated by selective responses of fish through visual stimuli of size, shape, colour and spacio-temporal frequency of movement elicited by the stimulus itself. Similarly, the investigation also describe the orientation-response of the fish being operated under the influence of dorsal light reaction. The orientation itself is operated by a reportoire of tropotaxis, telotaxis and menotaxis. It is suggested that these studies will play an important role in the successful propogation and survival of fishes, when feeding behaviour and food habits of different commercial fishes, their food requirements, feed efficiency and length-weight and food relationship have to be thoroughly worked out. Previous studies on carps have mainly been directed on the utilization of carbohydrates (Pjeyachandran

1976) Chinkichi *et al.*, (1976) have briefly reported utilization of protein by rainbow trout and carp. Present studies report that 35% proteinin the diet of the fish are best suited for propogation and economic feeding of the fish *B. putitora*.

Behavioural energetics as a useful denominator for relating social behaviour to production has been emphasized by Wolf *et al.*, (1972) and Pianka (1974). Intensive laboratory studies have been made on metabolic expenditure, conversion and nutrient re quirements (Beamish and Dickie, 1967; Beamish, 1974; Webb, 1975; Halver, 1976). No data is available on energy conservation mechanism utilized by animals. Protean behaviour as a means of defence mechanism has been reported by several workers (Humphries and Driver, 1967; and, Humphries and Driver, 1970). Present investigations introduce and describe the significance of protean behaviour as postural device for energy conservation in the fish *B. putitora*.

Indo-Pakistan several workers have made studies on the induced spawning of carps (Chaudhari, 1960, 1963, 1969; Qazi, 1965, Doha and Dewan, 1967; Dubey, 1969; Jafri, 1973, 1977). Present studies on the induced spawning indicate that the fish *B. putitora* can be bred experimental

CHAPTER SEVEN

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