Final Report

1.	**Project Title:**	Studies on resource base, ecological diversity and threats to Game Fish Mahsheer in Himalayan-Foothill Rivers
2.	**Project Start Date:**	January 2000
3.	**Project End Date:**	October, 2002
4.	**Report Prepared by:**	Dr. Nasim Akhtar, Chief Scientific Officer/Deputy Director General, Animal Sciences Institute, National Agricultural Research Centre (NARC), Pakistan Agricultural Research Council (PARC), Islamabad

6.	**Project Team:**	
	i. Dr. Nasim Akhtar, Project Director ii. Muhammad Zafar, Research Fellow, M.Sc. University of Arid Agriculture, Rawalpindi (UAAR) iii. Abdul Nazir, Research Fellow, M.Sc. University of Arid Agriculture, Rawalpindi (UAAR) iv. Muhammad Afzal, Senior Scientific Officer (AFP), ASI, NARC v. Abdul Rab, Senior Scientific Officer (AFP), ASI, NARC vi. S.M.H.M Naqvi, Assistant Scientific Officer, (AFP), ASI, NARC vii. Ms. Ruqia Bibi, M.Sc. Student, University of Peshawar, NWFP	
7.	**Reporting Period:**	January, 2000 – October, 2002 (the project life was extended to complete the studies and to meet the desired goal of the project)
8.	**What is the long term goal of the project:**	
	a) Delineation of species of Mahseer fishes (*Tor* spp.), and their taxonomical characterization in Rivers Haro and Soan and allied dams (Rawal Dam and Khanpur Dam) in Himalayan foothill region. b) To study breeding, feeding and other habits of Mahseer under natural conditions and to studies these parameters under controlled as well.	

	c) Pattern of Mahseer population structure, distribution and local adaptations (if any) under different ecological regimes. d) Listing of other cohabiting fish species using same aquatic ecosystem resource competitors. e) Identification of stakeholders for current Mahseer resource exploitation, usages and conservation. f) To provide information on various ecological, hydrological and social changes posing reduction or elimination threats to Mahseer.	
9.	**List of significant changes to objectives during the reporting period:**	Nil
10.	**What have been the important development during the period under review: (Summary)**	
	a) With the help of meristic counts, morphometric measurements and allometric growth ratio, condition factor (k) and other systematic account, the present findings scientifically establishes that all the fishes under study belonging to the group of Mahseer fishes which are inhabiting Soan River (tributaries in Islamabad and Rawalpindi region), Korang River and Haro River systems, belongs to the genus *Tor* and the precise species is *Tor putitora* and not *Tor tor* as erroneously reported by some authors. The sexual dimorphism, however, exists in depth of body of male and female gender which probably provided a basis to label some male specimens of *Tor putitora* as *Tor tor*.	

b) *T. putitora* can survive at ambient atmospheric temperature in Rawalpindi/Islamabad region (and up to well below 16^{o}C water temperature) under captive condition (both concrete flow-throu race-ways as well as earthen ponds) which shows that mahseer can be reared in fish farms. However, careful experimentation is needed to determine the requirements of the fish for domestication.

c) The known feed ingredients as used in countries like Nepal for preparing artificial feed for other Mahseer are found to be readily available in the local markets. This feed when tried on golden mahseer (*Tor Putitora*) in the form of pelleted feed showed encouraging results insofar as palatability and acceptance is concerned. These results leads to the way for further exploration into suitable diet developments on economic basis.

d) It is concluded that *T. putitora* does not feed at low temperature (below 16^{o}C).

e) The fish is sensitive to transportation possibly due to low thresh-hold levels for stress. Proper handling, more oxygenation and in specialized polythene bags with shorter hauling distances, however, reduces the vulnerability of the fish during transportation.

f) The fish was found suitable for tagging (floy-anchor fin-tagging) which paves way for *in situ* studies of the fish for conversation.

g) Because Mahseer serves as a primary food source as well as a source of economic security, and because it is central to the biodiversity of freshwater eco-system, the subject of this fish must be promoted to the level of a key policy issue to the addressed by all facet of the national community. It should not simply to seem as something which is merely the concerned of specialist

	scientists. There exists substantial data on food fish supply, projected needs for fish, and threats to sustainability in various regions of the world. Communicating that information, via those who help shape opinion, is what will really "bring home" the importance of effective fishing policies. Leaders can help the public understand that fish supply is not just an oceanic issue. Fish is a food source, economic commodity and biological necessity relevant to both the development and developing world. h) Science can make a positive contribution to every socio-economic, resource or environmental issue involving fish. Once central contribution today's scientists can make to the dialog on fish is to consider any relevant subject from an integrated, multi-dimensional perspective. The scientific research reflected under these initiatives is ultimately dedicated to the alleviation of human suffering. This initiative is designed to improve people's quality of life, while sustaining fish production and protecting the natural world in which we live.	
10.	**What important activities or developments do you expect in the next reporting period:**	This is the final report.
11.	**Problems encountered during the period under review and measures taken to address:**	There were extreme problems regarding non-availability of fund, as the final installment has not amounting to rupees one hundred thousand as yet not been received. There were also surmounting problem due to

		difference in the accounting procedures at the departmental levels.
12.	**Is there any thing you would like from WWF-P to help a facilitate you in your work:**	Nil

Chapter 1

BACKGROUND AND RATIONALE

To shape a vision for the future of aquatic life as its contribute to food security, better livelihoods and nutrition for the poor in developing countries as well as the role of fish as game, there is a dire need for understanding the issues which effect the sustainability of the fish in the future. Fish also provides unique biodiversity in the aquatic medium. The world fish production is about 115 million metric tones and 84% of this comes from the marine sector and 16% from the inland (freshwater) sector. A wide variety of salmonids, carps and catfishes provides a basis for sport fisheries world over. Owning to their importance both as food and game there is a worldwide campaign to conserve particularly most wanted fish species through scientific management and for which it is essential that the biological and ecological profile of the fish in question be known in as much as possible. In Pakistan too the vast fisheries resource endowments provide opportunity for both food and game (although at a limited scale). The freshwater fishes used in sports are trout in cold waters and mahseer in semi-cold to warm waters and less importantly are some freshwater catfishes. Mahseer is also a prime quality food fish in Pakistan and hence the species is under more fishing pressure. The species has only been limited in natural waters with no history of culture in Pakistan.

Towards better understanding of the issue, it is deemed appropriate to introduce the fish and fisheries profile of Pakistan, so that the context in which the given studies were conducted could provide a better and generalized vision to the user of this report.

FISHERIES PROFILE OF PAKISTAN:

Fisheries as a sub-sector of agriculture play a significant role in the national economy and towards the food security of the country and it contributes, on an average, about 1% to the total GDP, this amounts to about 4% of the GDP of the agriculture sector. Moreover, it absorbs 1% of the country's labor forces. It is considered as one of the most important economic activity along the coastline of Sindh and Balochistan. It has been estimated that about 400,000 fishermen and their families are dependent upon the fisheries sector for their livelihood.

In the year 1999-2000, almost 92,000 metric tones of fish and fishery products valued at US $ 139 million were exported from Pakistan.

Total fish production in Pakistan in 1999 was 654,500 metric tones out of which 474,4000 metric tones (about 72%) was caught from the marine water and the remaining from the inland waters. About 20% of the fish produced from inland water aquaculture.

Inland fisheries resources comprise of a net work of rivers, vast irrigation canal system, natural lakes, like Kinjhar and Manchar, man made reservoirs (Tarbela, Mangla etc.) and small dams which hold a tremendous potential for the development of capture fisheries in the country.

BIOGEOGRAPHY:

Pakistan covers a land area of 796,095 km^2, almost all of which might be considered part of the watershed of the River Indus. From the Arabian Sea coast and the mouths of the Indus near the Tropic of Cancer, Pakistan extends some 1,700 km northward to where the Indus is young, among the mountains of the Himalayas, Hindu Kush and Karakorum. Pakistan has a coastline of c.1,046 km with 22,820 km2 of territorial waters and 196,600 km^2 EEZ (Pernetta, 1993).

Pakistan is endowed with an immense wealth of marine and inland fisheries resources. We possess a coastline of 1,100 km along the Arabian Sea. There are territorial water between the coast and 12 nautical miles. Beyond this there is an Exclusive Economic Zone (EEZ) between 12 nautical miles and 200 nautical miles (370 km).

FISHES IN PAKISTAN:

Pakistan's fisheries comprises of both inland and marine fisheries. The following section is aimed as elucidating briefly the fishes found in freshwater aquatic resources.

Fresh water fishes and distribution:

The total number of freshwater fish species described until now is 167. They belong to 8 orders, 24 families and 65 genera. Based on their distribution, these fishes are divided into 5 Ichthyogeographic regions as follows:

Northern Mountain Region:

This region comprises the northern mountain areas of Pakistan and Kashmir above 1500m altitude. It includes the Northern Areas (Gilgit, Diamir and Skardu), upper parts of Chitral, Swat and Kaghan valleys. The fish fauna predominated by loaches (*Noemacheilus*) and catfish genus of *Glyptosternum*. Some South Asian forms belonging to genera *Labeo, Tor, Puntius, Garra, Oampok, Botia* and *Glyptothorax* have also been described.

Yaghistan Region:

The region was previously named as the North-Western Montane Region. This area is between 1000-1500 m altitude. The Koh Safaid Range in the north, the Suleman Range in the east, the Marri-Bugti hills in the south and the central Brohui Range in the South West border it. In the North West, it is extends into the Afghanistan areas drained by the rivers Kurram, Tochi, Gomal and their tributaries. The fish fauna is a mixture of south Asian, high Asian and west Asian forms, but south Asian form predominates.

Aba-Sine Region:

This region includes the southern parts of the Malakand Division, the vale of Peshawar, the sub-montane Hazara, the adjoining parts of the Punjab and Kashmir, north of the Safiad Koh and Kala Chitta Ranges. It extends into south eastern part of Afghanistan drained by the river Kabul and its tributaries. The fish fauna of this areas is predominantly south Asian but some high Asian forms are also found.

Mehran Region:

This region was previously named as the Indus plain region. It comprises the Indus, plain, adjoining hills, i.e. Kohat Hills, the Salt Range and Pothwar Plateau in the north and Sindh – Baluchistan hills in the south west. The fauna of this region is south Asian, except, few west Asian forms. Rarely genus Schizothorax may also be found.

Gedrosian Region:

This region comprises of the Baluchistan plateau, west of central Brahui and Hala Ranges. The northern part of this range is drained by the rivers of Lora and Mashkel, which end into salt lakes of Hamun-i-Lora and Hamun-i-Mashkel, respectively. The Southern part of the range is drained by the rivers Hingol, Dasht and their tributaries, which fall into Arabian Sea. The fish fauna is a mixture of west Asian (Lora Drain) and south Asian form (rest).

All the species which were brought in Pakistan for culture system, however, they could not attain a right status in culture, however, they have been accidentally been released in natural waters so they are found in a number of man-made artificial lakes.

FRESHWATER DIVERSITY IN PAKISTAN:

Habitat Diversity:

By virtue of climatic variations, physical differences and other abiotic factors a variety of freshwater habitats are existent in the country. The freshwater ecosystems can the classified in various ways i.e. through their nature water flow (lentic or lotic) depth profiles as well as shape size and type. Freshwater habitats can also be classified into coldwater regions and warm-water regions with an arbitrary transitional cool-water area. The variation in ecosystem ranges from streams, rivers, freshwater lakes, manmade reservoirs, rain fed mini-dams in barani areas, inundated flood plains, ponds, bundh and Indus delta.

Bio-diversity, population decline and danger of extirpation:

It is estimated that there are more then 200 species of fish that frequent fresh waters of Pakistan of these a number of species are endemic to this region. However, so far 167 species have been described for their taxonomic status. Nevertheless, some species like those in Mahseer group of fishes have been described differently by different authors, thereby indicating immense need for in depth studies of systematic, morphometric characterization and meristic studies. Conflicting reports on the different species of Mahseer that prevail in Pakistan has made it more clear that elaborative and in depth studies are needed not only to look into the fish at species level but also to find out the existing strains within the species having salient characteristics that the specialists would like to preserve in the form of gene bank for the future use. Insofar as the extinction of some of the freshwater species in concerned it is worth noting that although none of the species are yet recognized as endangered at national level, nevertheless, at least two of the threatened species which are of utmost commercial important, i.e. *Tor putitora* and *Hilsa ilisha* may attain the status of endangered species soon if steps are not taken to conserve the species. *Tor* used to migrate indiscriminately from flood plains to Himalayan foot hills for breading and the creation of Mangla and Tarbella dams blocked there migratory instinct. Whereas *Hilsa* needed about 200 km miles northward run for spawning from our Arabian Sea Coast in to river Indus, which got blocked by the creation of G.M. and Kotli barrages (with ineffective fish ladders). Many northern cold water hill stream loaches of the genus *Noemachilus* and *Triplophysa* are threatened; at least

10 species of cyprinids are rare and vulnerable; coldwater indigenous snow trout- has a limited range of distribution and is being out competed by the introduced exotic trouts and thus is of special concern. Considerable faunistic studies has been done in Pakistan to identify the fishes and their natural distribution, however, a large number of species have yet not been described in terms of their habitat requirement and population. The issue becomes more important when we look into the matter in the perspective of the range of climatic and habitat diversity prevalent in the country. Moreover, the human activity in the last 5 decades, siltation from deforestation, water-logging, agriculture, highway construction, diversion and regulation of rivers through creation of dams, barrages and other water works has greatly decreased available suitable habitat. The habitat loss resulting from pollution in form of organic mater, toxic substances is also threatening. Drought is yet another natural calamity which has hit the country hard in the previous three years causing deleterious effects on the ecologies particularly causing aquatic habitat losses/modification. Consequently, regardless of present population sizes, those species with very limited distribution and critical habitat requirements or both may be extirpated in Pakistan as a result of habitat degradation. Therefore, thorough research investigations are imperative not only to determine distribution, taxonomic status, population size and habitat requirement of these species for placing them in appropriate categories relative to the degree of their danger of extirpation but also to devise a rational conservation program for their protection.

Many of the Cyprinids, especially carps, are widely captured and form the mainstay of culture operations. Depending on their growth and utility in culture systems, the carps are grouped as the major carps (*Catla catla, Cirrhinus mrigala, Labeo calbasu, Labeo rohita*) and minor carps (*L. fimbriatus, L. bata, C. cirrhosus, C. reba*). A few exotic carps, as indicated below, have also been introduced into the country mainly for culture puroposes (*Hypopthalmichthys molitrix, Ctenopharyngodon idella, Cyprinus carpio*). The mahseers are also included in cyprinidae. Though many species of the genus *Tor* are found in the high altitude cold waters of Indian sub-continent, some species like *Tor tor* and *Tor putitora* occur in warmer waters. The genus *Tor* thus reveals a wide range of species diversity as regards adaptation to different ecological conditions. There is a serious decline of mahseer fishery in different ecosystems endangering its very existence, thus warranting adequate conservation of the fishes. With continued urbanization, a research based program for establishment of sanctuaries, nurseries for salvage of juveniles during fluvial conditions, and artificial breeding technologies for stocking of vulnerable fishes such as *Tor* spp. is necessary.

POLLUTION:

Very little study has been done to find out the impact of pollution on rivers, adjoining streams and nullahs of Pakistan. Domestic wastes is probably one of the main source of organic wastes which mostly enters the riverine system untreated resulting in high loads to rivers especially in urban areas. Refuse also contributes substantial pollution loads to such rivers. There are additional large inputs of organic wastes from agriculture-based industries such as poultry farms, tanneries, textile factories, pulp and paper mills, sugar processing etc. High concentrations of suspended solids

are commonly present in rivers due to land erosion following deforestation and mining operation. Industrial discharges are treated as well but their percentage is quite low. There is a lack of multi-disciplinary river basin management body in Pakistan having responsibility for the prevention and control of pollution as well as other functions relevant to river basin management including fisheries. Resources currently available for monitoring control and research on water pollution are highly inadequate.

FISHERIES AND AQUACULTURE (ECOLOGICAL APPROACH):

Ecological approach (agro ecology and interaction with other sector):

The country has been divided into ten broad land resource regions (Hussain and Ahmed, 1990) and of which Northern mountain region, Barani lands Irrigated plains and coastal areas (not taken into account here) are significant from fisheries and aquaculture point of view. It is essential to note that no zonation has been made from Fisheries point of view so as to develop aquaculture in accordance with the physiographic ecological and climatic parameters of the given region. The areas, however, are known from the point of cold water and warm water fisheries areas, but again no information is available for transitional areas and their limits. So the prime need for the advancement of aquaculture in this country is delineate and clearly demarcate various Fisheries regions in Pakistan for the rational development of management particularly farming.

Northern mountain areas:

In Northern Mountain areas, soil erosion, gully erosion, mass wasting, and subsequent heavy sediment load in river waters, are some of the important issues that effect the fisheries including mahseer fishery and aquaculture in the region. The land degradation and availability of less land has augmented the trout culture in raceway flow-through systems as water is abundant.

Barani area (The present studies were confined to the river systems in barani tract):

The barani tract or rain-fed region over Pothwar plateau and lower Himalayan Piedmont plains. The area is characterized as having sub humid hot, sub tropical, semi arid hot sub tropical and semi arid very hot regions. The region is pre dominantly dry farmed along main streams. These main streams and a number of smaller streams have been dammed for storing surface run off waters. These storage reservoirs are popularly known as mini dams and are used for rearing fish as well, however, with very low to nil managemental input levels.

The river Haro, Soan, Kansi and other streams have either been over harvested or are slowly losing their importance due to sedimentation and municipal industrial influx.

Irrigated plain:

Irrigated plains is one of the most important regions of the country which covers the Indus plains commanded by the world's biggest irrigation net work and is the main granary of Pakistan. It includes the irrigated plains of Punjab, Sindh and Peshawar-Mardan valley and covers about 137,800 sq. km. The climate is hyper arid to semi arid and subtropical. On the bases of agro-climatic conditions the area is further devisable in five zone. Three distinct soil surfaces viz. i) higher and other river plains, ii) lower and younger sub recent river plains, and iii) active and recent river plains are distinct with a small part in Indus delta comprising estuary plains in the southern extremities. These three soil resources have distinct characteristics from ponds point of view as well. The aquacultural engineering requirement and water

budget differs saliently in these areas, however, both the issues are not accounted for in the prevailing fish farming systems.

Introduction of canal irrigation system in the country has aggravated the problem of water logging and ultimately soil salinization. It is estimated that out of about 6 m ha waterlogged and saline area (Ahamd, 1990) at about one million ha the waterlogged pond have been created. In some of these waterlogged areas water is retained throughout the year while in others the water level varies and fluctuate with the water level of the adjoining water bodies.

RESOURCE BASED APPROACH (VARIES AQUATIC SYSTEMS):

Rivers and man-made reservoirs:

Characteristics of capture fisheries are dominated by the Indus River system which starts from the mountains of northern Pakistan and is joined by four large rivers that flow through most of the extent of Punjab and finally drain into Arabian Sea in Sindh province after covering a distance of about 2,900 km. It has the largest contiguous irrigation system in the world.

The five major rivers join the river Indus. The fish fauna of Indus river system in northern part is cold-water type, while the greater middle and southern part of the system represents warm water fisheries zone. Greater differences exist between various zones of one river than between homologous zones of different rivers. Therefore, it is imperative to study any river system at a continuum to determine succession of characters along its length. Hardly any study has been done in Pakistan to determine the effects of other uses of rivers and their level on fisheries. River modification under Indus Basin development has changed almost entire profile of our major rivers. Consequently, the fish communities in rivers have been subjected more to a range of external influences than internal events.

Six large manmade reservoirs were created in the past three decades through the construction of dams and barrages over the rivers in Pakistan, which provide about 0.25 m. ha area for fish production. In addition to these there are several small dam reservoirs. These reservoirs are limnologically very different from the mini-dams reservoirs of Barani area.

Lakes (sweet/slaine and other wetlands):

In Sindh province alone these are more than 100 natural lakes of different sizes covering an area of about 101,000 ha. Among them the Haly, Kinjhar and Manchar lake are quite active in fish production. Halijee lake is about 18 sq. km., Kinjhar is 120 sq. km. and Manchar is 160 sq. km in area. Due to insufficient management, the Manchar lake dried up completely twice during the last 15 years (Baloch, 1993). This lake alone supports 2,000 families of fishermen. Apart from these big lakes, a cluster of small lakes called Bakar Lake occupy an area of 400 sq. km. The natural lakes in Punjab are spread over about 7,000 ha. Some of the lakes like Nammal Lake (480 ha), Ucchali Lake (943 ha), Jahlar Lake (100 ha), Kalar Kahar Lake (100 ha), Kharal Lake (235 ha) and Khabakki Lake (283 ha) are located in salt range and are too saline to support, amongst the currently culturable fish species of commercial importance. Salinity in some lakes exceeds to that of sea water. Plankton

productivity is unimaginably quite low and do not fulfill even the lowest standards of the plankton level. Shrimp culture is another side with potential for good returns from these abandoned waters. Establishment of shrimp hatchery and development of nutritional and economic diets is another factor to ponder about.

Wetlands are other unique environments with shallow and fluctuating water levels; these are spread over vast areas. Changes in land use practices in areas around wetlands are causing changes in water quality and water regime.

OBJECTIVES

Objectives of this study are to:

1. Delineation of species of Mahaseer fishes (*Tor* spp.), and their taxonomical characterization in River Haro and Soan and allied dams (Rawal Dam and Khanpur Dam) in Himalayan foothill region.
2. To study breeding, feeding and landing habits and habitats of Mahseer.
3. Pattern of Mahseer population structure, distribution and local adaptations (if any) under different ecological regimes.
4. Listing of other cohabiting fish species using same aquatic ecosystem; resource competitors.
5. Identification of stakeholders for current Mahseer resource exploitation, usages and conservation.
6. To provide information on various ecological, hydrological and social changes posing reduction or elimination threats to Mahseer.

STUDY AREA:

The studies were based on Haro river and Soan River and its tributaries mainly rivers Korang and Nulah Gomrah. The Haro river originating from Murree hills (foot-hills of Himalayas) flow meandering down hills and reaches Khanpur some 12 kms from Haripur where the water has been blocked by damming giving rise to Khanpur dam. Likewise the tributary of the Soan rising again from the Margalla and Murree hills of Himalayan foot-hills, when enter into Islamabad a dam has been created on the river Korang giving rise to Rawal dam reservoir. The studies were undertaken from not only sites selected on the rivers Haro, Korang, Gomrah but also the catch analysis of fishes caught from Khanpur and Rawal dams is included in the present study.

Physical characters of Rawal Dam reservoir:

Location: On Korang River

Type of Dam: Earth and rock fill

Maximum Capacity: 2.48×10^8 m^3

Surface area: 828 ha

Average: depth 15 m

Rawal Dam reservoir ($33^o40'N$, $73^o24'E$), commonly known as Rawal Lake, was created in 1962 to provide drinking water for Islamabad. Damming the Korang River, in the Potohar region some 10 km from Islamabad, created it. The maximum capacity of the reservoir is 2.48×10^8 m^3, the surface area is 828 ha and the average water depth is 15 meter.

Physical characters of Khanpur Dam reservoir:

Khanpur Dam Reservoir (NE) was created in 1983 to provide drinking water for Islamabad. It also provides irrigation water to some 14765 ha. It was created by damming the Haro River, some 35 km from Islamabad. The surface area of reservoir varies from 1806 ha (maximum) and 215 ha (minimum). The average depth of the reservoir is 15 meter. The gross storage of the reservoir is 0.132 km^3 with a total catchment area of 798 km3.

The reservoir is under the control of Water and Power Development Authority (WAPDA), which is responsible for its regulation and stocking. In past the reservoir has been leased for commercial exploitation. The reservoir was extensively exploited with gill nets of varying size (George et al. 1988). The present management of Khanpur Dam Reservoir is determined by the Pakistan Fisheries Ordinance 1961 regulations. Closed seasons (1st May to 31st August annually, which was previously observed from 1st June to 31st August), control of gears and minimum size limit of fish are used to ensure sustainable yield.

Chapter-2

STUDIES ON MERISTIC COUNTS, AND MORPHOMETRIC MEASUREMENTS AND SPECIATION OF MAHSEER (*TOR SPP.*) FROM HIMALAYAN FOOT-HILL KORANG AND HARO RIVERS SYSTEMS (HARIPUR AND ISLAMABAD REGION), PAKISTAN

INTRODUCTION:

Mahseer (*Tor putitora*) is the most important Cyprinid fish of the South Asian Subcontinent. It is also known as golden Mahseer and is usually considered as a sportive fish by the anglers, because of its big size, fighting properties and as an excellent game fish (Shrestha, 1990).

Identification of a species plays a key role for the behavioral study. Different methods are used for identification but meristic counts and morphometry are considered as earliest and authentic methods for the identification of species (Nayman, 1965). Meristic counts mean any thing that can be counted while morphometry is the external measurement of an organism (Talwar and Jhingran, 1992).

According to Mirza (1982), four species Mahseer were reported in Pakistan. Ahmad (1963) listed two species of Mahseer from West Pakistan i.e. *Tor tor* (Hamiliton) and *Tor putitora* (Hamilton). Later, Mirza (1967) described a new species, Tor zhobensis from the river Zhob in the North East Balochsitan while Mirza and Omer (1974) recorded *Tor mossal* (Hamilton) from the river Hero in northern Punjab.

In Pakistan limited information is available on the Meristic and morphometric characteristics of this important game fish, since four species of *Tor* are reported from the country, it is necessary that in all types of biological studies, recognition or identification of the species must be done.

Taxonomic problem due to difficulty in determining species with reliability exists due to the reason that patchy studies have been done to describe biological characteristics including basic characters of taxonomy, such as meristic counts and morphometric measurement. Present study is designed with objectives to determine what kind of species of Mahseer exists in Korang River and also to determine the meristic counts and morphometirc measurements of *Tor putitora*.

MATERIAL AND METHODS:

During the period (January-June 2000) tributaries of Soan river Korung Stream, Nala Gummraa, Simili Dam Nala, Rawal Dam and Khanpur Dam were visited monthly. During these trips the netting was made by using cast net of mesh size 1". The fishes of various size were caught, detail of each trips given in the Table-1.

Ninety specimens of *Tor putitora* (9-27 cm total body length) were collected from Korang river located in Islamabad and regulated by construction of Rawal Dam with the help of cast net of circumference 2-2.5 m and of mesh size 2.5 inch. The Korang river is considered to be the spawning ground of Mahseer. Fish were killed at the

spot and preserved in 5% formation solution. The fish were tagged by using the tagging material in the dorsal fin.

Distribution of fish into three groups in accordance with the total length of the body was done as below:

Group-A **9-15 cm (30 specimen)**

Group-B **15-21 cm (30 specimen)**

Group-C **21-27 cm (30 specimen)**

The meristic and morphometric measurements were done with the help of magnifying glass model 50 m/m Dia. (China), stage microscope Model Wild M7A (Switzerland) and electric balance Model EP-12 Ka (Yagami International Japan) and Scales, divider and vernier caliper.

The fish were identified and conformed to be the species under investigation according to the Talwar and Jhingran (1992), Mirza (1982) and Sen and Jayaram (1982).

Condition factor "K" was calculated by the formula suggested by Weatherly (1972).

$$K = W \times 100L^{3}$$

Where; K = condition factor, W = body weight and L = total length of fish

Statistical analysis including regression and correlation coefficient were carried out by a computer package (Lotus 123) using following formula:

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

Where; W = weight, T.L. = total length and a & b are regression's constants.

RESULTS AND DISCUSSIONS:

a) Fish Catch Analysis from the flowing waters:

It was found through the analysis of total fish sampled from streams and rivers that Mahseer fish constituted that 83.3% of the total catch while all other species constituted 16.66%. The water quality of these running waters which included pH, Temperature and Conductivity. The catch analysis is presented in Table-1 while the water quality analysis is presented in Table-2.

Table-1: Percentage of Mahseer fish composition from the flowing waters of Haro and Soan/Korang rivers systems studied

Visit Place	Fish Captured (Number)	Mahseer (*Tor putitora*)	Other species	Percentage of *Tor putitora*
Nala Gummara (upper reaches)	55	44	11	80.00

Korang River	32	28	4	87.5
Simli Dam Nala	22	18	4	81.81
Nala Gummara (lower reaches)	34	22	12	64.70
TOTAL	206	172	34	83.49

Water Quality Analysis:

The selected variables to determine the baseline quality of water from selected sites on the flowing water bodies are given in Table-2. The figures represents average values and the analysis of the data indicates that all these water were well within the range of relatively clean freshwaters with obvious traces of pollution (both inorganic and organic) at places where the civic activities were more pronounced.

Table-2: Selected water quality parameters from the flowing waters of Haro and Soan/Korang rivers systems studied

Visit Place	pH	Temperature (^{o}C)	Conductivity
Nala Gummara (upper reaches)	8.50	10.4	0.34
Korang River	8.60	11.0	0.36
Simli Dam Nala	8.05	15.0	0.40
Nala Gummara (lower reaches)	8.62	23.4	0.51

b) Fish Catch Analysis from the dams:

The catch analysis of the fishes from the two dams studied are presented in Tables-3 & 4 below:

Table-3: Fish Species Composition of Khanpur Dam Reservoir and weight-length ranges

Fish species	Number	Composition (%)	Weight ranges (g)	Length ranges (Cm)
Labeo dyocheilus	21	4.3	100-450	20.0-39.0
Cyprinus carpio	25	5.1	15-550	10.5-37.0
Tor putitora	260	53.3	10-650	7-43
Hypopthalmichthys molitrix	5	1.0	210-350	21.5-25.0
Puntius sarana	12	2.4	122-260	12.0-26.0
Barilius vagra	20	4.1	2.6-5.0	6.0-9.0

Oreochromis nilotcus	106	21.7	6.0-16.5	7.3-60.0
Schizothorax labiatus	24	4.9	206-219	20.0-21.0
Ompok bimaculatus	7	1.4	202-250	18.0-25.0
Hetropneustes fossilis	8	1.6	80-91	14.0-16.0

Table-4 Composition of fish in Rawal Dam Reservoir

Fish species	Percentage Composition by Number	Percentage Composition by Weight
Catla catla	0.17	0.43
Tor putitora	10.60	18.9
Labeo calabasu	5.90	0.97
L. rohita	0.17	3.30
L. dero	7.80	3.90
L. dyocheilus	26.0	25.8
Cirrhinus mirgila	14.0	14.4
C. reba	26.3	18.1
Cyprinus carpio	2.80	8.80
Hypopthalmichthys molitrix	1.60	4.00
Puntius sarana	0.34	0.01
Puntius ticto	0.33	3.20
Crossocheilus latius diplocheilus	1.90	0.90
Ompok bimaculatus	3.80	0.17
Ophiochephalus punctatus	0.17	0.34

Transportation:

Live fishes were transported to the research station AFRI by hauling the fish in tanks/plastic drums, which were well aerated. Then live fishes were released in the flow through raceways (7.0 x 1.5 m and 1.0 m) with a capacity of 10,000 liters. The water of each raceway was changed after every 3 days and water quality was studied regularly also. It was noted that fishes were quite susceptible to handling stress and as the fishes registered up to 25% mortality during each hauling trip.

Identification:

For the taxonomic the fishes were preserved in the 10% formaline solution and each fish was marked study which included both meristic counts and morphometric are considered as earliest and aunthentic method for identification of species (Nayman, 1965). The meristic characters were counted in number with the help of magnifying glass and stage microscope. All the Morphometric characters were measured in centimeter (cm) with the help of scale divider and verniar caliper.

Initially the fishes were graded into six different groups viz. A to F and the gradation of the fish according to body weight was done as under:

Group-A = 20-30g

Group-B = 30-40g

Group-C = 40-50g

Group-D = 50-60g

Group-E = 60-70g

Group-F = 100-200g

The results of the six groups (as reported earlier) is reproduced below for reference. And the morphometric and meristic characters and their measurement and counts are given in the following tables:

Table-5: Results of Meristic Counts in six groups (by weight) of *Tor putitora*

Groups No.	Dorsal fin rays	Pectoral fin rays	Pelvic fin rays	Anal fin rays	Caudal fin rays	Lateral line scales	Scales above lateral line	Scales below lateral line
A	iii-9	14-16	9	ii-5	19	24-27	4 ½	3 ½
B	iii-9	15-18	9	ii-5	19	23-25	4 ½	3 ½
C	iii-9	14-17	9	ii-5	19	23-27	4 ½	3 ½
D	iii-9	15-17	9	ii-5	19	24-26	4 ½	3 ½
E	iii-9	15-18	9	ii-5	19	24-27	4 ½	3 ½
F	iii-9	15-16	9	ii-5	19	25-26	4 ½	3 ½
Av. result	iii-9	14-18	9	ii-5	19	23-27	4 ½	3 ½

Table-6: Results of morphometric measurement in six groups (by weight) of *Tor putitora*

Group No.	Wt(g)	T.L(cm)	S.L(cm)	F.L(cm)	H.L(cm)	P.O.H.L.(cm)	Po.O.H.L (cm)
A	26.96 (23.5-29.5)	16.64 (16.6-17.4)	13.08 (12.5-13.9)	15.04 (14.4-15.7)	3.78 (3.6-4.8)	1.07 (1.2-1.4)	2.02 (1.9-2.1)
B	35.75 (30.9-39.8)	17.31 (15.5-19.5)	13.49 (12.0-15.0)	15.61 (13.9-16.9)	4.13 (3.5-4.8)	1.34 (1.1-1.7)	2.09 (1.8-2.4)
C	44.46 (40.1-48.3)	17.43 (16.5-19.6)	13.81 (12.8-15.9)	15.60 (14.0-18.1)	4.09 (3.8-4.5)	1.37 (1.2-1.7)	2.14 (1.9-2.5)
D	54.46 (50.2-59.5)	18.37 (16.5-19.5)	16.11 (12.8-16.0)	14.40 (14.0-18.5)	4.26 (3.6-4.9)	1.44 (1.3-1.6)	15.4 (1.8-2.7)

E	63.70 (61.4-66.4)	18.85 (18.4-19.8)	15.13 (14.0-14.9)	8.63 (16.3-16.7)	4.25 (4.2-4.4)	1.45 (1.4-1.5)	2.23 (2.1-2.4)
F	142.10 (100.4-163.9)	25.08 (24.5-26.0)	19.52 (16.9-20.3)	21.16 (17.3-22.9)	5.32 (4.2-5.7)	1.92 (1.6-2.1)	3.22 (3.1-3.6)

Table-7: Results of morphometric measurement in six groups (by weight) of *Tor putitora*

Group No.	H.W. (cm)	P.D.L (cm)	E.D. (cm)	B.D. (cm)	I.O.W. (cm)	I.N.W. (cm)
A	2.28 (2.2-2.4)	6.66 (6.2-6.8)	0.78 (0.7-1.8)	2.84 (2.6-3.0)	1.08 (1.0-1.2)	0.78 (0.6-1.2)
B	2.54 (2.3-2.9)	7.16 (6.4-8.2)	0.80 (0.7-0.9)	3.16 (3.0-3.4)	1.13 (1.0-1.2)	0.69 (0.5-0.8)
C	2.62 (2.4-2.9)	7.20 (6.7-8.1)	0.80 (0.7-0.9)	3.42 (3.1-3.8)	1.13 (1.0-1.2)	0.72 (0.6-0.8)
D	2.73 (2.5-2.9)	7.46 (6.1-8.6)	0.86 (0.8-1.0)	3.67 (3.5-3.9)	1.17 (1.1-1.3)	0.76 (0.7-0.8)
E	2.83 (2.7-3.0)	7.63 (7.3-7.8)	0.83 (0.8-0.9)	3.90 (3.8-9.0)	1.20 (1.1-1.3)	0.75 (0.7-0.8)
F	3.64 (3.2-3.4)	10.10 (8.6-10.4)	0.98 (0.9-1.1)	4.28 (4.2-5.2)	1.64 (0.9-1.1)	1.02 (1.3-1.7)

Table-8: Results of morphometric measurement in six groups (by weight) of *Tor putitora*

Group No.	L.U.J. (cm)	L.L.J. (cm)	D.F.B.L (cm)	D.F.H. (cm)	P.F.B.L. (cm)	P.F.H. (cm)
A	1.00 (0.9-1.2)	0.68 (0.6-0.7)	1.90 (1.7-2.5)	3.38 (3.1-4.0)	0.52 (0.5-0.6)	2.72 (2.6-2.9)
B	1.00 (0.9-7.2)	0.70 (0.6-0.9)	1.91 (1.7-2.1)	3.03 (2.4-3.6)	0.58 (0.5-0.7)	2.68 (2.4-3.2)
C	1.04 (0.9-1.2)	0.80 (0.7-0.9)	1.98 (1.7-2.8)	3.23 (2.8-3.5)	0.62 (0.5-0.9)	2.73 (2.4-3.2)

D	1.11 (1.0-1.3)	0.87 (0.8-0.9)	1.96 (1.7-2.2)	3.31 (2.8-3.7)	0.61 (0.6-0.7)	2.94 (26.35)
E	1.13 (1.1-1.2)	0.93 (0.8-1.0)	1.98 (1.8-2.2)	3.55 (3.3-3.8)	0.65 (0.6-0.7)	2.93 (2.7-3.0)
F	1.12 (1.3-1.7)	1.22 (1.1-1.3)	2.64 (2.3-2.9)	4.36 (4.0-4.7)	0.84 (0.7-0.9)	3.86 (3.4-4.4)

Table-9: Results of morphometric measurement in six groups (by weight) of *Tor putitora*

Group No.	V.F.B.L (cm)	V.F.H (cm)	A.F.B.L (cm)	A.F.H (cm)	H.C.P. (cm)	L.C.P. (cm)
A	0.54 (0.5-0.6)	2.38 (2.2-2.6)	0.84 (0.6-1.0)	2.36 (2.2-2.7)	1.52 (1.3-1.8)	1.88 (1.6-2.0)
B	0.61 (0.5-0.6)	2.40 (2.1-2.7)	0.95 (0.7-1.2)	2.11 (2.2-2.7)	1.56 (1.4-2.1)	1.88 (1.4-2.4)
C	0.60 (0.5-0.7)	2.47 (2.2-2.9)	1.17 (0.9-2.3)	2.57 (2.2-2.9)	1.42 (1.2-1.5)	2.06 (1.7-2.4)
D	0.66 (0.6-0.7)	2.59 (2.2-2.9)	0.94 (0.7-1.0)	2.47 (2.2-2.9)	1.53 (1.5-1.6)	2.0 (1.8-2.3)
E	0.68 (0.6-0.7)	2.45 (2.3-2.5)	0.98 (0.9-11)	2.58 (2.5-2.7)	1.48 (1.2-1.6)	2.05 (2.0-2.2)
F	0.86 (0.7-1.0)	3.30 (3.0-3.6)	1.28 (1.1-1.4)	3.02 (2.1-4.2)	2.34 (2.0-3.0)	3.02 (2.8-3.3)

With the completion of collection of fish from the selected places it was found that it would be more appropriate to gauge the fish by size and not by weight, therefore, the fish groups are reduced into three size groups with clear distinction in sizes rather then six weight groups. Therefore, taking fish from the previously reported studies, randomly picking them and mixing it with new samples, three core groups were created with 30 fish in each group in accordance with the total length of the body.

Group-A 9-15 cm (30 specimen)

Group-B 15-21 cm (30 specimen)

Group-C 21-27 cm (30 specimen)

The results of these size groups for their morphmoretric characteristics and merstic counts are given below.

From Table-10, it is clear that dorsal fin rays (iv-8), pectoral fin rays (i-14), pelvic fin rays (i-18), anal fin rays (iii-5), caudal fin rays (17), lateral line scales (26), scales above the lateral line (4) and scales below lateral line (3) remained constant in all groups of fish having different body length. It means that in all groups of fish having different body length. It means that meristic counts are independent of body size and

there is no change in meristic counts with increase in body length (Talwar and Jhingran, 1992; Vladykov, 1934).

Table-10: Meristic counts (Numbers) in six size groups of *Tor putitora*

Fish Distribution	Meristic characters							
	Dorsal Fine rays	Pectoral Fine rays	Pelvic Fine rays	Anal Fine rays	Caudal Fine rays	Lateral Fine rays	Scales above Lateral line	Scales above Lateral line
Group A	4*-8**	1-14	1-8	3-5	17	26	4-1/2	2-1/2
Group B	4*-8**	1-14	1-8	3-5	17	26	4-1/2	2-1/2
Group C	4*-8**	1-14	1-8	3-5	17	26	4-1/2	2-1/2

* Un-branded fins ** Branded fins

Morphometric characters of fish (Table-11) i.e., weight of fish, total length, standard length, fork length, body depth, pre orbital length of head, post orbital length of head and diameter of eye with increased when comparison was observed among three groups of different body length. These are close to the measurements reported for *Tor putitora* earlier (Mirza, 1982; Dasgupta, 1982).

Table-11: Morphometric measurements (cm) in six size groups of *Tor putitora*

Distribution Groups	Morphometric Characters							
	W.F.(gm)	T.L.	St.L.	F.L.	B.D.	P.O.L.H.	Po.O.L.H.	D.E.
Group A	28.32	13.46	10.46	12.05	3.26	1.04	1.56	0.85
(range)	(8.4-45.7)	(9-15)	(6.6-12)	(7.8-13.6)	(2.1-4.7)	(0.7-1.4)	(0.9-1.9)	(0.6-1.1)
Group B	58.02	17.57	13.4	15.32	4.08	1.1	1.94	1.02
(range)	(50.9-70.7)	(16.9-18.2)	(12.5-14.6)	(14.3-15.6)	(3.8-4.6)	(1.1-1.4)	(1.8-2.2)	(0.9-1.2)
Group C	114.92	21.67	16.84	18.94	4.86	1.6	2.83	1.14
(range)	(21.1-22.3)	(19-21)	(14.8-18)	(16.7-19.8)	(3.8-6)	(1.4-1.8)	(2.15-2.5)	(0.8-1.2)

W.F. = Weight of Fish T.L. = Total Lengths St.L. = Standard Length F.L. = Fork Length

B.D. = Body Depth Po.O.L.H. = Post Orbital Length of Head D.E. = Diameter of Eye

It is clear from the results (Table 12 to 14) that all the body parameters grow symmetrically when observed in different length groups. The same body parameters grow symmetrically when observed in different length groups of Mahseer spp. (Mann, 1976; Talwar and Jhingran, 1992).

Table-12: Morphometric measurements (cm) in six size groups of *Tor putitora*

Distributio	Morphometric Characters

n Groups	I.O.D.	I.N.D.	H.L.	H.D.	L.C.P.	D.C.P.	L.U.J.	L.L.J.
Group A (range)	0.91 (0.5-1.1)	0.66 (0.4-0.9)	3.41 (2.2-4.1)	2.1 (1.3-3.7)	1.66 (0.9-2.1)	1.48 (0.8-2.9)	0.73 (0.4-0.9)	0.62 (0.3-0.8)
Group B (range)	0.92 (0.9-1.1)	0.7 (0.7-0.9)	4.01 (3.8-4.3)	2.81 (1.5-2.7)	1.9 (1.5-2.4)	13.9 (0.6-2)	0.67 (0.5-0.9)	0.62 (0.4-0.8)
Group C (range)	1.24 (1.2-1.3)	3.72 (0.8-1.1)	4.94 (4.3-5.3)	3.30 (2.8-3.5)	2.44 (2.2-2.6)	1.88 (1.6-2)	0.67 (1-1.1)	0.85 (0.8-0.9)

I.O.D. = Inter Orbital Distance I.N.D. = Inter Nostril Distance H.L. = Head Length

H.D. = Head Depth L.C.P. = Length of Caudal Peduncle D.C.P. = Depth of Caudal Peduncle

L.U.J. = Length of Upper Jaw L.L.J. = Length of Lower Jaw

Table-13: Morphometric measurements (cm) in six size groups of *Tor putitora*

Distribution Groups	Morphometric Characters								
	L.D.F.	L.P.F.	L.Pl.F.	L.A.F.	L.Cu.F.	Lo.D.F.	Lo.P.F.	Lo.Pl.F.	Lo.A.F.
Group A (range)	2.92 (1.7-2.7)	2.34 (1.2-2.4)	1.91 (1.2-2.4)	2.14 (1.3-2.9)	3.36 (2.3-4.4)	2.92 (2.2-4)	2.34 (1.7-2.9)	1.91 (1.2-2.6)	2.14 (1.5-2.9)
Group B (range)	3.48 (2.6-4.1)	2.86 (2.7-3.3)	2.34 (2-2.7)	2.6 (2.2-2.8)	4.37 (4-4.8)	3.67 (3.4-4.1)	2.61 (2.7-2.9)	2.48 (2-2.9)	2.48 (2.3-2.8)
Group C (range)	4.26 (4.1-4.5)	3.5 (3.2-3.7)	2.78 (2.7-2.9)	3.22 (2.9-3.5)	5.16 (4.7-5.8)	4.18 (3.7-4.5)	3.42 (2.8-3.7)	2.82 (2.7-2.9)	3.32 (2.9-3.4)

L.D.F. = Length of Dorsal Fin L.P.F. = Length of Pectoral Fin L.Pl.F. = Length of Pevicl Fin

L.A.F. = Length of Anal Find L.Cu.F. = Length of Caudal Fin Lo.D.F. = Longest Dorsal Fin

Lo.P.F. = Longest Pectoral Fin Lo.Pl.F. = Longest Pelvic Fin Lo.A.F. = Longest Anal Fin

Table-14: Morphometric measurements (cm) in six size groups of *Tor putitora*

Distribution Groups	Morphometric Characters					
	L.D.F.B.	L.A.F.B.	P.D.L.	P.P.L.	P.Pl.L.	P.A.L.
Group A (range)	1.77(1.2-1.9)	0.92(0.9-1.1)	5.87(3.8-6.9)	3.25(2-3.9)	6.11(3.9-7.2)	8.90(5.6-10.3)
Group B (range)	2.03(1.9-2.1)	1.04(0.9-1.2)	7.11(6.8-7.8)	3.84(3.6-4)	7.04(6.6-7.4)	10.44(9.7-10.8)
Group C (range)	2.36(2-2.6)	1.24(1.1-1.3)	8.44(7.85-8.9)	4.66(4.1-5.3)	8.84(7.9-9.7)	13.2(12-14.2)

L.D.F.B. = Length of Dorsal Fin Base L.A.F.B. = Length of Anal Find Base P.D.L. = Pre Dorsal Length

P.P.L. = Pre Pectoral Length P.Pl.L. = Pre Pelvic Length P.A.L. = Pre Anal Length

The meristic counts and morphometric measurements of *Tor putitora* commensurate and are in confirmation with different studies (Talwar and Jhingran, 1992; Dasgupta, 1991; Valdykov, 1934 and Mirza, 1982).

Correlation between weight and length (condition factor):

The calculation of condition factor showed negative allometric growth. In groups A and B, where the value was 0.6, (as the value 1.0 is considered to show Isometric growth). However, the value increased upto 0.8 in groups C, D and E showing a trend to isometric growth (Table-15).

Table-15: Calculated condition factor of *T. putitora* specimens in different groups

Specimen No.	Group-A	Group-B	Group-C
1.	0.7	0.6	0.6
2.	0.6	0.6	1.1
3.	0.9	0.9	0.6
4.	0.6	0.9	0.9
5.	0.9	0.5	0.9
6.	0.5	0.9	0.7
7.	0.5	0.9	1.0
8.	0.6	0.9	
9.		1.0	
Mean C.F.	0.6	0.8	0.8

The statistical analysis of length weight data on the whole includes the log transformation regression of length weight data showing relationship with correlation co-efficient ($r=0.628$ $P<0.01$) having a general form Log W=Log a+b Log L. The values of the constants "a" and "b" and other regression parameters are given in Table-16. The regression co-efficient "b" is 2.263, which is less than 3 (A slope of ideal fish) also showing the negative allometric growth.

Table-16: The regression parameters of body weight (W) on total length (TL) for Mahseer *T. putitora*

Regression equation	Number	Correlation co-efficient r	Proportion of variance accounted for by the regression r^2
Log W = Log-1.198+2.263 Log T.L.	33	0.628**	0.3953

** P<0.01

The condition factor "K" was also analyzed statistically against total length and body weight (Table-17) and showed to be remained constant with T.L. and has a positive correlation with increases body weight.

Table-17: The regression parameters of condition factor (K) on total length (TL)

and weight (W) for Mahseer *T. putitora*

Regression equation	Number	Correlation co-efficient r	Proportion of variance accounted for by the regression r^2
K=1.333-0.030 T.L.	33	0.248*	0.062
K=0.405+0.008 W	33	0.601**	0.362

* P<0.0051 ** P<0.01

CONCLUSION:

With the help of meristic counts, morphometric measurements and allometric growth ratio ,condition factor (k) and other systematic account, the present findings scientifically establishes that all the fishes under study belonging to the group of Mahseer fishes which are inhabiting Soan River (tributaries in Islamabad and Rawalpindi region), Korang River and Haro River systems, belongs to the genus *Tor* and the precise species is *Tor putitora* and not *Tor tor* as erroneously reported by some authors. The sexual dimorphism, however, exists in depth of body of male and female gender which probably provided a basis to label some male specimens of *Tor putitora* as *Tor tor*.

Chapter-3

PERFORMANCE AND FEEDING RESPONSE OF *TOR PUTITORA* TO FORMULATED DIET IN RELATION TO TEMPERATURE UNDER CAPTIVE CONDITIONS

INTRODUCTION:

Aquaculture as an efficient mean of animal protein production has been accepted worldwide. Aquaculture has a significant positive contribution to food security through extensive and semi-intensive system (Edward 1977). Fish farming is gaining popularity in private and public sector in Pakistan. A number of fish species are now used in aquaculture viz. Endogenous major carps are *Labeo rohita, Cirrhirnus mrigala, Catla catla* and exotic carps are grass carp, silver carp. And they are used both in pond and reservoir systems (Afzal, 1994).

Beside these convention species they are many other species which are potential candidate for use in fish farming for a number of traits. One of such species in mahseer *Tor putitora*, the most important game fish in this region. The fish is inhabitant of clear shallow stream with the gravel bed all along the Himalayan foothills. Mahseer grows to a large size and ranks very high as food and considered game fish for angler (Chandy 1994). In Pakistan mahseer is not presently cultured and is under stress to the level of extension in the endemic natural waters due to damming of most of the Tor inhabitant water like river Haro, Indus and Hub in their upper reaches (Akhtar, 1999).

Conversation strategies and culture of a fish are the domains asking for provision of more precise information about the behavioral response of fish such as survival at various temperature in conjunction with growth under captive condition, acceptability of artificial diet and feed conversion and susceptibility levels to handling stress.

Supplementary feeding is known to increase the carrying capacity of culture system and can enhance fish production by many folds (Hepher 1975; Devaraj 1976). However, in Pakistan the use of supplementary feed is yet very limited.

The fish diets are usually rich in protein and vitamins therefore, they are expensive. The cost of feed in culture system may comprise upto 50% or more of total cost depending on the level of farming (Collius 1979). Therefore, the quality and quantity of fish fed is the major factor determining profitability of fish farming because feed itself represent single largest expenditure in farming (Devaraj and Seenappa, 1991). Protein requirement of the fish also varies from species to species, even in the same species at different stages of life. Protein is obtained either from animal or from plants sources. The protein requirement in the diet for maximum growth of fish lies between 35-50% depending on the genetic characteristic of the fish (Tocan and Jackson, 1985).

Mahseer (*Tor putitora*) is being cultured commercially in Nepal (Pantha, 1993) and attempts have been made in India and Bangladesh to improve the culture practices for sustainable yield (Haque, 1995). The present study is the first attempt to

collected young fish from wild and study the survival, growth and acceptability of artificial diet under captive conditions. The present study was conducted to achieve the following objectives:

1. To determine the survival, adaptability and maintenance of *T. putitora* (collected from wild) during transportation over a period of time at ambient temperatures under captive conditions.
2. To explore the availability of feed ingredients for preparing *Tor putitora* diet and feed formulation with desired protein level.
3. To determine the feeding behavior of the fish to test diet particularly in relation to temperature.

The study will provide preliminary information and a basis in commercial fish farming both in ponds and reservoirs for the rearing of mahseer.

MATERIAL AND METHODS:

The present study was conducted at NARC in Aquaculture and Fisheries Research Institute (AFRI) during September to December, 1999.

Fish collection and maintenance:

Fish for the present study were collected from the Nala Gumraa a tributary of Korung River. A small river originating from hilly areas of Murree and Islamabad. Five sampling trips were made to collect the specimen by using cast net of mesh size 2.5 cm^2. The fish were collected from a stretch of about 10 km in the stream starting from villages Bara Kahu, moving toward Pind Bagwal and culminating at Shah Nara. The meeting was also done in the tail water of Mal Nala and Simly Dam up stream but *Tor* spp. were not found in the catch. The fish were transported to the study site in fish holds. One hundred and twenty fish were caught during 5 trips. Thirty five fish were died during the transportation. The hauling was done at temperature 25-27^oC and the hauling distance was about 30 km.

Fish acclimatization:

The fish were kept in five flow through concrete raceways tank each of size 23.3 x 2.7 x 2.4 cubit feet for 30 days for acclimation. The water quality was studied and water was changed after 3 days. Fish were fed on the artificial diet to habituate the fish for formulated diet. Each fish were tagged by using anchor floy tag. Fishes were weighed by using electric balance Model No. EP-12 Ka (Yagmai International Japan) and distribution of fish into four groups in accordance with the body size was done as under:

Group A = 30-40 g

Group B = 40-50 g

Group C = 50-60 g

Group D = 60-70 g

The initial weight of each group are given in Table-1.

Table-1: Initial weight of four groups

S. No.	Group A (30-40 g)	Group B (40-50 g)	Group C (50-60 g)	Group D (60-70 g)
1.	33.6	46.2	53.3	62.7
2.	39.7	47.5	56.5	61.0
3.	38.6	40.0	58.0	63.0
4.	32.6	46.7	56.5*	65.4
5.	39.1	44.7	60.8	62.2
6.	32.0	46.2	55.5	67.7*
7.	36.2	40.5	50.3	67.8
8.	35.8	44.2	52.7	-
9.	32.3	41.5	55.9	-
10.	32.7	43.9	58.5	-

*Diet during first 15 days.

Water quality:

During this period the temperature, pH and conductivity were measured with the help of an electric thermometer, pH meter and conductivity meter respectively. The water of each raceway was changed twice a week.

Feed formulation:

A survey of market was done in Rawalpindi and four shops dealing with poultry feed and animal feed was visited and the data was collected. A feed used in Nepal for mahseer culture was selected as test diet (Pantha, 1993). The feed ingredients of this formula were surveyed in the market to find availability then purchased. All the dry ingredients were grinded by using the electric grinder. These ingredients were then weighed separately and mixed together in required quantity to get the desired level of protein. The feed was pelleted using the ordinary electric mincer and feed was dried.

Proximate analysis:

Proximate analysis of test diet was done by Feed Testing Lab. of Poultry Research Institute, Government of Punjab, Rawalpindi.

Statistical analysis:

ANOVA was used to determine the significance of the results.

RESULTS AND DISCUSSION:

Survival and adaptability:

The transportation of fish from wild condition to field was studied and it was found that in five different halts the survival percentage varied. Mortalities are shown in table-2.

Table-2: The survival rate during five trips

First Trip	Second Trip	Third Trip	Fourth Trip	Fifth Trip
Survival	Survival	Survival	Survival	Survival
12	22	13	25	17

The average survival rate during all five trip was 73 percent. *T. putitora* is found in waters of transitional temperature and sensitive to handling stress (Akthar, 1999). The present results confirm that the fish required proper post harvest handling and transportation to avoid mass scale mortality. The adaptability of fish under captive conditions during the study indicated that the survival rate of the fish was independent of body size.

Availability of feed ingredients:

Feed ingredients (Soyabeen meal, fish meal, wheat floor, maize flour, mustard oil cake and rice polish) were available from the local market. They survey indicated that these ingredients are available year round and in quantities required. However, the cost of these ingredients varied according to their demand and supply. A large variety of raw material are available which can be used as fed stuffs in Pakistan (New, 1984).

Water quality:

Water quality of experimental system was studied. During the experimental period temperature ranged from 8-16^{o}C, while pH ranged between 8.0 to 9.0.

Feed formulation and proximate analysis:

The referred feed formula was used to prepared the diet and detail of feed composition ingredients and proximate analysis are given in table-3,

Table-3: Feed ingredients and composition

Ingredients	Soyabean meal	Fish flour	Wheat flour	Maize flour	Rice polish	Mustard oil cake	Vitamin premix
Percentage	35	20	12	12	10	10	1

This feed is generally used in Nepal for commercial fish farming. The availability of feed ingredients formulation of pelleted feed and acceptance of the *T. putitora* can be nursed in tanks and ponds using artificial diets as in case in Nepal and India.

The results of proximate analysis is given in table-4.

Table-4: Proximate analysis

Ingredients	Dry	Moisture	Crude	Crude	Crude	Ash	Aflatoxin

	matter		protein	fat	fiber		(ppb)
Percentage	90	10	27	9.5	4.54	10	19

The literature reveals that feed has 30% protein whereas in the present study the ingredients were mixed strictly with Pantha's formula, the percentage of protein came 27 percent (Pantha, 1993).

Feeding:

Fish were feed on the test diet for thirty days. Fortnightly results were recorded. Mortalities in different groups are given in table-5

Table-5: Mortalities during feeding trials in four groups

Group A (30-40 g)	Group B (40-50 g)	Group C (50-60 g)	Group D (60-70 g)
0	0	1	2

During the feeding trials mortality rate was 8 percent. There was maximum mortality in high weight group. It was noted that there is positive relationship between the size and mortality. No study has been done earlier to corroborate or negate these findings.

There was continues decrease in weight in each group, which showed the negative growth of fish. The average weight loss in each group is shown in figure-1. The results were statistically non-significant. The average weight loss in groups A, B, C and D after fifteen days was 1.89g, 3.69, 2.57g and 2.86g respectively. The average weight loss after 30 days in group A, B, C and D was 3.77g, 4.67, 6.05g and 6.52g, respectively.

The comparison of weight loss among four groups was given in figure 2. The weight loss in group A was maximum and group C was minimum after 15 days. Average weight loss in group D was maximum and in group B minimum after 30 days.

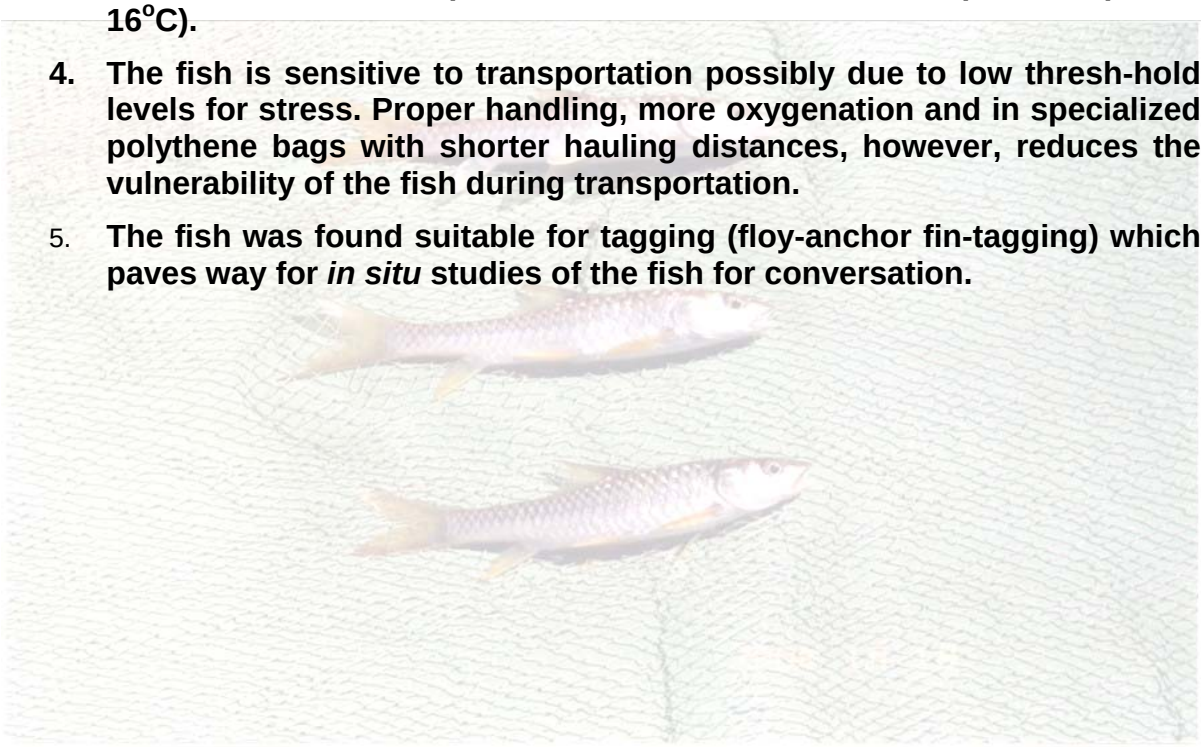
The fish in their normal environment usually undergo protected periods of starvation. The starvation in fish generally known as warm water species, corroborate with low temperature (Javaid, 1967). During their period various physiological parameters of the animals undergo pronounced changes. In carps as the temperature reaches below 10^{o}C activity level decreases, feeding stops (Huelt, 1979, Bailey, 1985, Ali, 1999). Four routine metabolic activity that is sustainability of the fish, body resources starts breaking (particularly fats starts disintegrating) which cause loss of weight. This implication is also evident in fish farming in Pakistan where the cold temperature causes cessation of feeding activity in fish throughout the growth period of our cultural able species varies from 7-9 months in Pakistan depending on the degree of coldness in temperature. *T. putitora* is also a cold blooded carp which has a highly suitable range of temperature between 18-30^{o}C (Akthar, 1994).

CONCLUSION:

1. ***T. putitora*** **can survive at ambient atmospheric temperature in Rawalpindi/Islamabad region (and up to well below 16^{o}C water**

temperature) under captive condition (both concrete flow-throu race-ways as well as earthen ponds) which shows that mahseer can be reared in fish farms. However, careful experimentation is needed to determine the requirements of the fish for domestication.

2. **The known feed ingredients as used in countries like Nepal for preparing artificial feed for other Mahseer are found to be readily available in the local markets. This feed when tried on golden mahseer (*Tor Putitora*) in the form of pelleted feed showed encouraging results insofar as palatability and acceptance is concerned. These results leads to the way for further exploration into suitable diet developments on economic basis.**
3. **It is concluded that *T. putitora* does not feed at low temperature (below 16^{o}C).**
4. **The fish is sensitive to transportation possibly due to low thresh-hold levels for stress. Proper handling, more oxygenation and in specialized polythene bags with shorter hauling distances, however, reduces the vulnerability of the fish during transportation.**
5. **The fish was found suitable for tagging (floy-anchor fin-tagging) which paves way for *in situ* studies of the fish for conversation.**



Chapter-4

IMPACT OF *EL NINO* ASSOCIATED DROUGHT ON SPAWNING AREAS, RECRUITMENT AND ABUNDANCE OF A VULNERABLE GAME FISH *TOR PUTITORA* (MAHSEER) IN KORANG RIVER AND ITS TRIBUTARIES UPSTREAM FROM RAWAL DAM, ISLAMABAD-PAKISTAN[**]

The current episode of *El Nino* confronted Pakistan with its associated phenomenon of drought causing heavy damages. While the damage to agriculture is well documented the impact on fisheries has not been considered. The present study documents the potential effects of drought-associated water decrease in Korang River and its tributaries (upstream from Rawal Dam) on breeding grounds, recruitment, and various population variables of important semi-cold water game as well as commercially important fish *Tor putitora* (Mahseer) which is distinctly known in the region for its vulnerability due to its affinity for habitat that are already critical due to river regulatory structures. The results based on 14 monthly samplings indicate that Mahseer inhibits the investigated river and natural streams as a self recruiting population. However, about 23.8% of the known spawning sites studied were found to be dried, 42.85 % were semi-dried while the rest were still offering favorable habitat for natural spawning. Recruitment variation of the fish has been correlated with hydrological conditions. The results provide the first sets of growth parameter estimates, its exploitation rates and size distribution of this fish from Pakistan in an overall context of species conservation.

The part of these studies were financed by WWF (Pakistan) through their grant (Project # 50018801).

[**] The above paper was accepted and subsequently presented in the prestigious 26th Annual Larval Fish Conference (July 22-26, 2002 – Bergen, Norway) held under the auspices of American Fisheries Society's Early Life History Section and the Norwegian Institute of Marine Research, the Research Council of Norway, the Norwegian Agency for Development Cooperation (NORAD), the Norwegian Ministry of Foreign Affairs, and the European Commission's Fifth Framework Program for Community Research (under the Quality of Life and Management of Living Resources Program).

Purpose of this study:

Assessment of drought damage to stream eco-system and associated *Tor* fishery

And Precisely the aim was to:

To study water decrease in Korang river (up stream from Rawal Dam) and its tributaries on:

- Habitat destruction
- Assessment of wild game fish *Tor putitora* fishery in terms of:
- Recruitment
- Population structure
- Weight length and condition factor relationship

Findings:

As part of wider climatic phenomenon current drought is extended over a greater expanse according to UN reports over 20 countries are in the clutches of DROUGHT, affecting 100 m people.

Climate of Pakistan:

(Most of land is classified as Arid and Sub-arid)

About 68% of land area under = 250 mm annual rainfall

About 30% of land area under = 250 mm annual rainfall

Causes of drought:

- Drought conditions appear when rain producing system fails in succession.
- Winter rainfall fails when tracks of western disturbances which move on to our area from the west remains at a latitude 35^0N hence
  - no secondary western disturbances from below 30^0N so (Sindh and Balochistan dry)
- Subsequent April-May go dry & Temperature become very high.
- In summer monsoon low (depression) form over Arabian Sea or Bay of Bengal fails to reach Pakistan-plains receive no to scanty rains.
- In NWFP and northern areas rain occur due to incursion of South West winds from the Arabian Sea when these are accentuated due to the passing western disturbances.
- Conditions further aggravate if the failure of summer rains is not supplemented rains during October.

Drought, flood *ENSO* and *El-Nino*:

- A study on Monsoon has shown that there is a good correlation between strong Southern Oscillation Index (cold events) and good monsoon years.

- A study on Pakistan monsoon rainfall has shown that in general there is decrease in rainfall in El-Nino years in all the seasons the pre monsoon. The monsoon and the post monsoon.

El-Nino and La-Nina:

- Whenever they appear they change the weather pattern e.g. *El-Nino* occurred in 1982-1983--- the Monsoon in 1983 failed badly.
- The same happened after *El-Nino* of 1997-1998.
- The year 1998 also recorded no significant flood events *La-Nina* at times becomes a source of abnormal weather and may bring flood conditions------
- Such resemblance need to be further examined.

Other Serious losses (Fisheries sector) (according to MINFAL Figures)

40,000 Fishermen have lost their source of earning

20% Reduced catches from inland fisheries sources

Self-perpetuation in mahseer population:

- The results based on 14 monthly samplings indicate that Mahseer inhibits the investigated river and natural streams as a self recruiting population.
- Recruitment variation of the fish has been correlated with hydrological conditions.
- The results provide the first sets of growth parameter estimates, its exploitation rates and size distribution of this fish from Pakistan in an overall context of species conservation.

Loss in breeding Grounds:

- About 23.8% of the known spawning sites studied were found to be dried, 42.85 % were semi-dried while the rest were still offering favorable habitat for natural spawning.
- Default in Migratory run of migratory breeding fishes (Mahseer)
- Possible loss of breeding INSTINCT due to loss of Fluvial Conditions (However, need confirmation)
- Reduction in distribution of Mahseer by size classes
- Reduced freshwater flow into critical habitats
- Decreased influx of nutrient rich freshwater
- Ecosystem and habitat loss

Chapter-5

IDENTIFICATION OF STAKEHOLDERS IN MAHSEER FISHERY AND POSSIBLE THREATS TO THE FISHERY, CONCLUSIVE REMARKS AND INTERVENTIONS NEEDED

The present studies basically were aimed to create base-line information on Mahseer that will shape a vision for the future of this aquatic life, with full contribute to the food security and livelihood of the nutrition of the people who live beside rivers and depend substantially on the fish. Mahseer is a key ingredient on the freshwater of fish menu especially in Punjab, NWFP, Azad Jammu and Kashmir and even for the dissidents living around Hub river system in Balochistan. Mahseer is also a vital factor in the environmental balance in the slow running shallow water systems all along the sub-Himalayan regions. Mahseer is perhaps the most vulnerable fish species of Pakistan as they are not perceived as being a high priority by leaders at all level of society. Who take full responsibility for the many fish related issues? Others more influential, voices, advocate the building of a dam are favor instituting certain employment policies which will, eventually, have a direct impact upon fish supplies and so upon the health and livelihood of the people. The following facts, however, needs to be understood:

1) The fishing sector depending on the Mahseer are some of the poorest and most neglected. It was found that as the Mahseer fetches prime price in the market, therefore, the vast majority of the fisherman who catch them cannot even afford to eat the fish they catch and handle. It was found in the present studies that their are over 200 households living around Rawal Dam and its feeding water systems who entirely depend for their livelihood on fishing. These fishermen folks are, however, more dependent on Mahseer fishery due to its prime quality. A general consensus was that their has been a clear downward fall in Mahseer fish landing since the creation of Rawal Dam in late 60s in as much as 70%. The more worrying situation that it is not only a decline in amount of catch but basically it is the upper-size class fish (which has a high value in market), which has already depleted to the alarmingly low levels. Whole fishery is, therefore, under a critical stress that needs to be addressed through artificial transplantation of Mahseer into suitable natural habitats.
2) One social angle of the whole fishery issue also that people in marginal fishing community living around Soan/Korang and Haro rivers systems are far less like to have access to health services and educational schemes that might help reduce their suffering.
3) Urbanization is having a major impact on the structure of the demand of fish. The demand of high value fish in Islamabad is on a increase. As income increase, wealthier people's taste is moving from low value herbivorous fish to high value carnivorous fish (Mahseer). The fact of the matter is that most of the consumers knowingly or unknowingly are asking for Mahseer fish whenever they are on a fish-vendor stall. All the fish are sold in the market to the unaware consumer by the name of Mahseer. This at one end signifies the importance of Mahseer to a common consumer and the other tends to put the fish under more and more fishing pressure day by day.
4) The Mahseer are increasingly getting popular hence there is much need to learn about fish, its breeding under artificial conditions and ways that could lead to

conservation of this species may be the concept of the protected areas is the best way to protect fish, by setting aside significant natural areas and shielding them as for as possible from human impacts upon both them and their environment. This is become a popular idea, however, I believe that protecting parts of the large rivers could simply lead to over-fishing elsewhere, what's more, the perspective of various organizations and stake-holders that want to put this concept into practice conflict, particularly in terms of the philosophy, funding and management which should govern such protected areas. Pakistan in fact lacks a neutral forum in which to air such dilemmas over different values. Other secondary stakeholders (such as tourists, tourists operators and recreational fisheries) also need to be considered when developing a mahseer fisheries management policy.

5) Mahseer are highly depending upon the environment in which they evolved and hence slight change in environment can devastate the mahseer living there. Sadly fish are at the receiving end of all kind of human activity, the building of dams, the diversion of rivers and drying up or alteration in habitats due to natural calamities such as drought or flooding, have all been found a profound impact on mahseer like many other species of fish. In fact access to freshwater is the most critical of all natural resource issues. Yet the fat of fishes often overlooked is associated debates, as is the impact the devastating of aquatic population has on the people who depend upon fish for their livelihood.

6) The fate of fish mahseer is intimately related toward climate. Certainly *el-nino* effect mahseer fisheries. But we are only just beginning to actual understand the effect they have on fish. Much more needs to be done to advance our knowledge of the links, which exists between fish and climate.

7) Rapid increase in human population changes in land use, and destructive fishing methods have degraded the aquatic habitats to appoint where they can barely support a rich Varity of aquatic species. These are the most fragile, yet also to the most vital, of the eco-systems that supports aquatic life.

CONCLUSIVE REMARKS AND INTERVENTIONS NEEDED:

Because Mahseer serves as a primary food source as well as a source of economic security, and because it is central to the biodiversity of freshwater eco-system, the subject of this fish must be promoted to the level of a key policy issue to the addressed by all facet of the national community. It should not simply to seem as something which is merely the concerned of specialist scientists. There exists substantial data on food fish supply, projected needs for fish, and threats to sustainability in various regions of the world. Communicating that information, via those who help shape opinion, is what will really "bring home" the importance of effective fishing policies. Leaders can help the public understand that fish supply is not just an oceanic issue. Fish is a food source, economic commodity and biological necessity relevant to both the development and developing world.

Science can make a positive contribution to every socio-economic, resource or environmental issue involving fish. Once central contribution today's scientists can make to the dialog on fish is to consider any relevant subject from an integrated, multi-dimensional perspective. The scientific research reflected under these initiatives is ultimately dedicated to the alleviation of human suffering. This initiative is designed to improve people's quality of life, while sustaining fish production and protecting the natural world in which we live.

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