OCCASIONAL PAPER No. 238

THE DECCAN MAHSEER FISHES

THEIR ECOSTATUS AND THREAT PERCEPTS

K. C. JAYARAM

Zoological Survey of India

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RECORDS OF THE
ZOOLOGICAL SURVEY OF INDIA

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Their ecostatus and threat percepts

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INTRODUCTION

India has vast aquatic resources with varied eco-climatic zones, which harbour a rich fish germ plasm resource. Out of 20,000 species of fishes known so far the world over 11% are in our country. About 2200 freshwater fish species have been reported by the National Bureau of Fish Genetic resources out of which 73 species (3.32%) are found in coldwater, 544 (24.72%) in warm freshwaters, 143 (6.51%) in brackish water and 1440 (65.45%) in our vast marine waters (Das, 1994). Available statistics show that India has vast potential for fishery resources and about 29,000 km length of rivers and about 1,13,000 km of canals, about 1.75 million ha of identified water spread in the form of reservoirs and about one million ha in the form of lakes and ponds (Dehadrai, 1987). In this invaluable aquatic resource the fishes of the family Cyprinidae comprising Carps form an important constituent. The Mahseer fishes belonging to this family differ in their size, flavour, activity from the true carps of Europe. It occupies the most important place among the Game fishes of India.

The very name Mahseer invokes nostalgic memories of limitless pleasure of angling for the fish in calm, cool and dales in the mountains of Himalaya, the Western and Eastern Ghats of our country. A good number of game fish lovers and enthusiasts would vouchsafe for the thrills they have enjoyed in hooking a ten pounder and also of the fellows, which gave them a fight and ran away. Innumerable records are known of landings of large sized mahseers and the challenges they posted to get them. The thrill when a big one swallows your bait and the 12-pound line whirrs away into the rapids leaving you gasping in excitement is an unparalleled and inexplicable experience. Records of Mahseers up to a length of 1.7 meters and weighing nearly a quintal or so are known (Thomas, 1897; Burton, 1940). The Putitor Mahseer or the Golden Mahseer is known to reach a size of 2.7 meters in length. "Mussullah" of the Deccan has tilted the scales at 54.1 kg in Karnataka rivers (Burton, 1945, Hora, 1943). Unfortunately with the fast changing environmental scenario and habitat shrinkage in our country Mahseers have become endangered due to over fishing and change in stream ecology in which these thrive. The National Committee on Agriculture (Anon, 1976) in its report on "Fisheries" stated that it has been reported that there has been a general decline in Mahseer fishing due to indiscriminate fishing of brood fish and adverse effects of our river valley projects. Unscrupulous elements are employing varied methods of destruction under the garb of fishing which include using crude home made by dynamites and even electrocuting to plunder the rivers. This is mainly because as is aptly called the "tragedy of the Commons" which means if something such as a forest area, a water body like remote river stretches, is without a owner or is unclaimed, forlorn or forsaken or not used it becomes the property of everyone and anyone who rushes to exploit it and ultimately destroy it beyond redemption. As a result of such undesired activities the Mahseer fishes are now in danger

of becoming almost extinct. Sighting records of large sized and heavy weight mahseer fishes are a rarity. In Protected Areas, sanctuaries by side of temples as in Dehu, Alandi on river Indrayni, Sringeri on Thungabhadra, Ramanathapura on Cauvery in Karnataka and water bodies in Sacred Groves they are zealously guarded. Even if caught from their habitats the size range is small. A slow recognition has now come of the danger of loosing these valuable resources from posterity. Some steps and efforts have been taken by State Governments as Karnataka, Himachal Pradesh and Maharashtra. NGO bodies as the Tata Electric company at Lonavla have also rendered yeomen service. To have the populations re-established as in olden days in all its natural habitats would be ideal but only a utopian dream under the present circumstances.

II. ACKNOWLEDGEMENTS

The investigations outlined in this monograph were carried out under the aegis of the Pitambar National Environment Fellowship awarded to the author by the Ministry of Environment and Forests, Govt. of India to whom I am greatly indebted. Dr. J. R. Bhatt, Additional Director, Dept. of Environment in the Ministry was all support throughout. The late Dr. C. V. Kulkarni, former Director of Fisheries, Govt. of Maharashtra gave me very useful suggestions and on his initiative and directive I contacted Sri S.V.Valsangkar, Retd. Fishery Development officer, Satara and Dr. S. N. Ogale of the Tata Fish Farm at Lonavla who assisted me in field collections, offered literature and helped in procuring the Deecan Mahseer fish specimens. The Karnataka state fisheries arranged my field work on both Dakshina and Uttara Kannada by providing transport facilities and the assistance of their field officers. In particular I am thankful to Dr. Shanumukha, Director and Dr. Abdul Hameed, Additional Director in this regard. In a similar manner the Tamil Nadu State fisheries department assisted in the field collection at Sholayar, Bhavani Sagar and Shri Bhaskaran of this department was of great help. Prof. Madhav Gadgil, Dr. Harish Bhatt, of the Centre for Ecological Sciences, I.I.Sc, Bangalore provided transport facilities and guidance. Prof. N.A. Madhyastha, Udupi corrected the localities in Karnataka. The Kerala Forest Research Institute at Peechi lent the services of Shri C. P. Shaji for collection of *mussullah* from difficult terrain in Maanchery. Dr. P. S. Easa of the same institute arranged my interaction with several anglers and sport fish lovers. Dr. A. Johnson of the Centre for Environmental Sciences, Alwarkurichi accompanied me in field collection in Dakhina Kannada at Sringeri. Dr. M. A. Arunachalam of the same center joined me in the field collection in Karnataka. Dr. K. P. Sanjayan, Guru Nanak College, Chennai greatly helped in the statiscal analysis and interpretation. The National Bureau of Fish Genetic resources, Lucknow gave me permission to reproduce their findings in respect of the Deccan Mahseer fishes. Dr. Sanjay Molur, Coordinator, IUCN, based at Conservation Breeding Specialish Group (CBSG), Coimbatore whetted and guided me in assessing the eco-status of the three species for which I am most indebted to him. The Australian Museum, Sydney, Rijksmuseum, Leiden, California Academy of Sciences, San Francisco, Salim Ali Center for Ornithology and Natural Sciences, Coimbatore lent their specimens

of *Tor* species for my examination. Drs. Walter Rainboth, Carl J. Ferraris gave their opinion regarding the generic status. Drs. Prachya Musikasithorn. Kobayakawa, H. H. Ng readily supplied some much-needed references. Shri Margabandu, Shri Seshan of ZSI, Chennai assisted in the photograph of some specimens. To all these persons I owe my sincere thanks.

III. Abbreviations and Condesations

AMS	—	Australian Museum, Sydney
CAS	—	California Academy of Sciences, San Francisco
HCPD	—	Height at Caudal peduncle
KFRI	—	Kerala Forest Research Institute, Peechi, Thrissur.
LCPD	—	Length of Caudal peduncle
LL	—	Lateral line
L/1	—	Lower lobe
RMNH	—	Rijksmuseum van Naturlijke Historie, Leiden
SL	—	Standard length
U/1	—	Upper lobe
ZSI HQ	—	Zoological Survey of India, Headquarters, Kolkata
ZSI SRS	—	Zoological Survey of India, Southern Regional Station, Chennai
ZSI WGRS	—	Zoological Survey of India, Western Ghat Regional Station, Calicut
ZSI WRS	—	Zoological Survey of India, Western Regional Station, Pune

IV. NAME, FAME AND ETYMOLOGY

The term Mahsir, Mahseer or Mahseer has several connotations. The existence of such a big sized game fish is known from Vedic times. Prashad (1932) in his article on "some pre-Linnaean writers of Indian zoology has shown on the authority of Seal (1915) that earlier Hindu writers as Caraka, Prasatpada, Susruta, Sankara and Omasvali had not only a fair good knowledge of the classification of animals but were also familar with their anatomical details. King Someswara (1127 AD) in his 'Matsyavinoda' or a chapter on Angling on the Manasollasa mentioned "Mahasila" which Hora (1951 : 159) identified as referable to the Deccan Mahseer *Tor mussullah*. It would thus appear that the earliest name pronounced for these fishes is 'Mahasila' by King Someswara (1127 AD). Based on this, other terminologies as 'Mahasir', 'Mahseer', 'Mahasher' etc seem to have originated. Thomas (1897) thought that the word Mahseer is perhaps derived from the Hindustani words 'maha'=great and 'sir', pronounced 'seer'=head, meaning big-headed which is apt as these have their head fairly large. A Persian derivation is 'mahi' fish and 'sher' lion in recognition of the fighting qualities of the fish. This is however inapt as is fanciful and far fetched. Yule and Crooke (1903) consider that the term Mahseer is derived from

'mahasiras' the reference not only to greatness or bigness of the fish mouth but also to the front part of the fish, the head and snout. A view is expressed that the derivation is from 'mahasirsha' without altering the gender. The dropping of the final 'sha' in a corrupt word is not improbable in the course of time. Siras' or sirsha' mean the same. It is possible the word Mahseer is a colloquial form of 'Mahasirsha' or 'Mahasiras' Lacy and Cretin (1903) opine that the word is derived from 'Mahasula', 'Mahasilka' which mean big scaled. The natives in parts of Maharashtra call even now the fish as 'Mahsol' It is a fact that the mahseer fishes have got bigger scales than any other freshwater Indian Cyprinids. The big scale is one of the easy way to identity characters for this fish. A big fully grown mahseer may have scales as big as the palm of one's hand. The scales are reported to be used as playing cards in some parts of India. Another derivative (Dhu, 1923) is from 'Matsya'–a Sanskrit word for fish used in Vedas and the Mahseer is undoubtedly the sacred fish of India. It is more likely that Mahseer is simply a corruption of Matsya.

Whatever may be the derivation, the name commonly accepted and widely used is Mahseer and is popularly applied to the nine species of this group known from the Indian subcontinent. The species are listed elsewhere (p. 6).

Of the nine species except *Tor mosal* and *Tor progenius* all other species are fairly established. Only three species are confined to the Deccan peninsula and more particularly along the Western Ghats. It is a well known fact that the Western Ghats is one of the 'Hot Spots' of Biodiversity in our country along with Assam and eastern areas. These three species have been subjected to heavy dissemination with the result that they have become endangered to a varying degree. In the following pages the discussion and treatment will only be in respect of these three species.

V. TAXONOMY

It is essential to know about the definite specific status of each species since much confusion is caused in fishery circles in exactly identifying the defining characters. This is mainly due to lack of comprehension of the taxonomic features of each species many of which overlap and vary. In fact, some problems have arisen in recent years in respect of the generic allocation of some species; such as *mussulah* Sykes being referred to under the genus *Hypselobarbus* Bleeker. These aspects are discussed below.

Most earlier workers as Hamilton-Buchanan (1822), Sykes (1841), Day (1877) grouped the Mahseer fishes under the genus *Cyprinus* Linnaeus or *Barbus* Cuvier, the wide basket for all fishes known at that time of taxonomic concept. It was Thomas Edward Gray (1834) who established the genus *Tor* to accommodate *Tor hamiltonii* Gray=*Cyprinus tor* Hamiton-Buchanan. Gray's *T hamiltonii* is an unneeded substitute for *Cyprimus tor.* Hora (1939) elucidated the generic features and subsequent authors followed the nomenclature. However it must be mentioned here, that Hora adopted it as a subgenus of *Barbus* Cuvier and not as a full-fledged genus. It was Smith (1945) who provided the correct generic status for the name which is now widely adopted. Though in a short sense the name

'Mahseer' is to be adopted for fishes under the genus *Tor* many naturalists and anglers have applied the name for all large sized carp species with big scales as those of *Accrrossocheilus* Oshima, *Chagunius* Smith etc.

The diagnostic features of the genus are detailed below.

1. Genus *Tor* Gray

Tor Gray, 1834, *Illustrations of Indian Zoology*, 2, pl.96 (type species *Tor hamiltonii* Gray, 1834 = *Cyprinus tor* Hamilton-Buchanan, by monotypy, an unneeded substitute).– Smith, 1945, *Bull U. S. Nat Mus.* No. **188** : 137 (generic status)-Sen & Jayaram, 1986, *Occ. Paper Zool. Surv. India* **39** : 3 (review).-Talwar & Jhingran, 1991, *Inland Fishes of India* 1 : 301 (Diagnosis).-Jayaram, 1999, *Freshwater fishes of the Indian Region* : 95 (Diagnosis, list of species).

Diagnosis : Body elongate anteriorly, trunk and peduncle smoothly tapering. Abdomen rounded. Head rather small, broadly pointed. Snout prominent, angularly rounded, often with tubercles. Mouth inferior to sub-inferior, upper jaw often protracting, no horny covering on lower jaw, small, maxillary not extending to vertical anterior margin of eye. Eyes far forward, large and not visible from below ventral surface. Infra-orbital bones rather narrow. Lips fleshy, fringed, continuous at angles of mouth, posterior lip with a median lobe (mentum), thick or thin or at-least with two notches delimiting the usual position of the lobe; post-labial groove continuous; lip condition variable, may even be hypertrophied. Pharyngeal teeth in 3 rows 2, 3, 5; 5, 3, 2. Four barbels, a pair each of maxillary and rostral. Dorsal fin with a scaly sheath at its base, inserted above pelvic fins,

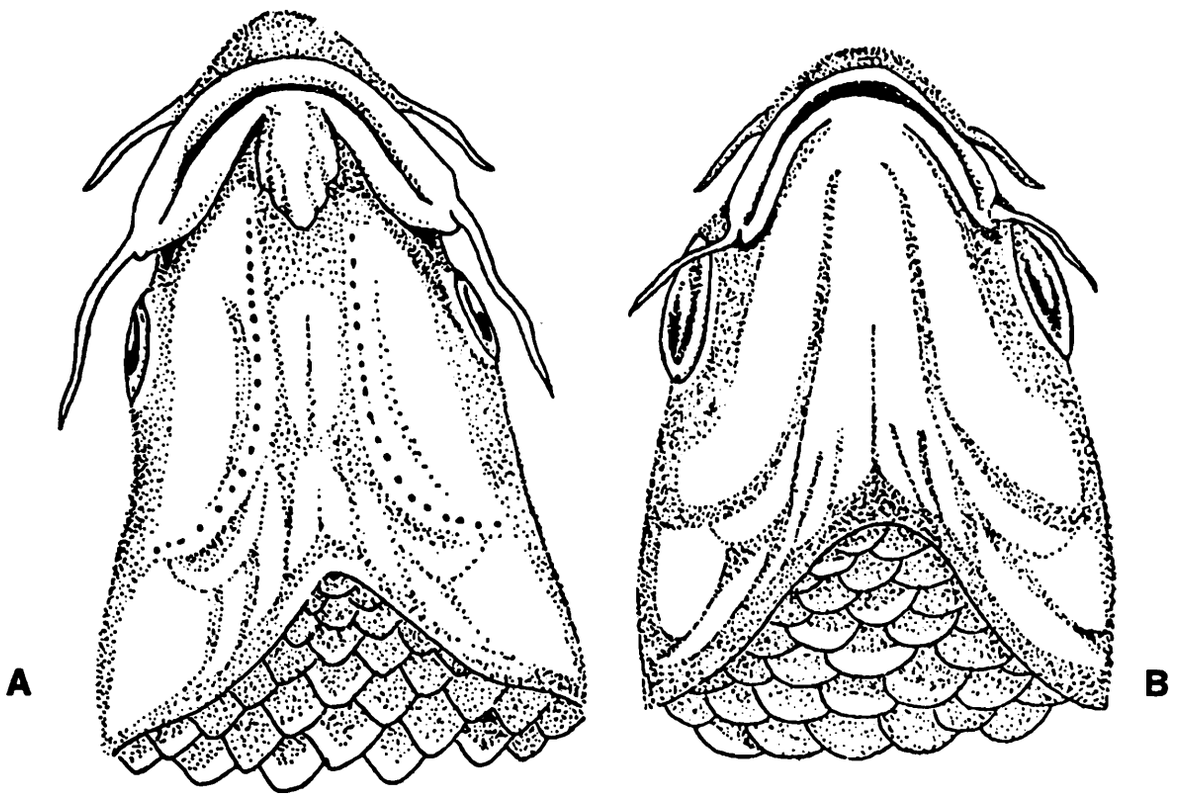

Fig. 1. A Ventral view of *Tor tor* (Hamilton-Buchanan) to show the continuous labial fold and the mentum. B. Ventral view of *Neolissochilus* species to show the discontinuous labial fold.

with 12 or 13 rays (eight or nine branched mostly), and a strong, stout smooth spine. Pectoral fins low. Anal fin with seven or eight rays (five branched mostly). Scales large, heavy, with numerous parallel striae. Lateral line complete with 22 to 27 scales running in middle lower part of caudal peduncle and terminating at mid-base of caudal fin.

Distribution : Throughout India, Bangladesh, China, Myanmar, Nepal, Pakistan, Thailand. Also Israel, Syria, most of Arabian peninsula south to Yemen.

Ramerks : The genus has been defined by many ichthyologists and the character of the median lobe (mentum) and the continuous post labial groove (Text-Fig. 1 A & B) have been indicated as diagnostic (Wu et al 1977; Chen & Chu 1985, 1989; Zhou Wei & Gui-Hua, 1996; Kottelat & Whitten, 1993).

Species

1. *Tor khmdree* (Sykes). India : Peninsular India especially Western Ghat hill streams in Karnataka, Kerala, Maharashtra and Tamil Nadu. Also Sri Lanka.
2. *Tor mosal* (Hamilton-Buchanan). Myanmar.
3. *Tor mussullah* (Sykes). India: South Indian rivers Bhavani, Cauvery, Moyar river systems. Also Krishna river system in Maharashtra.
4. *Tor neilli* (Day). India : Krishna, Tungabhadra river systems in the Western Ghats. Also Kurnool in Andhra Pradesh.
5. *Tor putitora* (Hamilton-Buchanan). India all along the Himalaya. Bangladesh, Nepal, Pakistan.
6. *Tor progenius* (McClelland). India; Arunachal Pradesh, Assam, Naga hills, Nagaland.
7. *Tor tor* (Hamilton-Buchanan). India : foothills of Himalaya, Assam, Bihar, Madhya Pradesh, North Bengal. Bangladesh, Pakistan.
8. *Nazirilor chelynoides* (McCelland). India; foothills of Himalaya as far East as Assam and the Ganga.
9. *Naziritor zhobensis* Mirza & Javed. Pakistan : Zhob river system.

The following species are also known whose systematic position is discussed under the respective nominal species with which they have been synonymised.

1. *Tor khudree malabaricus* (Jerdon) 2. *Tor kulkarnii* Menon 3. *Tor moyarensis* Arunachalam 4. *Tor megalepis* Jerdon 5. *Tor khudree longispinnis* (Gunther). Of the above nine valid species this monograph deals only with the three south Indian or Decean Mahseer fishes (*Tor khudree, T mussullah* and *T neilli).*

Key to the species of the Deccan Mahseers

1. Length of head considerably greater than body depth ..... *T khudree*
– Length of head considerably shorter than or more or less equal to body depth .. 2

2. Mostly 4½ scales between base of dorsal fin and lateral line. A distinct hump over occiput. Dorsal spine strong ..... *T mussullah*

– 3 to 3½ scales between dorsal fin base and lateral line. No such hump over occiput. Dorsal spine weak ..... *T neilli*

Tor khudree (Sykes)
(Text-Fig. 2)

Barbus khudree Sykes *Proc. zool. Soc. London* : 159, 1838 (type locality, Mutha Mula river, Pune).-Sykes, **2**: 357, 1841 (Mutha Mula river, Pune).-Jerdon, *Madras J. Lit. & Sci.* **15** : 313, 1849.-Bleeker, *Verh. Bat. Gen.* **25** : 60, 1853 (name only, list of fishes from India).-Gunther, *Cat. Fish. Brit. Mus.* 7 : 130, 1868 (as a synonym of *Barbus mosal).*- Hora & Misra, *J. Bombay nat. Hist. Soc.* **39** : 505, 1937 (Waldi, Darna rivers, Deolali); : 511 (Aounda river, Deolali); : 512 (Lake Beale, Deolali) : 513 (Godavari river, Nasik city); 515 (Narasullah Wadi, Bagoor village, Deolali).–Hora & Misra, *J. Bombay nat. Hist. Soc.* **40** (1) : 25, text-figs. 1 & 2, 1938 (systematic position, description; headwaters of Godavari river).-Hora, *J. Bombay nat. Hist. Soc.* **43** (2) : 167, 1942 (Poona waterways), pl. 1 (specimen from Bhawani river). Hora, *J. Bombay nat. Hist. Soc,* **44** (1) : 6, fig. 3, 1943 (River Ulhas, Bombay).-Hora, *J. Bombay nat. Hist. Soc.* **44**(2) : 166, 1943 (comparison with *B. mussullah; B. hamiltoni* and *B malabaricus* synonymised).

Barbus (Tor) khudree. Hora & Misra, *J. Bombay nat. Hist. Soc.* **40** : 24 (Mysore). -Hora, *J. Bombay nat. Hist. Soc.* **44** (1) : 5 (Ulhas, Cis Ghat area, North Bombay).-Hora, *Rec. Indian Mus.* **44** : 195, 1942 (name only, distribution given as Sri Lanka, Peninsular India, Deccan and Satpura Trend).-Mahmood & Rahimullah, *J. Bombay nat. Hist. Soc.* **47** : 109, 1945 (Manjira river, Nizamsagar).-Chauhan, *Rec. Indian Mus.* **45** : 270, 1947 (Ang river, Bolangir dist. Orissa, identification doubtful).-Menon, *Proc. nat Inst. Sci. India* **17** (6) : 484, 1951 (distribution given as Sri Lanka, Peninsular India, Pachmarhi, Kaimir hills on Satpura-Vindhya trend).-David, *Indian.J. Fish.* **2** (1) : 32, 1955 (record of Chauhan 1947 cited).

Tor tor, Deraniyagala, *Spolia zeylanica* **6**, 23, pls. I, IV, 1930 (Sri Lanka, misidentification).

Puntius (Tor) khudree, Kalawar & Kelkar, *J. Bombay nat. Soc.* **53** : 672, 1955 (Kolhapur)

Barbus humiltoni (nec Gray), Jerdon, *Madras Lit. & Sci :* **15** : 211 (freshwaters of southern India).

Tor khudree, Chauhan & Ramakrishna, *Rec. Indian Mus.* **51** (3), pl. 12, fig. 7, 1953 (Ang river Salebhatta, Bolangir state, Orissa).-Rajan, *J. Bombay nat Hist. Soc.* **53** (1) : 45, 1955 (Bhavani river headwaters).-Rajan, *Proc. Indian Acad. Sci.* **58** : 296, 1963 (Pykara and Moyar rivers, Nilgiris).-Datta & Majumdar, *Rec. zool. Surv. India* **62** (1 & 2) : 91, pl. 8, fig. 4, 1970 (Fateshsagar Lake, Parwan rivers, Jaisamund lake, Rajasthan; misidentification.)-Venkateswarlu, *Indian J. Zoolomy.* **13**(3) : 122, 1972 (name only; Bihar, misidentification).-Hora, *J. Zool. Soc. India* **57** (!–4) : 149, text-fig. 73, 1962 (Orissa, U. P. Peninsular India).- David, *Proc. nat. Sci. India* **33** (B) : 280, 1963 (Godavari, Krishna rivers).-Jayaram, *Handbk. Freshwater fish India:* 124, pl. 3, E, 1981 (Karnataka, Kerala, Maharashtra, Sri Lanka).–Jayaram et al, *Occ. Paper Zool. Surv. India* No. **36** : 71, fig. 16, 1982 (Cauvery river throughout).- Tilak & Sharma, *Game fishes of India and Angling*: 46, figs. 8 & 9, 1982 (Madhya Pradesh, Deccan and Peninsular India)–Sen & Jayaram, *Occ. Paper Zool Surv. India* No. **39** : 7, 1982 (Peninsular India south of Tapi river).-Venkateswarlu, *Occ. Paper zool. Surv. India* No. **56** : 39, 1984 (vernacular names).-

Datta & Barman, *Rec. zool. Surv. India* **82** (1-4) : 279, 1985 (Namdhapa National park).-Talwar & Jhingran, *Inland Fishes*, **1** : 303, fig. 106, 1991 (Deccan and entire peninsular India, Sri Lanka).-Pethiyagoda, *Freshwater fish Sri Lanka:* 133, 1991 (fast flowing rocky streams above 1000 meters, Sri Lanka).-Menon, *J. Bombay nat. list. Soc.* **89** (2) : 210–228, 1992 (systematic position discussed).-Ghate, *Proc. I National Symp. Env.Hydraulics* : 120, 1992 (Rivers Neera near Veer Dam, Pune, rare and seasonal).-Ghate, Wagh, Lakhande, *Proc. I Symp. Env. Hydraulics* : 110, 1992 (River Mula Mutha, Pune, recorded for the first time from the type locality; topotype).-Easa & Basha, *Kerala Forest Res. Inst. Bull.* No. **104** : 29, 1995 (Kanjirapuzha, Maancherry in Chaliyar river system).-Jayaram, *Occ. Paper Zool. Surv. India* No. **160** : 107 1995 (Upper reaches of Krishna river, Sangli, Satara districts, Maharashtra, Sri Sailam in Andhra Pradesh).-Shaji, Easa & Chand Basha, *J. Bombay nat Hist. Soc.* **92** : 361, 1995 (Cheenkarnaipuzha, Valayanchal, Narikadavu in Aralam Wildlife sanctuary, Kerala).-Jayaram, *J. Bombay nat Hist. Soc.* **94** : 53, 1997 (differentiation from *Tor mussullah* discussed). -Manimekelan, *J. Bombay nat. Hist. Soc* **95** (3) : 437, 1998 (Moyar near Kargudi, Mudumalai Wildlife sanctuary).-Shaji & Easa. *J. zool. Soc. Kerala* **6** & **7**. 89, 1999 (Chalakudy river).-Jayaram, *Freshwater fishes of the Indian region* : 96, 1999 (Peninsular India especially Karnataka, Kerala, Maharashtra hill streams, Sri Lanka).- Menon, *Occ. Paper Zool Surv. India* No. **175** : 57, 1999 (check list).

Barbus malabaricus Jerdon, *Madras J. Lit & Sci.* : 312, 1849 (type locality mountain streams of Malabar).-Gunther, *Cat Fish Brit. Mus.* **7** : 82, 1868 (treated as a doubtful species of *Barbus).*- Day, *Fish India* : 567, pl. 138. fig. 6, 1877 (Courtallam).-Day, *Fauna Brit. India Fish* **1** : 314, 1889 (South Canara down Western Ghats to Travancore hills).- Jenkins, *Rec. Indian Mus.* **3** : 289 (1909).-Annandale, *Rec. Indian Mus.* **16** : 125, 1919.- Hora & Law, *Rec. Indian Mus.* **43** (2) : 235, 1941.-Hora, *J. Bombay nat. Hist. Soc.* **44** (2) : 166, 1943 (synonymised with *Barbus khudree).*-Johnsingh & Vickram, *J. Bombay nat. Hist. Soc.* **84** (3) : 531, 1987 (successfully introduced in Tamirabarani river above Bhanatheertham water falls).-Venkateswarlu & Rama Rao, *Occ. Paper Zool Surv. India* No. **87** : 13, 1986 (equivalent to Day's *Puntius malabaricus).*-Kulkarni, *J. Bombay nat. Hist. Soc.* **57** : 672, 1955 (Kolhapur).-Kulkarni, *J. Bombay nat. Hist Soc.* **75** (3) : 652, 1978.-Sen & Jayaram. *Occ. Paper Zool. Surv. India* No. **39** : 13, 1981 (South Canara, Western Ghats).

Barbus (Tor) khudree malabaricus, Macdonald, *J. Bombay nat Hist Soc.* **44** (3) : 52, 1944 (S. Canara, Western Ghats, Travancore Hills).-Silas, *J. Bombay nat. Hist. Soc.* **49** (Valparai, Vannamudi bridge, Anaimalai hills).

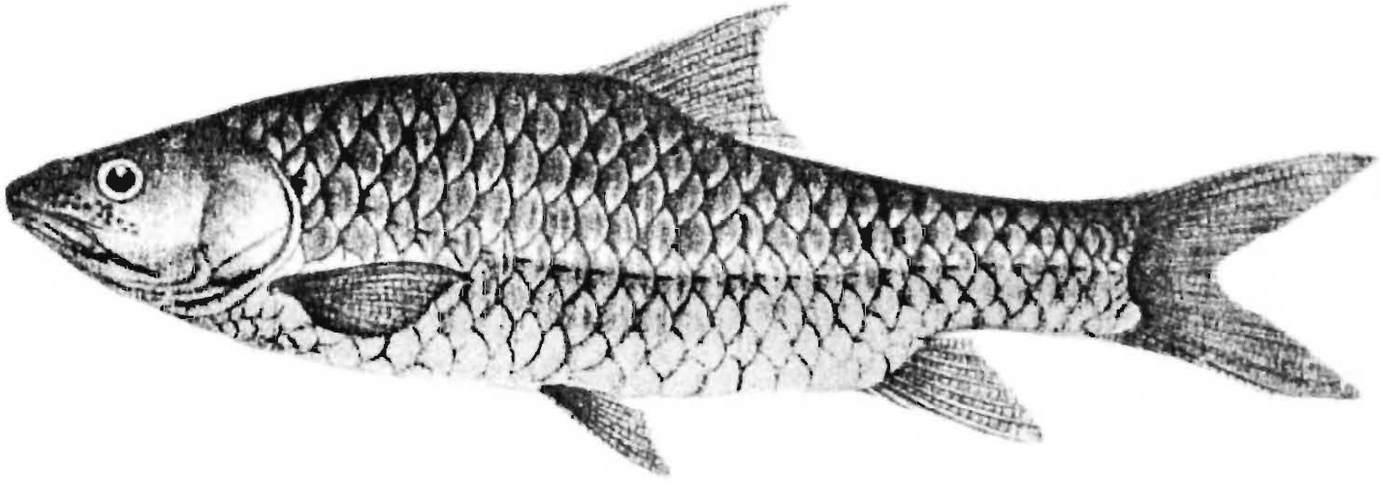

Fig. 2. *Barbus (Tor) khudree* Sykes X ca ½ drawing made from colour sketch sent by Dr. M. Suter.

Barbus longispinis Gunther, *Cat. Fish Brit. Mus.* **7** : 132, 1868 (Ceylon).

Tor khudree longispinis, Silas, *Bull Nat Inst. Sci. India* No **7** : 251, 1952 (Sri Lanka).- Jayaram, *Handbk. Freshwater Fishes of India* : 124 : 1981.

Barbus megalepis Jerdon (nec McCleland), *Madras Lit. & Sci.* **15** : 311, 1849.

Tor kulkarnii Menon, *J. Bombay nat. Hist. Soc.* **89** (2) : 210–228, pls. 1-3, figs 1–5, 1992 (type locality Darna river, Deolali).

Vernacular Names : Arraham, Irraham–Telugu. Barsa, Warris, Khudchee, Khadra, Khadashie Marathi. Nill Meenu–Kannada. Attu kendai, Menival–Malayalam. Kudi, Khusra–Oriya. Bringa, Poomeen, Ponnuseni, Kardi-Tamil.

Specimens Studied :

RECENT COLLECTIONS

1. ZSI SRS Unregd. Five exs. 112-442 mm SL River Kapila at village Shesheela, Bethangade taluk, Dakshina Kannada, Karnataka, Karnataka state, K.C. Jayaram coll. 11-04-1996.

2. ZSI SRS Unregd. Two exs. 164 & 325 mm SL, Thingale, Sita Nadi, Dakshina Kannada, Karnataka state, K. C. Jayaram coll. 11-04-1996.

3. ZSI SRS Unregd. Two exs. 213 & 223 mm SL, Satara fish market, Satara district, Maharashtra state, purchased. K. C. Jayaram coll. 05-05-1988.

4. ZSI SRS 10 exs. 143 to 206 mm SL, Morna River, tributary of Koyana River, Satara dist., Maharashtra state, K.C. Jayaram coll. 28-01-1997.

5. CAS 141230, Two exs. 162 & 195 mm SL, Pune, Pune district, Maharashtra state.

6. CAS 141229, Two exs. 59 & 60 mm SL from the surf in a rock cave at Konival 10 miles south of Trivandrum, Kerala state. A. W. C. T. Herre coll. 19-01-1941.

7. CAS I34603, two exs. 64 & 79 mm SL, Deolali, Nasik dist. Maharashtra state. A. G. L. Fraser coll. Oct. 1935.

8. ZSI unregd. Six exs. 60-107 mm SL. Chenkarimpuzha, Malapuram dist. Kerala state, C.P. Shaji coll. 20-04-1995.

9. ZSI Unregd. Four exs. 90-140 mm SL Chalakudipuzha, Athrapalli near Chalakudy, Kerala state, C. P. Shaji coll. 20-04-1995.

10. ZSI Unregd. One ex. 105 mm SL, Pullikayam, Chaliyar River, Kerala state, C. P. Shaji coll. 18-05-1996.

11. ZSI Unregd. Two exs. 117 & 140 mm SL, Periyar Lake, Kerala state, L. K. Arun coll. 1995.

12. ZSI Unregd. One ex. 56 mm SL, Oonchahalli, Gangavali river, Uttara Kannada dist. Karnataka state, K. Vasantha coll. 31-05-1996.

13. SACON three exs. 63-113 mm SL, Karimpuzha, Malapuram dist. Kerala state, D. F. Singh & A. Manimekalan coll.

14. ZSI Unregd. 55 exs. 32-165 mm SL, Morna River , tributary of Koyana River, Satara dist. Maharashtra state, K. C. Jayaram coll. 28-01-1997.

15. ZSI Unregd. One ex. 464 mm SL, Koyana reservoir, Satara dist. Maharashtra state, K. C. Jayaram coll. 27-05-1997.

16. ZSI Unregd. Two exs. 40 & 48 mm SL, Thunga River, Upstream of Sringeri, Dakshina Kannada, Karnataka state, K.C. Jayaram coll. 12-02-1997.

17. ZSI Unregd. 17 exs 21-36 mm SL Thunga River, upstream of Sringeri, Dakshina Kannada, Karnataka state, S. Johnson coll. 12-02-1997. (Data not taken).

18. ZSI Unregd. Two exs. 144 & 175 mm SL, Thunga River, Chiplagudde, Dakshina Kannada. Karnataka state, K.C. Jayaram coll. 11-02-1999.

19. ZSI Unregd. Two exs. 188 & 234 mm SL, Thunga River, Hariharapura, Dakshina Kannada, Karnataka state, K. C. Jayaram coll. 12-02-1999.

EARLIER COLLECTIONS

20. ZSI Unregd. Three exs. 86–169 mm SL, Satara fish market, Satara dist. Maharashtra State, Krishna river survey, K. C. Jayaram coll. 01–01-1988.

21. ZSI Unregd. One ex. 180 mm SL, Panchwad village, west of Karad, Satara dist. Maharashtra state, K.C.Jayaram coll. 20-02-1987.

22. ZSI Unregd. One ex. 165 mm SL, Karad fish market, Karad, Satara dist. Maharashtra state. K. C. Jayaram coll. 01-01-1988.

23. ZSI Unregd. Two exs. 139 & 156 mm SL, Mahuli village, Satara dist. Maharashtra state, K. C. Jayaram coll. 01-01-1988.

24. ZSI Unregd. One ex. 245 mm SL, Krishna River at Huvinahadagi, Raichur dist. Karnataka state, K. C. Jayaram coll. 22-12-1987.

25. ZSI Unregd. One ex. 139 mm Sl, Krishna river at Lingalagattu, Srisailam, Kurnool dist. Andhra Pradesh, K. C. Jayaram coll. 03-06-1988.

26. ZSI Unregd. Five exs. 79-124 mm SL, Wai fish market, Wai, Satara dist. Maharashtra state, K. C. Jayaram coll. 09-03-1990.

27. ZSI Unregd. Two exs. 157 & 185 mm SL, Venna Lake, Mahabaleshwar, Satara dist. Maharashtra state, K. C. Jayaram coll. 07-05-1988.

28. ZSI Unregd. 13 exs. 33–97 mm SL, Ondishi village on Krishna river headwaters, Satara dist. Maharashtra state, K. C. Jayaram coll 08-05-1988.

29. ZSI Unregd. One ex. 87 mm SL, Krishna River at Babaladi, Jamkhandi, Bijapur dist. Karnataka state, K. C. Jayaram coll. 19-05-1988.

30. ZSI Unregd. Two exs 90 & 105 mm SL, Mydrasal village, Sangli, Satara dist. Maharashtra state, K. C. Jayaram coll. 16-05-1988.

CAUVERY RIVER COLLECTIONS

Data not incorporated in this monograph due to non-availability of earlier records/ data sheets owing to long time lapse.

31. ZSI Unreg. Two exs. Cauvery River at Tiruvelangadu at regulator with Vikraman River, Thanjavur dist. Tamil Nadu, K. C. Jayaram coll. 17-02-1972, 25-01-1974.

32. ZSI Unregd. Two exs. Kudamurutty River at Rajagiri at its bifurcation as Tirumalairajan, Kudamurruty, 16 km West of Kumbakonam, Thanjavur dist. Tamil Nadu, K. C. Jayaram coll. 23-03-1973, 29-01-1974.

33. ZSI Unregd. Two exs. nursery canals on bank of Kudamurutty River at Rajagiri, TK Head, Thanjavur dist. Tamil Nadu, K. C. Jayaram coll.

34. ZSI Unregd. One ex. Coleroon River at Lower Anicut, 26 km east of Kumbakonam town. Thanjavur dist. Tamil Nadu, K. C. Jayaram coll. 30-11-1974.

35. ZSI Unregd. Three exs. Coleroon River at Grand Anaicut, 43 km west of Thanjavur town, Thanjavur dist. Tamil Nadu. K. C. Jayaram coll. 28-03-1973, 03-02-1974, 01-02-1977.

36. ZSI Unregd. Six exs. Kudamurutty River at its bifurcation from Cauvery River as Tirukattupally, Thanjavur dist, Tamil Nadu, K. C. Jayaram coll. 28-03-1973, 03-02-1974, 02-01-1977.

37. ZSI Unregd. Three exs. Cauvery River at Mayanur below Mayanur relulator. 21 km west of Kulithalai town, Tiruchy dist. Tamil Nadu, K. C. Jayaram coll. 03-04-1973, 07-02-1974.

38. ZSI Unregd. Six exs, Aiyan channel at Vathalai village, Tiruchy dist. Tamil Nadu, K. C. Jayaram coll. 06-04-1973.

39. ZSI Unregd. Three exs. Cauvery at Bagamandala, 33 km west of Merkere, Coorg dist. Karnataka state, K.C. Jayaram coll. 04-10-1975, 04-05-1977.

40. ZSI Unregd. Two exs. Cauvery River at Sivasmudram falls, Karnataka state, K. C. Jayaram coll. 18-10-1975, 13-05-1977.

MISCELLANEOUS COLLECTIONS

41. ZSI SRS Unregd. One ex. 254 mm SL Nizamsagar Andhra Pradesh, T. Venkateswarlu coll.

42. ZSI SRS F. 12523/1, two exs. 137 & 102 mm SL Darna River, A. G. L. Fraser coll. No date known.

43. ZSI SRS F 12522/1, one ex. 48 mm SL Darna River, Pimpalgaon village, A. G. L. Fraser coll. No date known.

44. ZSI SRS F. I 695/2, one ex. Krishna River, Satara, Satara dist. Maharashtra state, H. S. Rao coll. No date known.

A total of 184 specimens of different sizes and almost covering the entire range of distribution of the species have been studied over a period of many years. However detailed measurements and analysis were done only on 102 examples, unless otherwise stated, on which basis the following description is drawn.

Description : I-III, 6-9 (ii, 9 in 45%); P.i, 9-15 (i, 13 in 27.8%); V. (i, 7-8) (i, 7 in 50%) A.i-ii, 4-6 (i, 5 in 83%); C. 7-9 + 9 + 9 (8 + 8 in 63.8%). Dorsal and ventral profiles slightly arched tapering more towards anterior. No narked hump at occiput. Head small, 28.6(21.7-29.0), body depth 26.3(21.7-29.0), pre-dorsal length 50.0(45.2-55.6) (N = 96), post-dorsal length 52.6(45.5-55.6) (N = 95) all in percent of standard length. Eyes not visible from below ventral surface, in anterior part of head, moderately large 58.9(40.0-00) in percent of snout length, 66.7(38.5-100) in percent of inter-orbital width, which is flat. Eyes 21.3 (14.5-31.3), snout 37.0 (22.7-62.5), height of head at occiput 71.4 (58.8-100), head width

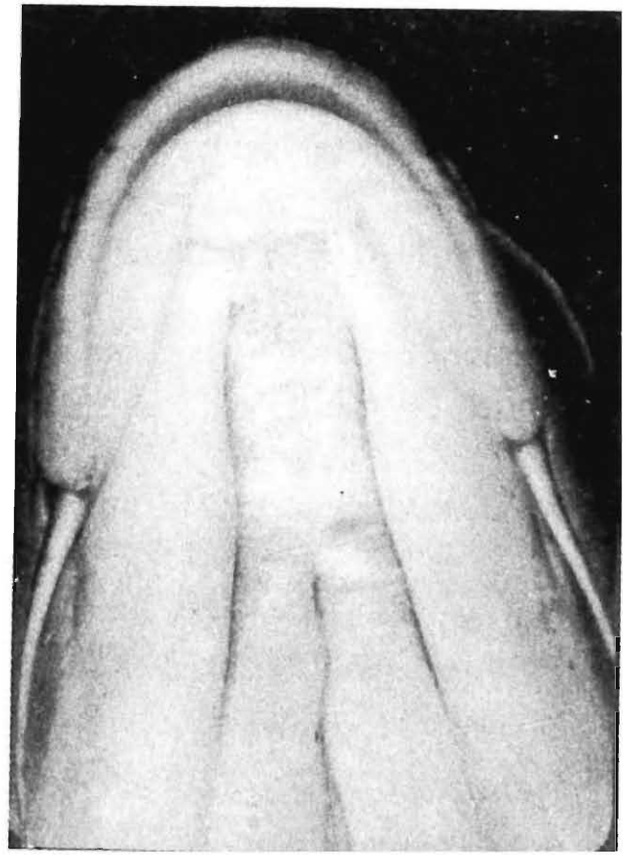

Fig. 3. Ventral view of *Tor khudree* (35 mm SL) Showing the mentum.

52.6 (40.0–71.4), mouth width 23.8 (17.5 - 47.6) (N = 100) in percent of head length. Mouth narrow, lips fringed, lower lip produced as a median lobe (mentum) of varying extent, labial fold continuous (Text-Fig.3). Two pairs of barbels : maxillary and rostral, may be

as long as diameter of eyes. Dorsal fin shorter than body depth, inserted in advance of the pelvics and somewhat nearer to tip of snout than to base of caudal fin; dorsal spine strong, bony but smooth. Pectoral fins concave in shape, shorter than the head and separated from the pelvics by a considerable distance. Pelvic fins similar to pectoral and provided with an axillary scale, not reaching the anal fin base. Anal fin short without any prolongations; anal fin last ray inserted 5–10 scales posterior to caudal fin base (8 scales in 56.5%). Anal opening at base of anal fin in 69%, rarely two scales anterior (7.5%). Caudal peduncle height 40.0 (31.2-50.0) (N = 100), length of caudal peduncle 58.8 (45.5-83.3) in percent of head length, 66.7 (43.5–90.9) percent in its height. Caudal fin deeply forked, its rays or lobes not produced.

Distribution : Mainly confined to Western Ghat streams in peninsular India. The species has been recorded from the following river systems : KRISHNA : Mutha–Mula, Pune, Aounda, Darna, Waldi, Deolali, Manjira, Nizamsagar, Sangli, Satara, Sri Sailam. Godavari : Nasik. Cauvery : Bhavani, Pykara, Moyar, Bhavani River. Kerala : Manjeri, Chailyar, Chalakudy.

Scales : Lateral line 21-28 (25 in 22.6%); Pre-dorsal 4-8 (6 in 44.1%); Pre-anal 8-17 (16 in 34.3%); Dorsal fin/Lateral line 2½ 4½ (3½ in 92.1%); Pelvic fin/Lateral line 1½-3½ (2½ in 95.1%). Anal fin/Lateral line 1½-2½ (2½ in 90.2%); Circumpeduncular scales 7-12 (9 in 37.8%).

Gill rakers : 10-21 (12 in 29.9%).

Colour : In fresh specimens light bluish to cement gray with paired fins fringed with red. A black variety is not uncommon as seen at Theerthahalli. Scale colour, dorsal half of body with black marks at base; a diffused black spot may be seen at base of candal fin. In spirit preserved specimens grayish above and silvery below.

Notes on Synonymy : *Barbus megalepis* and *B. malabaricus* were described by Jerdon (1849) from mountain streams of Malabar. The first species was recorded with a query and it was stated : "I obtained a single specimen of what I consider may be this fish in the Cauvery at Seringapatam. It was only a few inches long but the fishermen, who call it *kudis*, said that it grew to an enormous size" He characterized it as Head to body as I to 3, 25 scales along the side in 6 rows : D.12, A.7. Hora (1943) considered the species as a synonym of *mussullah* in view of the statement that the fish grows to enormous sizes. But the scale count and local name indicates that it is a synonym of *T khudree* as has been correctly done by Menon (1999) in his Checklist.

Barbus malabaricus (Plate I) was characterized by Jerdon as follows : "Head to whole body as 1 to 4; height 3½ times in its length; 4 long cirri; 23 scales along the body in 6 rows. D. 3-8. A. 2-8; pale brownish olive above silvery beneath, fins ringed with red." He further stated : "I have taken this handsome barbel only in mountain streams in Malabar it rises to the fly sometimes, and also take a bait of boiled rice. I have not seen it more than 10 inches long, but from the rapid growth of one I have kept alive for some months I imagine it attains a much longer size."

Judging from the above description Hora (1943a) opined that it is insufficiently described which is a fact. Day (1865) did not mention it in his Fishes of Malabar. Gunther (1868) included it as a footnote among the doubtful species of *Barbus*. Day (1877) however in his Fishes of India described the species in full and included it among those with 4 barbels in which the last undivided dorsal ray is articulated or if osseous very weak. He gave the distribution and colour, which is variable. Hora (1943a) examined the specimens from Day's specimens from Canara and from the measurements and counts initially thought that it might be a synonym of *Barbus khudree* but for lack of adequate material could not definitely separate the species from *khudree* specifically. Silas has undertaken the study of chromosome patterns of the two species at the NBFGR Unit at Cochin and is of the opinion that the species is different from *khudree.*

Barbus longispinnis was described by Gunther (1868) from Sri Lanka stating that it was different from *Labeobarbus tor*. Day (1877) considered both the species as junior synonyms of *Barbus hexastichus,* a sub-Himalayan species. Deraniyagala (1930) chose to identify the *Tor* he collected in Sri Lanka as *Tor tor (=Barbus tor* Hamilton) but subsequently decided to treat the Sri Lankan taxon as *Tor khudree longispinnis*. Pethiyagoda (1991) in his excellent treatise on the Sri Lankan fishes observed a significant degree of dimorphism among Sri Lankan *Tor,* he considered *longispinnis* as a synonym of *khudree,* which is now currently accepted.

Tor kulkarnii Menon is a dwarf form of *Tor khudree* as stated by the author himself and Dr. Ogale of the Tata Fish Farm at Lonavla has not been able to segregate the species, which only confirms its status. *Puntius coorgensis* Jayaram has been synonymised with *Tor khudree* by Menon (1999) incorrectly; the species has an interrupted labial fold and the mentum is absent which are characters defining the genus *Tor.*

Tor mussullah *(Sykes)*
(Plate II)

Burbus mussullah, Sykes, *Trans. zool. Soc. London* **2** : 356, 357, 1841 (type locality Sirur, Maharashtra state).- Gunther, *Cat Fish. Brit. Mus.* **7** : 83, 1868 (as *species inquirende;* under *Barbus tor).*- Day, *Fish India* : 573, 1877 (as a synonym of *B. tor).*-Annandale, *Rec. Indian Mus.* **16** : 135 : 1919 (Upper Krishna, Satara, local name *Masundi* identified by Hora in 1942 as *Tor khudree).*- Spence & Prater, *J. Bombay nat. Hist. Soc.* **36** : 472, 1932 (Upper Krishna at Satara).-Hora, *J. Bombay nat. Hist. Soc.* **43** (1) : 1942 (as a synonym of *Barbus curmuca).*-Hora, *J. Bombay nat. Hist. Soc.* **44** (2) : 166, 1943 (*Barbus megalepis* Jerdon nec McClelland synonymised).

Tor mussullah, Chacko, *Contrib. Fw. Fish Biol Sci.* **4** : 6, 1952 (occurrence near Hogenakal falls, rare).- Silas, *J. Bombay nat. Hist. Soc.* **51** (3) : 581, 1953. (Mahabaleswar Lake, R. Krishna at Wai).- Misra, *Rec. Indian Mus.* **57** (1–4) : 149, 1952 (freshwaters of peninsular India).-David, *Proc. Nat Acad. Sci. India* **33**(2) : 280, 1963 (Godavari and Krishna rivers).-Jayaram, *Handbk. Fw. Fish India* : 124, 1981(Cauvery, Bhavani Rivers, Poona).-Tilak & Sharma. *Game fishes of India and Angling* : 53, fig. 12, 1982 (Deccan and Mysore, Krishna River).-Jayaram et. al *Occ. Paper Zool Surv. India* No. **36** : 72, 1982 (name only).-Talwar & Jhingran, *Inland Fishes of India.*

1 : 306, 1991 (Peninsular India : Krishna and Godavari rivers).- Jayaram, *Occ. Paper Zool. Surv. India* No. **160** : 96, 1995 (name only, Krishna River system).-Jayaram, *J. Bombay nat. Hits Soc.* **94** (1) : 48-55, 1997 (systematic status discussed).-Jayaram, *Freshwater fishes of the Indian Region* : 96, 1999 (Bhavani, Cauvery, Moyar River systems on South India. Also Krishna River system in Maharashtra).

Hypselobarbus mussullah, Menon, *J. Bombay nat. Hist. Soc.* **89** (2) : 210, 1992 (considered as synonym of *Tor khudree).*- Menon, *Occ. Paper zool Surv. India* No. **175** : 59, 1999 (considered as synonym of *Tor khudree).*

Vernacular Names : Mossullah, Telugu; Masundi, Tamil; Mahsiya, Masund, Mahoi, Marathi.

Specimens studied :

1. ZSI Hq. 1338/2, 1339/2. Two exs. 95.0 & 157.5 mm SL, Deccan, F. Day coll.

2. ZSI HQ. 9578/1. Four exs. 103-160 mm SL, Krishna River, Satara dist. Maharashtra state, C. D. McIver coll.

3. ZSI WRS. P. 1334. One ex. 197 mm SL, Panchaganga River system, Maharashtra state, 04-08-1977.

4. Modern College, Pune, one ex. 195 mm SL, Neera River near Veer Dam, Satara, Kolhapur road, Maharashtra state, Vilas Pawar coll. 07-10-1991.

5. ZSI WGRS 5946. Four exs. 153-215 mm SL, Meenmutty, Malappuram dist. Kerala state, P.M. Suresh coll. 26-02-1998.

6. SACON one ex. 259 mm SL, Tengumarahada, Moyar River, 30 km from Bhavanisagar, F. F. Singh & A. Manimekalan coll. 23-11-1994.

7. KFRI. Two exs. 130 & 138 mm SL, Chinnar River near Munnar, Kerala state, Manoj coll. 08-10-1995.

8. ZSI SRS, unregd. Two exs. 257 & 310 mm SL, Thunga River, Sarada peetam, Sringeri, Dakshina Kannada, Karnataka state, K. C. Jayaram coll. 09-02-1996.

9. ZSI SRS unregd. Three exs. 290-363 mm SL, Harangi nursery, Kodagu district, Karnataka state, K. C. Jayaram coll. 13-02-1996.

10. ZSI SRS unregd. Five exs. 241–369 mm SL, Mancherry River near Panampuzha, Malappuram district, Kerala state, C. P. Shaji, Joseph and A. C. Jaikumar coll. 08-01-1997.

11. ZSI unregd. One ex. 366 mm SL, Solayar river, Periyar dist. Tamil Nadu, Tamil Nadu fisheries dept. coll. Aug. 1997.

12. ZSI WRS unregd. Three exs. 382–488 mm SL, Koyana reservoir, Satara district, Maharashtra state, K. C. Jayaram coll. 27-05-1997.

13. ZSI SRS unregd. One ex. 564 mm SL, Walwahn lake, Pune district, Maharashtra state, K. C. Jayaram coll. 31-05-1997.

14. ZSI SRS unregd. Five exs. 82–201 mm SL, Morna River 27 km downstream of Koyana River, Satara dist. Maharashtra state, K. C. Jayaram coll. 28–01-1997.

Description : Based on 34 exs unless otherwise stated. D I-III, 8-9 (II, 9 in 65%), P.i. 11-16(ii, 14 in 52.3%) V.i-ii, 7-9 (i, 8 in 58.8%) A. i–ii, 4-6 (i, 5 in 62.8%); C. 6–9 + 6–9 (8+8 in 32.2%).

Dorsal profile steep with a hump at occiput, rising up to dorsal fin base; ventral profile slighltly arched tapering towards caudal base. Hump pronounced, noticeable in adult examples, though may be in varying degrees in juveniles. Head small, 27.8 (23.3-33.3), body depth 28.7 (23.8-31.2), pre-dorsal length 52.6 (47.6-55.6), post-dorsal length 52.6 (49.6–62.5) in percent of standard length. Eyes not visible from below ventral surface, in anterior part of head, not very large, 37.6 (33.3–45.5) in percent of snout, 48.3 (32.2–90.97) in percent of inter orbital width that is flat. Eyes 16.7 (10.2-25.0), snout 37.0 (33.3–45.5), head width 52.6 (40.0–62.5), height at occiput 71.4(55.6–90.9), width of mouth 22.7 (18.5–32.2) (N = 33) in percent of head length. Mouth narrow, lips thick, with a continuous labial fold, lower lip forming a median lobe (mentum) of varying size. Two pairs of barbels maxillary and rostral, short.

Dorsal fin inserted nearer tip of snout than caudal fin base or equidistant, concave in shape, anterior most first branched ray and spine may be produced as a filament. Dorsal fin shorter than body depth, dorsal spine strong, smooth, non-flexible. Pectoral fins concave in shape, as long as or shorter than head and separated from the pelvic fin by a considerable distance. Pelvic fins occasionally with an axillary scale, concave in shape, innermost ray nearly half the length of the anterior most ray and not reaching anal fin. Anal fin short, last simple ray may be produced as a conical tip, fin just reaching caudal fin base. Last anal fin ray at 7–10 scales to caudal fin base, anal opening more or less at base of anal fin but in 46.9% one scale anterior. Caudal peduncle height (33.3–52.6), length of caudal peduncle 66.7 (47.6–90.9) in percent of head length (N = 34). Height of caudal peduncle 58.8 (40.0-83.3) in percent of its length. Caudal fin deeply forked, its ray not filamentous.

Distribution : Contained in isolated pockets of Maharashtra, Karnataka, Kerala and Tamil Nadu in the Krishna, Godavari and Cauvery river systems.

Scales : Lateral line 21–28 (26 in 26.5%) pre-dorsal 4-8 (6 in 41.2%), pre-anal 11-17 (14 in 23.5%), Dorsal fin/LL 3½-4½ (4½ in 70.6%), Pelvic fin/LL 2½ - 4 ½ (2½ in 55.8%), Anal fin/LL 2½ - 3 (2 ½ in 61.8%). Circumpeduncular 8-12 (11 in 38.2%), Gill Rakers 12-16 (16 in 25.0%).

Colour : Brown to dark brown in alcohol preserved specimens, abdomen pale. In live condition the fish are dark in colour as seen at Sringeri, rarely a lighter variety is seen. Body and fins are of uniform colour.

GENERIC STATUS OF *BARBUS MUSSULLAH* SYKES

Menon (1992) referred *Barbus mussullah, B. kolus, B. dubius, B. lithopidos, B. micropogon,*

B. m. periyarensis, B. thomassi and *B. kurali.* to the genus *Hypselobarbus* Bleeker. Of these excepting the first one all others are now placed under the subgenus *Gonoproktopterus* Bleeker.

Bleeker proposed the genus *Hypselobrbus* in the year 1860 initially without any type species; however later *B. mussullah* was designated in 1863 : 199. *B. nancar* was also included under this genus. Of these, the second species is from East Indies and the first one is from India. Bleeker (1863-64) defined the genus as below (only major relevant characters quoted).

p. 429 "11. Lineae lateralis inconspicua.

A. Pinna dorsalis subelongata, ante pinnam analem desinens. Labium inferius bilobuni.

Strips c. Barbini. Cypriniformes cheilognathini pinna anali radio dentato nullo, dentribus phayngealibus uroque latere uni-ad tri-serratis parcis, nunquam plus quam I

Series 1 AMBLYGASTRI

Subseries 1. ACANTHOPHORI

Barbini amblygastri pinna dorsali spina armata

B. Squamae anales squamis ceteris non-majores.

p. 430 b. Apertura branchialis lata su praeoperculo vel sub oculo desinens.

bb. Oculi membrana palpebralli non-velati.

+ Pinna analis pauciradiata. S. Rictus parvus yet mediocris anter oculum desinens.

SS Rostrum genaeque tuberculis vel verrucis obsitae. Rostrum conicum. Spina dorsalis gracilis edentula. Cirri 4. Vela null. *Hypselobarbus* Blkr. (Subg. *Hypselobarbus. (Gonoproktopterus, Tambra* Blkr.) Spec. Cogn. 4."

For *mussullah* Bleeker based and relied on the description and 'image' of Sykes (1841). The fact remains that Sykes' description and figure of his species are inadequate and inaccurate. Sykes described the species as below : (Text-Fig 4A & B)

p. 356 'genus ***Barbus,*** Cuv.

Barbus mussullah
(Tab. LXI, Fig. 4)

A. *Barbus* with 12 rays in the dorsal, 8 in the anal and 16 in the pectoral fins with the mouth furnished with 4 very short cirri : and tuberculated nose; sometimes 3 feet and more long, and a foot high, and weighing 42 pounds. Pectoral fins of 16 rays; ventral of 9 rays; dorsal fin of 12 rays, including the first double ray : anal fin of 8 rays, including the first double ray; tail forked, of 24 rays, including the short ray; at each exterior side

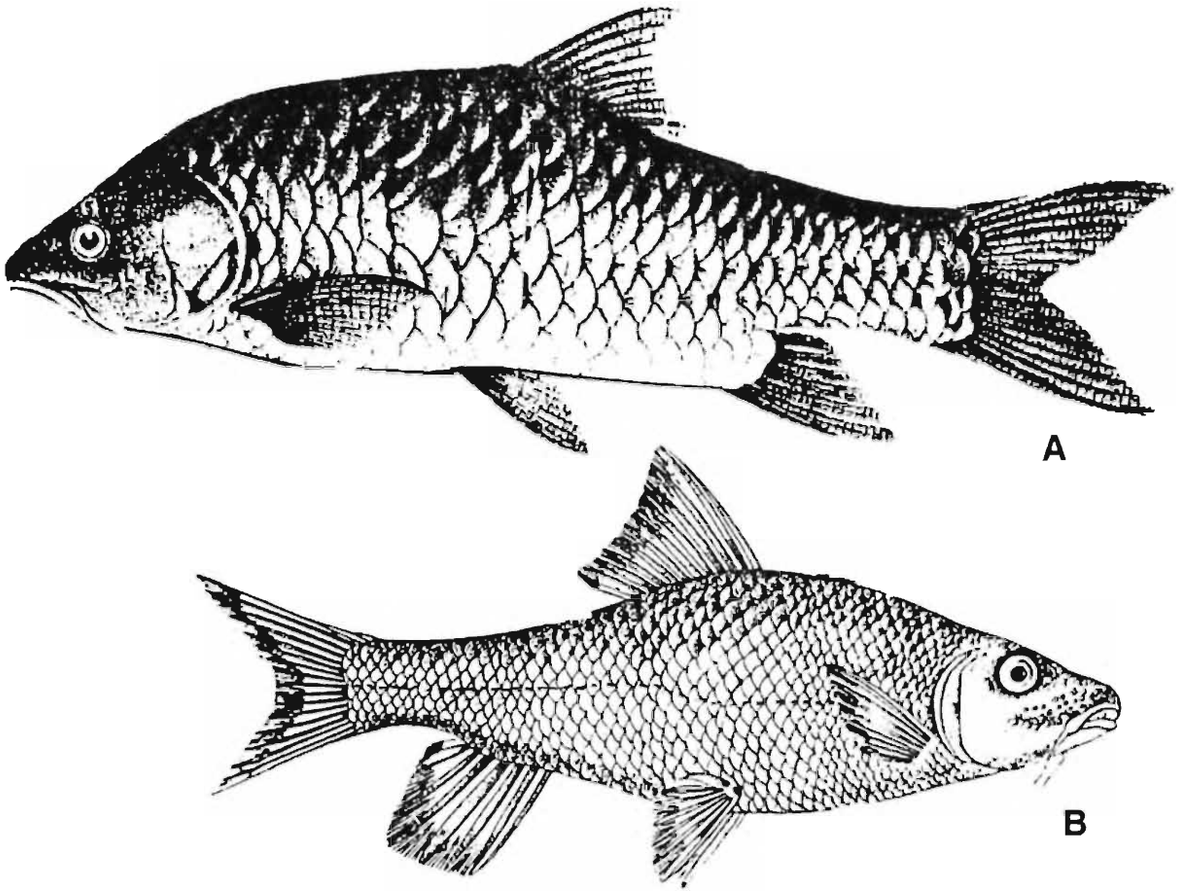

Fig. 4. A. *Barbus (Tor) mussullah* Sykes X ca 1/4 drawing made from a colour sketch sent by Dr. M. Suter. B. Original sketch of *Barbus mussullah* as given by Sykes, 1839.

of the insertion of the tail; a remarkable projecting prominence between the upper lip and nostrils, giving to the fish the appearance of being Roman-nosed; the eyes are situated far back and between the eyes and corners of the mouth there are a number of circular, rough prominent papillae, but these are not constant; corners of the mouth furnished with a short feeler, and the base of the nasal prominence, near the tip, also furnished with one on each side; dorsal fin in the center of the back, on a **prominence which slopes suddenly behind** (Bold lettering mine) (Plate III, figs. A & B) ventral fins on the center of the belly on a perpendicular from the first dorsal rays; tail suddenly narrows below after the anal fin : anal fin with posterior angle bluntly rounded off. The lateral line is slightly arched at the shoulder, then falls, and runs straight to the anal fin; over this it rises a little and then runs straight to the centre of the fork of the tail : The whole of the upper parts of the fish covered with large coarse silvery scales, having blue and red reflections, and on the under parts a yellow tinge prevails; it is very bony, and its length to the end of the fork of the tail is 12 inches, and height 3 inches; but its greatest growth is 5 feet. When small this species resembles the *Kolus*, but in the latter, the colour is more reddish-silvery, the fins are reddish and the *Mussullah* is a much coarser and infinitely larger fish. A male brought to me at Seroor from the Goreh River, measured in length 3 feet 4 inches, and its height 1 foot and weighed nearly 42 lbs. avoirdupois. p. 357/ the flesh wanted flavour. The *Mussullah* differs from the *Mosal* of Dr. Hamilton in having 1 ray less in the dorsal

and pectoral fins, and in the first rays of these fins being double instead of quadruple; in the latter respect and indeed in many others resembling the *C. Putitora*, it also differs in having the nose and upper lips tuberculated and in colour. The prominence on the nose is also marked. Russell describes three Barbels, calling them Cyprini, but none of them are identified with the present fish."

Sykes does not indicate the number of lateral line scales but from the figure a count of 48 can be made. The median lobe or (mentum) not seen as the figure is only of a lateral view. The anal fin is shaped oddly but it may be an artistic fancy. Rainboth (1986) opined that Bleeker probably referred *mussullah* under *Hypselobarbus* on the image of Sykes and in (1989) he stated that from the figure of Sykes the species cannot he placed under the genus *Tor*, but only under *Hypselobarbus* Bleeker.

However, Annandale in 1919 collected some specimens from the Krishna River at Satara and gave a figure (Text-Fig. 5) which clearly shows the correct meristic counts of the fish. Annandale correctly identified it as *mussullah* and referred it as belonging to the Mahseer group *(Tor)*. This fact seems to have been overlooked by Rainboth (1989) and Menon (1992).

Moreover *Tor* is defined clearly by Kottelat & Whitten (1993) as with the lower lip developed with fleshy lobe of at least with two notches delimiting the usual position of the lobe. Wu et al (1977), Chen & Chu (1985, 1989) define *Tor* as with the lower lip with a median lobe or mentum. Further it may be noted that Sykes himself referred to the similarity of his species to *C. putitora*, which is undoubtedly referable to *Tor*. Day (1877) also synonymised the species under *Barbus tor*. It may be noted here that *Genoproktopterus* is a subgenus of *Hypslobarbus* as indicated by Bleeker himself and also by Eschmeyer in his Catalog of Fishes. *Gonoproktopterus* differs from *Tor* in not having a mentum, the snout with a median lobe and lateral lobes, very large gill rakers and lips covered with dense tiny papillae (Talwar & Jhingran, 1991 : 158). Above all *Tor* Gray 1834 predates *Hypselobarbus* Bleeker, 1860. Thus the generic status of *mussullah* is clear and the species belongs to the genus *Tor* only.

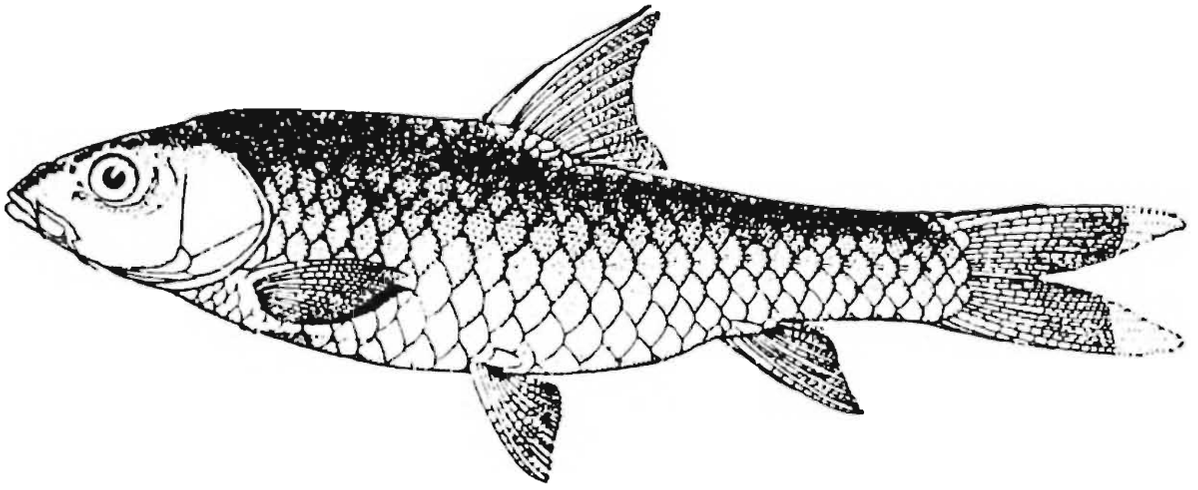

Fig. 5 *Barbus mussullah* Sykes known from Satara as *masundi* X ca 4/7. Lateral view of young specimen described by Annandale.

Specific Status

There is much ambiguity in respect of the specific status also of this fish. I have discussed briefly (Jayaram,·1997a) the confusion caused because of absence of first hand collection of the fish from its wide range of distribution in the Western Ghats. Sykes described *Barbus mussullah* in 1838 in a paper read before the Zoological Society of London entitled 'On the fishes of the Decean' On page 159 the species was described along with *Barbus khudree* and *Barbus kolus. B. mussullah* was described again in 1839 : 56 and in 1841 : 356. The last publication has a more detailed account with figure of the fish depicted in plate 61, fig. 4.

Jerdon (1849) in his account of the freshwater fishes of southern India described *Barbus megalepis* from Srirangapatam, Cauvery River, Karnataka, which is a synonym of *B. mussullah.* He listed *B. mussullah* from the same area but did not collect any specimens probably because he was not aware that his *megalepis* was *mussullah* only. Gunther (1868) in his Catalogue of fishes considered *mussullah* as species *inquirendae.* Day (1877, 1889) synonymised *mussullah* with *Barbus tor.* After a gap of 30 years it was Annandale (1919) who reported certain specimens from the Krishna River at Satara, Satara district, Maharashtra as *Barbus mussullah.* He stated (p.135) "Sykes description of this fish is inadequate and his figure inaccurate, but he refers to and illustrates one trivial but apparently constant character that gives the confidence in identifying specimens sent by Mr. Mclver. This character is the presence under the eye of a group of small tubercles not confined to one side and not visible without the aid of a lens in quite young fish. A more important differential character not recognized by Sykes but shown in the figure is however to be found in the structure of the mouth, the opening of which is much more oblique than any race of *Barbus tor.* The extremity of the maxillary lies directly under the middle part of the eye. This is well shown on plate III. There are 13 (3/10) dorsal and 8 (3/5) anal fin rays, 25-26 scales on the lateral line. 4 rows of scales above it and 3 below. *B. mussullah* is common in the Upper Krishna where it occurs with the local race of *B. tor.* The Maharashtra fishermen of Satara never fail to distinguish the two species. *B. tor* they call Kudis, *B. mussullah* Masundi. Mclver to whom I am indebted for this information has caught a specimen of the Masundi 21 lbs in weight"

By referring the affinity of the fish to *Barbus tor* Annandale clearly estabished its identity as a distinct species of the *Tor* group. It is worth mentioning here that Hora (1942 : 166) on the basis of the character of tubercles erroneously considered *mussullah* and *tor* as the same as *khudree* although in an earlier work (1941) on the fishes of Travancore he identified 13 examples from Kerala, Travancore as *Barbus (Tor) mussullah* that indicates that he knew the real *mussullah.* In (1942a: 5) he rectified his error after examining a large amount of additional material of *B. khudree* from the Western Chats and the information collected though Dr. M. Suter from the respective type localities. He described *mussullah* in detail.

Menon (1992) in dealing with the taxonomy of mahseer species of the genus *Tor* considered *mussullah* as the same as *T khudree.* He described a new species *T kulkarnii,*

which according to him is the dwarf form of *T khudree.* He took into consideration Rainboth's (1989) statement that *mussullah* does not belong to the genus *Tor* but to *Hypselobarlus* Bleeker. The main reason for his assignment of *mussullah* to *Hypselobarbus* is the poor description of the species by Sykes (1841). As stated already, Sykes's description is zoologically poor and incorrect. By large scales he means 44 scales along the lateral line and small scales 60-70. His drawing of *mussullah* shows that the species is characterised by large scales and about 48 can be counted. Moreover the dorsal fin is said to have 12 rays including the first ray and caudal fin 24. My count of *mussullah* specimens is more or less in agreement with the fin ray counts of Sykes. Annandale as stated earlier demonstrated that in plate III in Sykes work, the counts of dorsal and anal fin rays and the number of lateral line scales to be as it should be in *mussullah.* Hora (1942 : 167) relied more upon the tubercles and shape of mouth and also on Suter's field observations and concluded that *mussullah* as a synonym of *Barbus curmuca* overlooking the characters noted by Annandale. *B. curmuca* is referable to the subgenus *Gonoproktopterus* Bleeker.

Menon (1992) compared 20 examples of *T khudree* from the Deccan with four of his new species *T kulkarnii* and based on the graphical differences merged *mussullah* under *khudree.* Further it may be stated, that none of the above authors seem to have collected first hand *mussullah* specimens from its wide range of distribution in the Western Ghats and more so from Maharashtra which is its home. I have, as can be seen from the list of specimens, collected and studied both *khudree* and *mussullah* from a large series and their meristic and morphometric data have been recorded, analysed and compared which clearly establishes the separate identity of *mussullah.* My conculusion has been corroborated by Cytogenetic studies as well as statistical analysis.

Cytogentic Study

Kushwaha et al (2001) in the National Bureau of Fish Genetic Resources, Lucknow studied *Tor mussullah* and *T khudree* and compared their chromosome make up. Live specimens of *T khudree* (N=6) and *T mussullah* (N=7) were obtained from the Tata Electric Company's Fish farm at Lonavla. The specimens were juveniles with undifferentiated gonads. They were administered intramuscularly 0.05% cholchicine (1.0 ml/per 100 gm body weight). After two hours all specimens were sacrificed and kidney tissues were processed for chromosome preparations using routine hypotonic treatment, acetic acid methanol fixation, flame drying/air drying technique. NOR banding was carried out as per accepted techniques. Karyotyping of Giemsa stained as well as banded chromosomes was done according to standard classification.

It was found that the diploid chromosome number in *T khudree* was to be 2n=100 and the chromosome formula (CF) was derived as 18m+16sm+44st +22t (FN= 134). (Plate IV, Fig. 1). In *T mussullah* the diploid chromosome number of 2n+100 and the chromosome formula (CF) was established as 22m+24sm+24st+30t (Plate IV, Fig. 2). The results obtained by the authors are in agreement with earlier reports on chromosome number of other *Tor* species.

Ag-NOR banding of metaphase spreads revealed presence of multiple NORs in both the species. In *T khudree* NORS were present on 5 pairs of chromosomes (3rd and 6th sm; 8th and 16th st; 9th t). However in few metaphase spreads variation was found in number of NORs within and between individuals. The NORS were located terminally on short arm of 3rd and 6th sm 8th and 16th st and at centromeric position on 9th telocentiric chromosome (Plate IV, Fig. 3). In *T mussullah* NORs were localized on short arms of 2 pairs of chromosomes (4th sm, 4th st) at terminal position (Plate IV, Fig. 4)

The above comparison of karyotypes of *T khudree* and *T mussullah* revealed differences in chromosomal morphology between the two species. *T mussullah* is found to have more number of telocentrics (t) and less numbers of subtelocentrics (st) compared to *T khudree.* Further, heteromorphism has been observed in number and location of NORs between these two species. The authors on the basis of their findings concluded that the two species exist separately as against the view of Menon (1992). (Adopted from Kushwaha et al 2001 with permission).

Statistical Analysis

The morphometric and meristic data of *Tor khudree* and *Tor mussullah* were subjected to statistical analysis to find out their homogeniety and or heterogeneity. Chi square test, t test, and correlation matrix were drawn. The results are discussed below :

Chi square test : In order to ascertain whether the samples collected of *Tor khudree* and *Tor mussullah* are homogeneous or heterogeneous the above test was undertaken. The null hypothesis that all are homogeneous was assumed. The data are presented in Tables 1 & 2 for *Tor khudree,* Tables 3 & 4 for *Tor mussullah.* The values of significance were fixed as below :

0 = Reject Hypothesis (ie) Not homogenous.

More than 0.05 = Significant at 95% confidence level

More than 0.01 = Highly significant at 99% confidence level.

The calculated values of Chi Square were read against the table values taking N-2. Where the calculated values were more than the table value the hypothesis was rejected.

Table 1. Chi square test for *Tor khudree* samples. Morphometric characters

Sl. No.	Characters	N	Mean	SD	chi square value	table value	significance	A/R
1.	Standard Length	109	122.083	78.246	28.358	90.531	1	A
2.	Body depth	109	31.591	19.738	73.394	62.83	0.063	R
3.	Head length	109	35.477	20.472	49.037	72.53	0.629	A
4.	Eye diameter	109	6.968	2.878	124.055	28.87	0	R
5.	Width of mouth	109	8.477	4.974	111.083	33.92	0	R
6.	Int. Orb. Width	109	10.986	7.734	98.257	44.34	0	R

7.	Hd. width	109	18.611	11.557	58.615	58.124	0.037	R
8.	Snout length	109	12.885	7.734	81.183	42.557	0	R
9.	Ht. at occiput	109	24.610	14.059	60.229	62.83	0.064	A
10.	Pre-dorsal length	103	62.68	39.899	41.555	83.675	0.987	A
11.	Post-dorsal length	96	62.697	42.966	34.292	76.778	0.994	A
12.	HCPD	109	14.233	8.980	123.807	46.194	0	R
13.	LCPD	109	21.839	14.739	48.413	62.83	0.337	A
14.	Post-orbital length	94	16.782	10.351	70.234	43.773	0	R
15.	Pre-orbital length	96	20.651	10.96	60.75	50.999	0.0045	R
16.	Inter-nostril length	103	7.155	4.698	132.592	32.671	0	R

A = Accept the Null Hypothesis

R = Reject the Null Jypothesis

Table 2. Chi square test for *Tor khudree*. Meristic characters.

Sl. No. Characters	N	Mean	SD	chi square value	table value	significance	A/R
1. Standard Length	109	122.083	78.246	28.358	90.531	1	A
2. Dorsal fin rays	109	8.413	0.71	120.28	9.488	0	R
3. Pectoral fir rays	97	12.35	1.575	43.783	14.067	0	R
4. Pelvic fin rays	103	7.048	0.879	80.058	9.488	0	R
5. Anal fin rays	103	5.068	0.448	183.718	7.815	0	R
6. Caudal rays U/1	98	7.897	0.442	95.898	5.911	0	R
7. Caudal fin rays L/1.	98	7.867	0.586	44.84	5.911	0	R
8. Lat. Linc Scales	109	24.431	1.554	25.798	12.59	0	R
9. Dorsal fin/LL scales	109	3.534	0.278	342.514	9.49	0	R
10. Pelvic fin/LL scales	109	2.555	0.281	245.97	7.815	0	R
11. Anal fin/LL scales	109	2.527	0.346	193.716	7.816	0	R
12. Circumpeduncular	105	9.514	1.119	141.02	14.067	0	R
13. Gill rakers u/limb	88	3.477	0.922	127.38	11.07	0	R
14. Gill rakers 1/limb	88	13.102	2.149	83	19.675	0	R
15. Pre-dorsal scales	106	8.198	0.970	86.76	11.07	0	R
16. Pre-anal scales	109	14.771	1.808	92.56	16.92	0	R
17. Pre-pelvic scales	109	7.266	0.939	63.06	9.488	0	R
18. Mentum	100	4.097	3.526	141.56	27.59	0	R
19. Last anal/ caudal base scales	92	7.847	0.948	112.65	11.07	0	R

A = Accept

R = Reject

It will be seen that in respect of 16 morphometric characters studied (Table 1) the populations were homogenous for the following six characters.

Head length	Height at occiput
Pre-dorsal length	Length of caudal peduncle.
Post dorsal length	Standard length

All the other 10 characters show heterogeneity. This is in conformity with the importance and value of the above characters. These are not much variable as the position of the fins, caudal peduncle length etc are diagnostic. Other characters as body depth, eye position are variable related to growth. Also the population was heterogenous in respect of 19 meristic characters (Table 2). Counts vary even in individuals of the same species depending upon the size, habitat and thus show high variability. Moreover it may be reiterated here that most of the samples of *Tor khudree* were collected from diferent locations and were all introduced stock, bred artificially through hypophysation. This is reflected in the analysis.

Table 3. Chi square test for *Tor mussullah* morphometric characters.

Sl. No.	Characters	N	Mean	SD	chi square	table value	significance
1.	Standard length	34	242.06	116.25	1.765	4.194	1
2.	Body depth	34	65.765	30.48	2.471	43.773	0.55
3.	Head length	34	69.90	34.97	1.767	46.194	1
4.	Eye diameter	34	10.602	3.689	9.765	19.675	0.55
5.	Inter-orbital width	34	22.81	12.569	9.585	28.869	0.994
6.	Snout length	34	24.07	11.223	8.647	36.415	0.998
7.	Width of mouth	34	15.091	7.533	7.000	35.172	0.991
8.	Height at Occiput	34	47.75	25.283	3.529	41.337	1
9.	Pre-dorsal length	34	122.59	62.185	3.529	41.337	1
10.	Post-dorsal length	34	130.588	65.89	4.623	42.557	1
11.	Head width	34	35.75	17.156	10.353	37.652	0.996
12.	HCPD	34	29.60	14.634	5.529	40.113	1
13.	LCPD	34	44.60	22.718	5.529	40.113	1
14.	Post-orbital length	32	34.12	19.547	5.5	23.685	1
15.	Pre-orbital length	34	34.22	15.146	9.294	33.924	0.992
16.	Inter-nostril dist.	34	13.88	7.999	17.882	27.587	0.396

All values indicate acceptance

Table 4. Chi square test for *Tor mussullah* meristic characters

Sl. No.	Characters	N	Mean	SD	chi square value	table value	significance	A/R
1.	Standard Length	34	242.06	116.25	1.765	46.194	1	A
2.	Dorsal fin rays	34	8.765	0.431	9.53	3.841	0.002	R
3.	Pectoral fin rays	34	12.823	1.527	17.039	12.592	0.0091	R
4.	Pelvic fin rays	33	7.765	0.654	28.588	7.815	0	R
5.	Anal fin rays	34	5.206	0.479	26.882	5.991	0	R
6.	Caudal fin u/1	31	7.741	0.856	12.742	7.815	0.0052	R
7.	Caudal fin l/1	31	7.774	0.762	14.290	7.815	0.0025	R
8.	Circumpeduncular	34	10.059	1.043	14.235	9.488	0.007	R
9.	Lateral line scales	34	24.765	2.001	6.471	14.067	0.486	A
10.	Pre-dorsal scales	34	5.676	0.878	22.765	9.488	0.0001	R
11.	Pre-pelvic scales	34	14.5	1.638	10.471	12.592	0.106	A
12.	Pre-anal scales	34	6.853	1.048	11.000	9.488	0.266	R
13.	Gill rakers u/I	32	4.468	1.367	5.5	9.488	0.24	A
14.	Gill rakers l/I	32	16.000	2.016	14.687	15.507	0.655	A
15.	Dorsal fin/Lat Line	34	4.205	0.462	5.765	3.841	0.164	R
16.	Pelvic fin/Lat.line	34	2.852	0.485	2.941	3.841	0.863	A
17.	Anal fin/Lat.linc	34	2.970	0.563	15.238	5.991	0.0005	R
18.	Mentum	34	9.044	14.591	32.000	26.296	0.01	R
19.	Last anal ray/ caudal	34	8.588	1.018	2.470	7.815	0.480	A

A = Accept; R = Reject

In respect of *Tor mussullah* the 16 morphometric characters studied the population was found to be homogenous. However in respect of the meristic characters the population was homogenous only for the following characters : Gill raker count upper limb & lower limb, insertion of last anal fin ray, lateral line scales, dorsal fin/lateral line. Pre-pelvic scales. All others show no significance indicating heterogeneity. The above counts are highly variable and the differences between *Tor khudree* and *Tor mussullah* depend much on these counts.

t-test or test of significance has been employed for comparison of the two groups *Tor khudree* (group 1) and *Tor mussullah* (group 2). The principle that the total sum squares of a set of measurements can be broken into groups has been adopted. One set of sum of squares, the variation between the two group means and the other within the two groups has been calculated. From these two sums of squares independent estimate of the population variance is computed. If the estimate of the population variables has only slight difference the samples collected of the population are homogenous. Dividing the

larger variance by the smaller one tests it. The F or 5% or 1% variance ratio is read against computed values (t values) and the agreement or disagreement determined. The Null hypothesis that the two groups are homogenous is assumed. The data are presented in Tables 5 & 6.

Table 5. t-test for independent samples. Variables were treated as independent samples. Meristic characters.

Sl. No.	Characters	Group 1			Group 2			t value
		Mean	SD	N	Mean	SD	N	
1.	Standard length	122.08	78.246	109	242.06	116.25	34	6.892
2.	Dorsal fin rays	8.41	0.71	109	8.76	0.43	34	2.734
3.	Pectoral fin rays	12.35	1.57	97	12.82	1.53	34	1.52
4.	Pelvic fin rays	7.05	0.88	103	7.76	0.85	34	4.36
5.	Anal fin rays	5.07	0.45	103	5.20	0.48	34	1.53
6.	Caudal fin u/1	7.89	0.44	98	7.74	0.85	31	1.33
7.	Caudal fin 1/1	7.87	0.58	98	7.77	0.76	31	0.71
8.	Lat. Line scale	24.43	1.55	109	24.76	2.00	34	1.02
9.	Pre-dorsal scale	6.19	0.97	106	5.68	0.87	34	0.006
10.	Dorsal fin/LL	3.54	0.28	109	4.20	0.46	34	10.3
11.	Pelvic fin/LL	2.55	0.29	109	2.97	0.56	34	5.67
12.	Anal fin/LL	2.52	0.33	109	2.85	0.48	34	4.55
13.	Pre-pelvic scales	7.27	0.94	109	14.5	1.63	34	32.25
14.	Pre anal scales	14.77	1.81	109	6.85	1.04	34	24.26
15.	Circumpcduncular	9.57	1.12	105	10.06	1.04	34	2.51
16.	Mentum	4.12	3.56	98	9.04	4.59	34	6.43
17.	Gill rakers u/1	3.48	0.92	88	4.46	1.37	32	4.54
18.	Gill rakers 1/1	13.10	2.15	88	16	2.02	32	6.63
19.	Last anal fin	7.84	0.94	92	8.59	1.01	34	3.81

Values significantly different at 0.05 level.

Table 6. t-test for independent samples. Variables were treated as independent samples. Morphometric.

Sl. No.	Characters	Group 1			Group 2			table value
		Mean	SD	N	Mean	SD	N	
1.	Standard length	122.08	78.246	109	242.06	116.25	34	6.892
2.	Head length	35.42	20.47	109	65.76	30.48	34	6.644
3.	Body depth	31.59	19.74	109	69.89	34.97	34	8.06
4.	Snout length	12.88	7.74	109	24.07	11.22	34	6.56

5. Eye diameter	6.97	2.88	109	10.60	3.69	34	5.99
6. Inter-orbital width	10.99	7.73	109	22.81	12.57	34	6.61
7. Head width	18.61	11.55	109	35.75	17.16	34	6.67
8. Ht. at occiput	24.61	14.06	109	47.75	25.28	34	6.79
9. Width of mouth	8.48	4.97	109	15.09	7.53	33	5.88
10. LCPD	21.84	14.74	109	41.14	18.41	32	6.14
11. HCPD	14.24	8.99	109	29.60	14.83	34	7.39
12. Pre-dorsal length	62.68	39.89	103	122.56	62.18	34	6.53
13. Post-dorsal length	62.69	42.96	96	130.58	65.88	34	6.82
14. Pre-orbital length	20.65	10.96	96	34.22	15.15	34	5.58
15. Post-orbital length	16.78	10.35	94	34.12	19.54	32	6.39
16. Inter-nostril dist.	7.15	4.69	103	13.88	7.99	34	5.98

All values are significantly different at 0.01 confidence level.

It is seen that 15 morphometric and 13 meristic characters show significant differences between the two groups. The student's t values confirm to the conclusion. At 5% levels the table is 1.56 and at 1% level it is 1.6 that are much lower than the observed values. However in respect of the following six meristic characters the t values show no significant difference between the groups.

Pectoral fin rays 1.52.

Anal fin rays 1.53 Caudal fin upper lobe 1.33. Caudal fin lower lobe 0.71

Lateral line scales 1.02 Pre-dorsal scales 0.006

The above characters are known to be growth oriented and as such variations are to be expected. It may be recalled that chi-square values also reflect such variations in respect of meristic characters. The above confirm in general that the two populations are different and the Null hypothesis that they are homogenous is rejected.

Correlation

An attempt was made to study the correlation between the various morphometric and meristic characters of *Tor khudree* and *Tor mussullah.* Marked correlations at P less than 0.0500 were considered significant. The data are presented in Tables 7 & 8.

Table 7. Correlation between *Tor khudree* and *Tor mussullah* of morphomeric characters.

Characters	*Tor khudree* r-value	p ⊆	*Tor mussullah* r value	p ⊆
SL/Head length	0.778	0.0001	0.989	0.0001
SL/Body depth	0.989	0.0001	0.988	0.0001

SL/Pre-dorsal length	0.885	0.0001	0.989	0.0001
SL/Post-dorsal length	0.019	0.917	0.987	0.0001
LH/Eye diameter	0.757	0.0001	0.939	0.0001
LH/Snout length	0.702	0.0001	0.985	0.0001
LH/Pre-orbital length	0.003	0.098	0.959	0.0001
LH/Width of mouth	0.771	0.0001	0.972	0.0001
LH/Head width	0.776	0.0001	0.983	0.0001
LH/Ht. at oceiput	0.777	0.0001	0.968	0.0001
LH/LCPD	0.786	0.0001	0.962	0.0001
LH/HCPD	0.770	0.000 I	0.987	0.0001
LCPD/HCPD	0.987	0.0001	0.968	0.0001
Snout/Eye diameter	0.865	0.0001	0.934	0.0001
10W/Eye diameter	0.982	0.0001	0.942	0.0001

Table 8. Correlation between *Tor khudree* and *Tor mussullah* in meristic characters.

Characters	*Tor khudree*		*Tor mussullah*	
	r-value	p ⊆	r value	p ⊆
SL/LL scales	0163	0.355	0.386	0.840
SL/DF rays	0.334	0.054	0.487	0.784
SL/Anal rays	0.308	0.076	0.150	0.397
SL/Caudal u/1.	0.306	0.078	0.327	0.059
SL/Caudal 1/1	0.312	0.073	0.337	0.052
SL/PDS	0.065	0.713	0.115	0.530
SL/Pre-pelvic	0.057	0.749	0.130	0.463
SL/Pre-anal	0.055	0.759	0.183	0.297
LL/DF scales	0.267	0.127	0.312	0.072
LL/Pelvic scales	0.668	0.707	0.113	0.524
LL/Anal scales	0.218	0.216	0.106	0.550
LL/Circumped.	0.114	0.520	0.211	0.231
SL/Gill raker u/I	0.194	0.271	0.219	0.213
SL/Gill raker l/1	0.181	0.306	0194	0.272

Less than 0.05 Significant. More than 0.05 not significant

In respect of correlation of characters between the two species it is seen that morphometric characters all are significant excepting LH/Pre-orbital length and SL/Post

dorsal length in *Tor khudree.* Conversly in respect of meristic characters all show no significant correlation. It would appear that morphometric characters are more dependable than meristic. Also the high significance of morphometric characters indicate the separate identity of the two sepcies. The maximum r-values for *mussullah* as against for *khudree* also appear to confirm their separate distinctness.

Tor neilli (Day)
(Text-fig.6)

Barbus neilli Day, *Proc. Zool. Soc. London :* 581, 1868 (type locality, Kurnool, River Tunghabhadra). - Day, *Fish India :* 569, pl. 140, fig, 4, 1877. Beavan, *Handbk freshwater fish India:* 45, 1877 (Tamboodra river). - Narayan Rao & Seshachar, *Hlf.yrly. J. Univ. Mysore:* 130, 1927 (Thunga and Bhadra river systems).- Venkateswarlu & Rama Rao, *Occ. Paper Zool. Surv. India* **87** : 1986 (equivalent to Day's *Puntius neilli).* - David, *Proc. nat. Ins Sci. India* **22** (3) : 152, 1956 (Bhadra River at Bhadravati). - Sen & Jayaram, *Occ. Paper Zool. India* No. **39** : 15, 1981 (uncertain status). - Talwar & Jhingran, *Inland fishes* 1 : 303, 1991 (synonym of *Tor khudree)*

? Barbus khudree Sykes, *Trans. Zool Soc. London,* **II** : 357, 1841. Bleeker, *Verh. Bat Gen.* **25** : 60, (1853).- Jerdon, *Madras J. Lit & Sci.* **15** : 313, 1849.-Menon, *Occ. Paper Zool. Surv. India* No. **175** : 58, 1999 (synonym of *Tor khudree).*

Barbus (Puntius) neilli, Hora, *Rec. Indian Mus.* **44** (2) : 195, 1942 (name only, Coorg, Wynaad, Nilgiris).

Puntius neilli, Jayaram, *Handbk. Freshwater fish India :* 101 (distribution) : 106 (key), 1981.

Tor neilli, Jayaram, *Mahseer. The game fish :* C 25 (Tungabhadra River, Krishna River system) : C 31 (systematic status) 1994.-Jayaram, *Occ. Paper Zool. Surv. India.* **160** : 96, 1995 (name only, Krishna river system).-Jayaram, *The freshwater fishes of the Indian. region :* 96, 1999 (key).

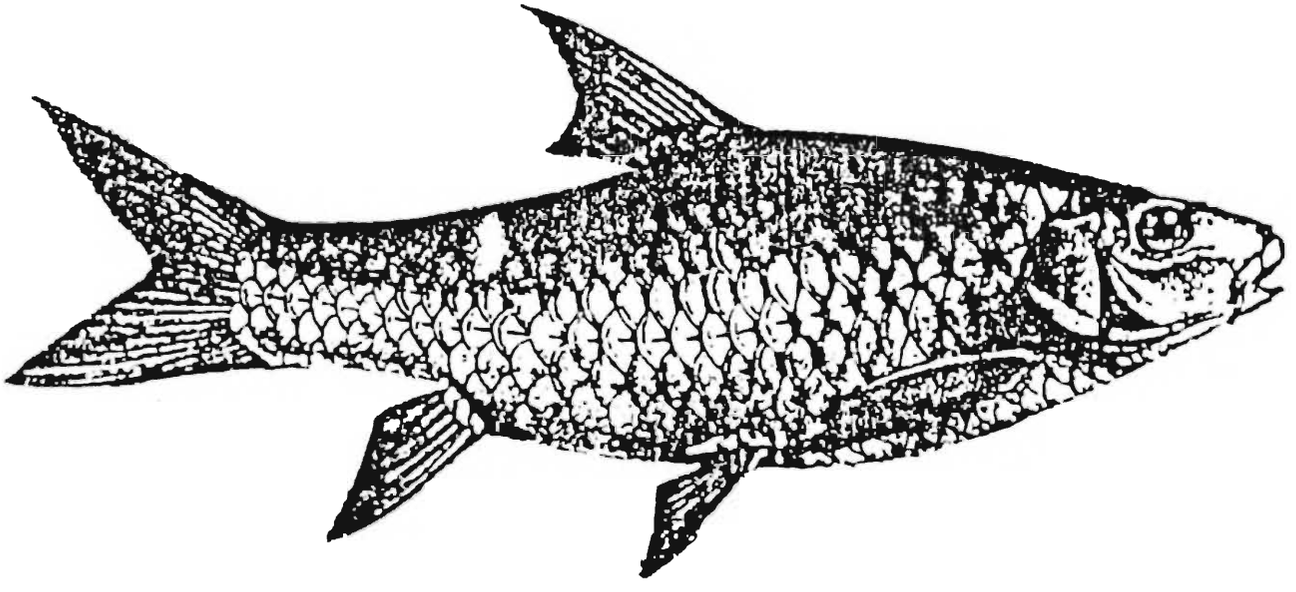

Fig. 6. Outline drawing of *Barbus neilli* as figured by Day, 1877.

Local Names : Nil.

Specimens studied : RMNH 8668, One ex. 140 mm SL, Deccan, F. Day Coll. (Caudal fin damaged). ZSI F. 2295, One ex. 62 mm SL. purchased, F. Day, (badly damaged no data could be taken).

Description : Based on one example RMNH 8668 (Plate V, A & B).

D. III, 8; P. i, 11; V.i, 8; A. i, 6; C. damaged (only two middle rays seen, others damaged during transit).

Dorsal profile arched rising gently up to dorsal fin base, thereafter tapering towards caudal fin base; ventral profile not arched. No marked hump at occiput. Head small 28.6, body depth 28.6, head length nearly equaling body depth, pre-dorsal length 52.6, post-dorsal length 50.0 in percent of standard length. Eyes moderately large, on the upper part of head, not visible from below ventral surface, 62.5 in percent of snout length, 52.6 in percent of inter-orbital width which is flat; eyes 20.5, snout 33.3, head width 17.9, height of head at occiput 62.5, width of mouth 17.9 in percent of head length. Mouth narrow, lips slightly fringed, lower lip produced as a small median lobe (mentum). Labial fold continuous. Two pairs of short barbels, rostral and maxillary, all shorter than head length.

Dorsal fin shorter than body depth, inserted almost above pelvic fin insertion, nearer to tip of snout than caudal base. Spine smooth, weak, osseous. Pectoral fin as long as head excluding snout, longer than pelvic fin not reaching later. Pelvic fin inserted nearer caudal fin base than tip of snout, not reaching anal fin. Anal fin when laid flat reaches caudal in base. Least depth of caudal peduncle 45.5, length of caudal peduncle 71.4 in percent of head length, height 66.7 in percent of its own length. Lateral line straight.

Distribution : Krishna River system, Tungabhadra River

Scales :

Lateral line	26
Pre-dorsal	5
Pre-anal	14
Pre-pelvic	6
Dorsal fin/Lateral line	3½
Pelvic fin/Lateral line	2½
Anal fin/Lateral line	2½
Cicumpeduncular	9
Gill rakers.	Not taken

Colour : Silvery above lateral line with a tinge of yellow below it. Fins with a bluish tinge in some specimens, reddish in others. The juveniles have a dark spot at the base of the caudal fin. Eyes golden (Day, 1877). In preserved examples dark brown.

Remarks : Day (1877) described this species as *Barbus neilli* from Tungabhadra River at Kurnool, Andhra Pradesh. He collected more than one example as seen from his statement that his largest specimen "personally seen was 38 Ibs" and the example figured, stuffed is 22 inches long, This is justified by Whitehead & Talwar (!976) who elaborated the life history of Francis Day and gave a very useful table of new genera and species described by him with registered numbers of possible type specimens in different world institutions. Under serial number 75 *Barbus neilli* with the following details of specimens deposited are given.

Calcutta 2295 (7151, f) London 1868. 10.27.16-17* Sydney B 7870 Leiden 2638. F = figured specimen, *Dry specimen"

Through the kind courtesy of Dr. Mark Mc Grouther, Collection Manager, Australian Museum, Sydney 1 obtained relevant data of Day's specimen present in their museum. The details given by Dr. Mc Grouther are as below :

'Data for *Barbus neilli* AMS 870, SL 84.2 mm, BD at pectoral base–18.6 mm, BD greatest at D fin origin–20.7 mm, HL- 23.4 , No of barbels–0, LL scales–47 (scale rows) approx. due to poor condition, Scale rows between LL & Pelvic fin base–3, Scale rows between D fin origin & LL–13 approx, due to poor condition. Do not understand what you require regarding the nature of the dorsal spine (NB there are no dorsal spines, (all are rays) or the labial fold"

It is very clear the specimens are not *Barbus neilli* and may have been wrongly labeled; the photo (plate VI) reproduced here also clearly indicates it to be some other Cyprinid fish but not *Barbus.*

The specimen from Leiden Museum is clearly referable to *Barbus neilli* as can been seen from the photo (Plate V, A & B) and data presented. The ZSI specimen is completely damaged and is of no use for purpose. Ferraris et al (2000) have however designated the Sydney example as a possible syntype, which is an error. The specimen in the BM or one in Leiden qualifies for this designation. The Natural History Museum, London that is supposed to prossess two examples has not responded for several direct and indirect requests.

The late Dr. A. David of Central Inland Fisheries referred (!963) three specimens from Bhadra River at Bhadravati, Karnataka. I had been to this locality in 1990 and the fishery officials are do doubt aware of the species but since the entire dam channel bed has been cement concreted no fish is available. The examples collected by Dr. David are not also traceable.

Till such time specimens are collected it is best kept as a separate though it may appear to be *Tor khudree.*

A comparison of the morphometric and frequency of meristic characters of the three species is given in Tables 9 & 10.

Table 9. Comparison of morphometric data of three species of deccan mahseers (All data in percentage)

Sl No.	*Tor khudree*	N	*Tor mussullah*	N	*Tor neilli*	N
1. SL/Body depth	26.3 (21.7-29.0)	102	28.7 (23.8–31.2)	34	28.6	1
2. SL/LH	28.6 (21.7–29.0)	102	27.8 (23.2–33.3)	34	28.6	1
3. SL/Pre-dorsal	50.0 (45.2–55.6)	96	52.6 (47.6–55.6)	34	52.6	1
4. SI/Post-dorsal	52.6 (45.5–55.6)	95	52.6 (47.6–62.5)	34	50.0	1
5. Snout/Eye diameter	58.9 (40.0–100.0)	102	52.6 (27.0–62.5)	34	62.5	1
6. Int.OrbWdth/Eye	66.7 (38.5–100.0)	102	48.3 (32.2–90.7)	34	52.6	1
7. LH/Eye	21.3 (14.5–31.3)	102	16.7 (102–25.0)	34	33.3	1
8. LH/Snout	37.0 (22.7–62.5)	102	37.0 (33.3–45.3)	34	33.3	1
9. LH/Head width	52.6 (41.0–71.4)	102	52.6 (40.0–62.5)	34	17.9	1
10. LH/Ht. at ocpt	71.4 (58.2–100.0)	102	71.4 (55.6–90.9)	34	62.5	1
11. LH/Wdh.Mth.	23.8 (17.5–47.6)	100	22.7 (18.5–32.2)	33	17.9	1
12. LH/LCPD	58.8 (45.5–83.3)	102	66.7 (47.6–90.9)	34	71.4	1
13. LH/HCPD	40.0 (31.2–50.0)	100	50.0 (33.3–52.6)	34	45.5	1
14. LCPD/HCPD	66.7 (43.5–90.9)	102	58.8 (40.0–83.3)	34	66.7	1

Table 10. Frequency distribution of certain meristic characters in three species of deccan mahseer.

1. Dorsal Fin rays

Species

	N	I,6	I,7	I,8	I,9	II,7	II,8	II,9	III,8	III,9
Tor khudree	102	2	5	6	4	2	36	46	1	–
Tor mussullah	34	–	–	2	2	–	6	22	–	2
Tor neilli	1	–	–	–	–	–	–	–	1	–

2. Pectoral fin rays

	N	i,9	i,10	i,11	i,12	i,13	i,14	i,15	i,16
Tor khudree	90	3	12	13	20	25	15	2	–
Tor mussullah	34	–	–	7	7	6	11	2	1
Tor neilli	1	–	–	1	–	–	–	–	–

3. Pelvic fins rays

	N	i,5	i,6	i,7	i,8	i,9
Tor khudree	96	8	12	48	28	–
Tor mussullah	33	–	–	9	21	3
Tor neilli	1	–	–	–	1	–

4. Anal fin rays

	N	i,4	i,5	i,6	i,7	ii,5	ii,6
Tor khudree	96	6	80	7	2	–	1
Tor mussullah	34	1	22	10	–	–	1
Tor neilli	1	–	–	1	–	–	

5. Caudal fin rays

	N	6+6	6+7	7+7	7+8	8+7	8+8	8+9	9+7	9+8	9+9
Tor khudree	93	–	–	6	9	18	50	6	–	2	2
Tor mussullah	31	1	2	3	4	4	10	3	1	1	2
Tor neilli	I	Damaged									

6. Lateral line Scales

	N	21	22	23	24	25	26	27	28
Tor khudree	102	3	10	19	20	23	20	7	–
Tor mussullah	34	3	2	4	5	6	9	3	2
Tor neilli	1	–	–	–	–	–	1	–	–

7. Pre-dorsal scales

	N	4	5	6	7	8
Tor khudree	102	3	20	45	29	5
Tor mussullah	34	2	13	14	4	1
Tor neilli	1	–	1	–	–	—

8. Dorsal fin/Lateral line scales

	N	2½	3	3½	4	4½
Tor khudree	102	2	2	94	1	3
Tor mussullah	34	–	–	10	–	24
Tor neilli	1	–	–	1	–	–

9. Pelvic fin/Lateral line scales

	N	1½	2	2½	3	3½	4	4½
Tor khudree	102	1	1	97	–	3	–	–
Tor mussullah	34	–	–	19	–	14	–	1
Tor neilli	1	–	–	1	–	–	–	–

10. Anal fin/Lateral line scales

	N	1½	2	2½	3	3½
Tor khudree	102	2	8	92	–	—
Tor mussullah	34	–	–	21	–	13
Tor neilli	1	–	–	1	—	—

11. Pre-pelvic scales

	N	5	6	7	8	9
Tor khudree	102	5	15	31	47	4
Tor mussullah	34	4	10	11	7	2
Tor neilli	1	–	1	–	–	–

12. Pre anal scales

	N	8	9	10	11	12	13	14	15	16	17
Tor khudree	102	1	—	2	1	8	14	16	13	35	12
Tor mussullah	34	—	–	–	1	5	2	8	7	8	3
Tor neilli	1	—	–	–	–	–	–	1	—	—	—

13. Circumpeduncular scales

	N	7	8	9	10	11	12
Tor khudree	98	2	14	37	36	7	2
Tor mussullah	34	–	2	8	10	13	1
Tor neilli	1	–	–	1	–	–	–

14. Gill rakers on lower limb

	N	9	10	11	12	13	14	15	16	17	18	19	20	21
Tor khudree	87	—	1	5	11	26	14	13	7	4	2	1	1	2
Tor mussullah	32	–	–	–	–	2	1	5	3	8	7	3	2	1
Tor neilli	1	NOT TAKEN												

15. Last anal fin ray to caudal fin basc (scales)

	N	5	6	7	8	9	10
Tor khudree	93	2	8	12	52	18	1
Tor mussullah	34	–	–	6	9	13	6
Tor neilli	1	–	—	–	–	1	

16. Anal opening position

	N	at base of fin	one scale forward	two scales forward
Tor khudree	94	65	22	7
Tor mussullah	32	14	15	3
Tor neilli	1	—	1	—

DISTRIBUTION AND LOCATION

MAHARASHTRA

In peninsular India especially along the Western Ghats the mahseers are distributed in isolated pockets. *Tor mussullah* is sporadically distributed in Maharashtra, Karnataka, Kerala and Tamil Nadu. *Tor khudree* is extensively cultivated at Lonavla fish farm; fry and fingerlings are stocked all over the river systems in the south by the respective state fishery departments. A brief list and description of different locations where mahseers are located and where personal attemps were made to collect is given in the following pages.

Maharashtra appears to be the home of *Tor mussullah* and *khudree*. The state is endowed with rich waters of Krishna, Indrayni, Warna, upper reaches of Godavari and other rivers with their numerous tributaries and distributaries. The state government has almost utilized the storage capacity of these rivers as much as possible by construction of dams, barrages and weirs. These serve for power generation, irrigation purposes besides for stocking of commercially valuable fish species. A tree diagram of the Krishna river system in Maharashtra (Text-Fig. 7) would show the efficient utilization of these waters.

Mahseers are reported to be present in the Koyana River and its reservoir besides the tributaries joining it. As already stated earlier *Tor mussullah* was described by Sykes (1839) from a male specimen collected from Sirur, Ghod River (18°50' N, 74°20' E) located adjacent to the road from Pune to Nasik via Ghod Nadhi town, 65 km north east from Pune (Plate VII). It is a tributary of Bhima River that ultimately joins Krishna in the Karnataka state. A dam is constructed 10 km upstream 200 to 300 meters long and the water stored with a depth of six to eight meters (November 1998). It is seasonal; most part, excluding a few perennial pools along the course of the river, is dry. The margins were with aquatic weeds. mostly Chara and somewhat submerged. The water was clear, cool and the river bed with laterite soil. The villagers are aware of the hump-backed

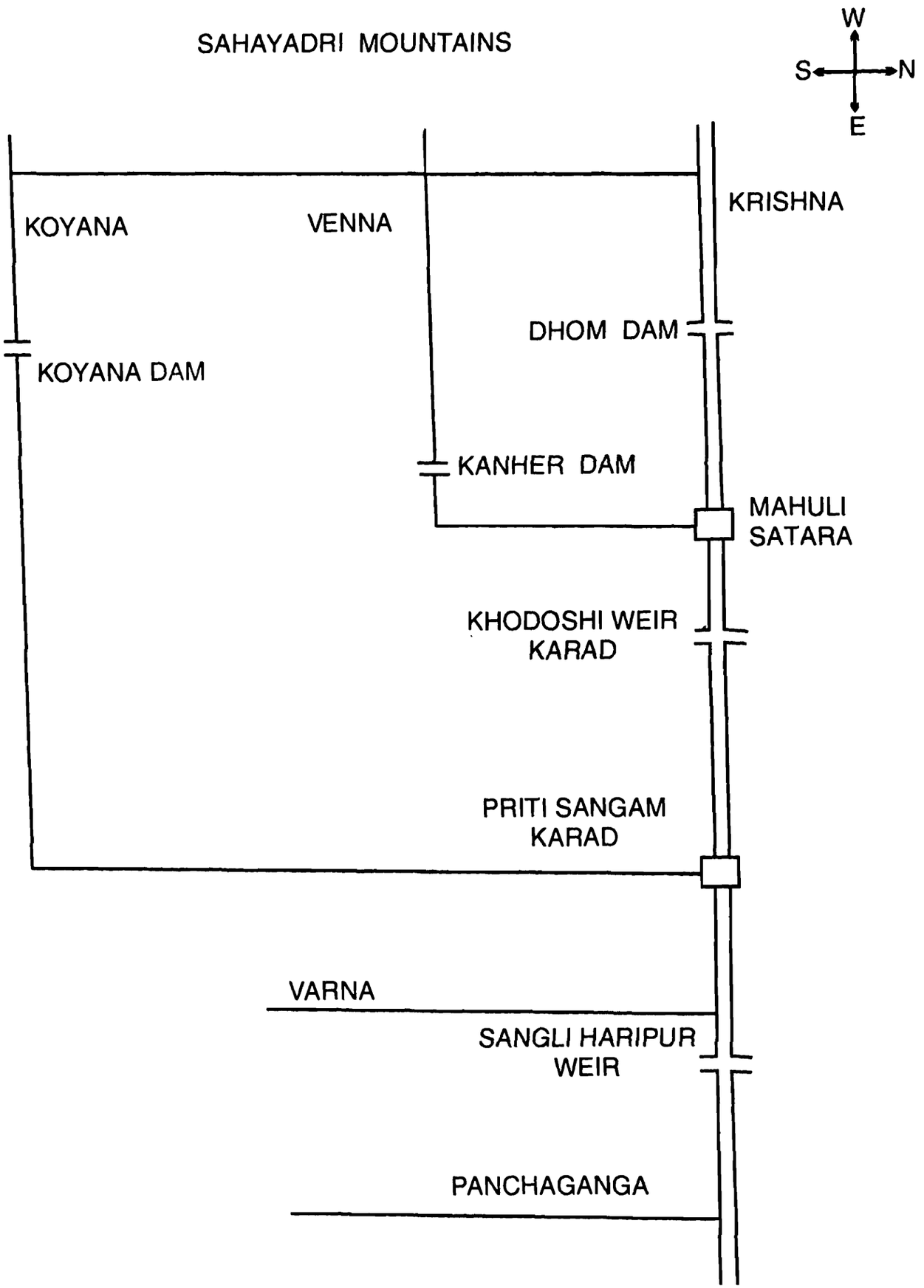

Fig. 7. Tree diagram of Krishna river system in Maharashtra.

mussullah and they clearly distinguish *khudree* as the one without the marked hump. All sizes and age groups are available in fish catches; sometimes a fish weighing about 20 kg is also obtained during early part of the monsoon when they migrate upstream for spawning. Mussullah is rarely caught mostly during summer when the water level recedes forming deep water pools. An attempt was made to collect specimens but with no success.

The Koyana River that harbours a good adult population of *mussullah* and *khudree* is a major tributary of the Krishna River. Although both emerge from Sahayadri range of mountains they flow apart in opposite directions. Koyana flows westwards and the Krishna eastwards at the point of origin, but both of them turn southward and flow separately a considerable distance before forming the Preeti Sangam at Karad. Both the rivers get the benefit of high rainfall of 6182 mm/annum at Mahabaleshwar and surrounding areas during the South–West monsoon. Nevertheless owing to the large bowl-like catchment area of 871.78 sq.km the Koyana receives maximum quantity of rainfall in that area. Consequent to the construction of the dam at Helwalk in Patan Tahsil, Satara district in 1961 a huge reservoir of 2796.4 mem, popularly called Shivaji Sagar has come into existence. This reservoir is located in between two high mountain ranges running parallel to each other for a considerable distance with steep slopes on either side. The mountain has rich and thick forest, natural and man-made, all along, within the stretch of the river valley. The reservoir is 45 km long with a maximum width of one km at dam site, tapering towards distance upstream end at Tapola. With the onset of monsoon the reservoir gets filled up within the initial two months of the season every year. This causes sudden increase (3½) times in storage with fresh and oxygen rich waters ideally suited for breeding of the Mahseers *T. mussullah* and *T khudree*. By the end of the monsoon the ecosystem changes from a fluviatile to lacustrine conditon. Owing to release of water for power generation, the maximum expanse of the water column in the reservoir gets reduced from 11,535 ha with depth of 78.8 m receding further slowly for the year. Prior to the construction of the dam the shallow and seasonally filling stretch of the Koyana River did not have much of a fish production, particularly in the now submerged portions. In contrast, the fish production now in the Shivaji Sagar is 65 mt per annum approximately, which comprise 20% of Mahseeer (both species together) roughly working out to 13.14 mt. Both *mussullah* and *khudree* are almost in equal proportions. In respect of yield, *mussullah* is caught to the extent of 6.57 mt/annum. (See Valsangkar, 1993 for catch statistics, gear etc). *T mussullah* has been observed (along with *khudree*) in Bhatgar reservoir on Yelwandi-Nira River, Veer reservoir on Nira River, both in Pune district. Warana reservoir on Warana River, Sangli district, and in Krishna River at Wai, Satara district (Jayaram et al. 1999). The species is stocked in the Walwahn Lake of the Tata Electric Company at Lonavla.

KARNATAKA

Karnataka also harbours the mahseer species though not to the vast extent as Maharashtra. *T mussullah, T khudree* and *T khudree malabharicus* are reported to be occuring in Karnataka waters. Of these the status of the last species has already been clarified. The

first two are rarely found in natural waters and sights are of sporadic occurrence only. However thanks to the sustained breeding and hatchery experiments carried out at the Tata Electric Company's Fish farm at Lonavla *T khduree* is extensively stocked in different water bodies in Karnataka. *T mussullah* is found only in selected temple sanctuaries in rivers Kaveri and Thunga. Some of the locations where these were located are as below :

Muthathi. In the Kaveri system and in the main river, a distance of 18 km from Mekatadu has been leased out by the Karnataka state fishery department to the Wildlife Association of South India (WASI, Bangalore). This stretch is in a jungle terrain and in a restricted area where military training is also conducted. The Association permits fishing for the Mahseers on payment of a fee (Rs. 2500/ for five days) and jungle lodges are constructed along the banks of the river. Mostly foreigners come and catch the fish by angling and the fish are reported to be released into the river after taking weight, length and photography. Photographs found at the association premises (1995) at Bangalore show some large sized *mussullah.* It is reported that a 50 kg fish has been caught. The bait *ragy* paste and nylon thread is used as line. Three hooks can also be used, spoon fishing is also done. In the month of January fishes do not come out since the water is cold. During heavy floods in the Cauvery in 1993 many mature fishes were reported to have died and washed downstream to Tamil Nadu stretch, but this cannot be vouchsafed in the absence of records.

Thunga River flows through a rocky, boulderus stretch in the Shimoga district. At **Teerthahalli** and **Hariharapura** sanctuaries are situated in the river stretch near some temples at Chiplagudde near Melge (Plate VIII, Fig. B) a temple for Ganesha is on the bank. Large sized *Tor khudree* coexists with the other carp species in this stretch. They swim freely unhindered in large numbers and come to the shore steps (Plate VIII, fig. A) to take puffed rice offered by pilgrims. No fishing is permitted. The river is about 200 yards wide with water stretch confined near the temple to about 50 to 100 yeards width. Not very deep but the bed is bouldecrus and rocky. Secrub jungle adorns the banks.

Hariharapura near Koppa is a fine sanctuary for Mahseers where on the Thunga these fishes are protected. A dam is contructed at Gajanur (Plate IX, Figs. A & B). The river is narrow, hardly 100 yards wide, with rocky bed. The river flows along the backside of a large mutt where a Shiva temple with architectural sculptures of the 15th century engraved on the stonewalls is present. Being inside a residential complex access is not easy and the fishes are zealously guarded. Sanctity is attached to the bubbling life. No *mussullah* could be seen but many *khudree* were abundant.

Sringeri is hardly an hour's drive from Hariharapura and the river Thunga flows (Plate X) over a very rocky bed with big boulders projecting from the river bed. Sringeri mutt situated on the banks of Thunga is a large complex where pilgrims throng for worship of the Shankaracharya. *Tor mussullah* are seen in large numbers in good size and they come near the stone steps to pick up purfted rice offering of the pilgrims (Plate XI).

Tor khudree are also seen but in lesser numbers. Two varieties were seen, one black and another white. The river is 300 yards wide but the stretch is confined only to 100 yards and the shallow stream is littered with waste plastic material thrown by the pilgrims.

Ramanathapura on the Cauvery is 50 km from Hassan, Shimoga district. Here also a temple is constructed on the bank making the stretch a sanctuary. A fish farm of the Karnataka state fishery department is on the bank. The river is 200 yards wide, water stretch hardly 50 to 75 yards only, slow and sluggish. Large congregation of fish were seen, fed by the few pilgrims with puffed rice. Large sized *Puntius carnaticus* were seen but no mahseers were available. Local people are very curious and well informed and are environment conscious.

Harangi reservoir is accessible from Kushal Nagar, Coorg district, reached by road from Mysore, or from Medikere. The Fishery department maintains a nursery, eight km away from the town. *Tor khudree* is reared with fingerlings obtained from the Tata Electric Company's fish farm, Lonavla. Three examples were collected from the nursery tanks. Sri Rame Gowda, Asst. Director of Fisheries said that *mussullah* and *neilli* are present in the Cauvery. A stretch of 28 km from Guddehosur to Virajpet has been leased to Kodagu Wildlife Association where fingerlings of *Tor khudree* have been released.

Other locations visited in Karnataka are as below :

River Payashwini or **Sullia** at Shesheela is 80 km from Mangalore on a road branching off from Bantavala Cross Road on NH 48. The river is reached taking a diversion before Uppinangadi to Puttur. The river stretch is with boulders and bund made of shingles and rocks making a big pond in the river Sulliya. A nationalized bank branch is on the banks of the river. The Manager of the bank keeps a watch over the fishing activities and protecting the mahseer fishes. The river is 150 yards wide, 8 to 10 feet deep with clear water on a boulderus bed. Thick jungle vegetation covers the banks.

A blue tailed variety of mahseer with pink coloured paired fins was seen in plenty. They were of sizes ranging from one to three feet. Along the periphery about a dozen golden coloured fishes were also seen, each of about a foot long that was not attracted by the offering of puffed rice. These were rohu (*Labeo rohita)*, which have been introduced.

Pacchanaiken Gundi on River Kumaradhara at Subrahmanya. Approachable through forest track. Kumaradhara River is 75 yards wide with clear water, 3 to 5 feet deep with thick jungle vegetation on the banks. Khudree mahseers of light gray variety with cement colour body of about a foot long were moving in a shoal and darted away on the approach of men. Some were found in a big rock pool and where there was coverage by foliage; many were seen congregating.

Sita River (Brahmabydarkal Garadi Temple at Thingale). The river is at the base of Agumbe hills amongst picturesque scenery. Riverbed is with pebbles and shingles and the stretch of water is only about 50 to 75 yards. The northern bank was deep with about

five feet of water. Khudree specimens of greenish hue over body, with dorsal and caudal fins black, paired fins pink were seen.

Aganashini River (Plate XII) at Heekuli village Hangarhole joins the main stream. River very shallow hardly one or two feet, deep, water spread about 50 yards but bank to bank spread is about 200 yards. Stream flow slow with rocky bed. No mahseers were seen through other Cyprinids were plenty.

Bedthi River 35 km away east of Sirsi town. Stream very rocky confined to a middle stretch with rock pools. Sirsi-Bedthi River at Manchikeri 40 km away from Sirsi where Shalamala River joins Bedthi. A rocky stream but no mahseers were seen.

Oonchahalli on Gangavali River. A narrow stretch in a deep gorge, open stream but with ever green vegatation on the banks. Fish habitats were less; but one example of *Tor khudree* was collected.

Kali River at Kadra. The river is proposed to be dammed at this place. The stream forms a wide water spread, 33 meters wide, tree stumps 50 years old all strewn up on the river bed. No mahseers were seen.

Jog Falls on Sharavathi. Stream wide with boulders but here and there sandy beds are seen.

KERALA

Pookotu Lake at Vythri (6 June 1996). 57 km north of Calicut. The lake is 18.1 ha in area, hardly 2 or 3 feet deep infested with aquatic weeds (*Valliseneria*), *Nelumbium* with turbid water and marginal vegetation of forest trees. Being a tourist spot the habitat is much disturbed. No mahseers were seen.

Nedungaryam River near Nilambur (January, 1997). A tributary of Chaliyar River. The river stretch is 150 feet wide, shallow with clear water, sandy bed with stray boulders. Stream flow through reserve forest area. *Tor mussullah* is known to occur here.

River Karimpuzha at Nilambur (January, 1997). The river is accessible from Kerala forest Res. Sub center. River 300 feet wide but stream flow confined to 100 feet only. Water stagnant with occasional deep pools of one or two feet depth. Stream bed strewn with boulders. Water is used for bathing and washing cattle. Fishermen throw grenades and kill fish. *Gonoproktopterus curmuca* were found dead because of such practice. *Tor khudree* and *T mussullah* are killed in this fashion but no sample could be obtained.

Lower reaches of Karimpuzha at Maancherry near Panampuzha (9 January 1997) Accessible from KFRI center 29 km west. River flowing in a gorge with deep sides. Width of river 100 feet; thick vegetation, difficult terrain with rocks and boulders abutting. No regular track except foot-path. Stream width 50 feet. Collected *Tor mussullah* besides *G. curmuca*. Small specimens of a red finned *mussullah* were also collected.

Maancherry river, upper reaches of Karimpuzha (January 1997). Stream width 10 to 16 meters with boulderus bed, 75% gravel, 5% pebbles, 10% bed rock, Canopy cover 60%. Collected by gill net *Tor mussullah.* Pectoral, anal and caudal fins red coloured when alive.

The following areas in Kerala are also reported to abound in mahseers. Parambikulam, headwaters of Bhavani River.–*T khudree.* Chalakudi River system at Athapadi, Kalakkad, Mundanthurai- *T khudree.* Periyar Thekkady, Achankoil, Chinnar. *T khudree.* Kallada River upstream, Kulathupuzha–*Tor khudree malabaricus.*

TAMIL NADU

Moyar River at Thengumarhada (Plate XIII). Riverbed with clayey soil with rocks here and there forming rock pools. River width hardly a meter. As we go upstream the area becomes rocky but river with sandy bed. Reports of occurrence of mahseers are made and catches are also not uncommon. A large sized specimen of *Tor mussullah* was obtained with the help of Tamil Nadu State Fishery officials.

A summary of locations where mahseer species *Tor mussullah, T khudree* and *Tor neilli* is given below. By the term natural population it is implied that the presence of artificially bred and trans-located stocks are excluded. The list has been compiled from published records and information provided by anglers, state fishery officials and fellow scientists but it must be stated that some of them may not have the reported mahseer fishes in view of the vast and fast anthropogenic changes that have taken place in the country.

MAHARASHTRA

Rivers

1. Koyana
2. Warna
3. Indrayani
4. Bhima
5. Mutha Mula
6. Krishna
7. Godavari headwaters
8. Ghod
9. Paswana
10. Neera
11. Wenna
12. Panchganga
13. Doodganga

KARNATAKA

1. Thunga
2. Bhadra
3. Thungabhadra
4. Krishna
5. Godavari
6. Harangi

7. Payashwini
8. Kumaradhara
9. Cauvery
10. Sita
11. Aganashini
12. Bedthi
13. Gangawali
14. Kali
15. Sharavati
16. Venkatapur
17. Bhadravati

KERALA

1. Chalakudy River–*T khudree*
2. Karimpuzha–*T mussullah*
3. Chalakudypuzha-*T khudree*
4. Maancherry–*T mussullah*
5. Parmbikulam reservoir–*T khudree*
6. Sholayar dam - *T khudree*
7. Upstream of Periyar-*T khudree*
8. Headwaters of -Bhavani–*T khudree*
9. Athapadi on Chalakudy River–*T khudree*
10. Kalakad-Mundanthurai–*T khudree*
11. Meenmutty–*T mussullah*
12. Thekkady, Thanikudi–*T khudree*
13. Achankoil–*T khudree*
14. Chinnar, Champakad–*T khudree*

The following Wild Life Sanctuaries in Kerala (except Silent Valley National Park) are known to habour *T khudree.*

Wayanad–Kabini River (*Tor mussullah* reported in 1921 by Hora)

Chinnar
Parambikulam
Periyar
Peechi
Neyyar
Thellekad
Shendremey
Idukky

Aralam wildlife sanctuary (Cheenakkanipuzha, Uruthpuzha, Valayamchal, Narikadavu) has *khudree* reared.

TAMIL NADU

1. Sholayar
2. Cauvery upper reaches
2. Bhavani
4. Moyar

ANDHRA PRADESH

1. Krishna
2. Nagajuna sagar dam
3. Thungabhadra at Kurnool
4. Thungabhadra dam at Hospet

ORISSA

1. Headwater of Brahmini
2. Mahanadi

DETERMINATION OF ENDANGERED STATUS

Depending upon the extent of threat percepts various terminologies have been coined by the international community for both animals and plants to classify and group them into workable complexes. It becomes obvious that the threatened categories are protected, conserved for their continuation and ultimate human prosperity.

Conservation technologies have been in vogue in our country since the Vedic and historical times (1500 BC–800 AD). From a study of references to Fish in Kautilya's Arthasastra (ca. 300 BC) it is clear that during those times fishing was a well-established industry and fish was regarded as an article of staple diet. The ancient Indians posssessed a considerable general knowledge of the habits of fishes and used that to practical purposes. Hora (1948, 1951, 1953) in a series of articles highlighted these aspects. Historically king Ashoka (246 BC) in his Pillar Edict V enumerated terms for conserving animals (see Hora 1950, 1951).

Conserving the animal groups or even the natural world can be grouped under four pillars of conservation : Ethical, Esthetic, Scientific and Economic (Vladykov, 1973). Conservation of freshwater fishes in our country has become of utmost priority. With rapid industrialization, growth of urban areas, construction of dams and hydroelectric projects, buildings, rail, roads and encroachment of vast areas of forestland for agricultural extension with monoculture have brought about distinct and direct disturbances in our natural ecosystem. Canalization of streams as a result of dam constructions and diversion of water through cemented canals, which deny these canals leaf litter and forest debris besides foliage covers as most of them are open to the sky without any cover has done immense harm. The smooth bottom mostly concreated have no bottom biota of plant or animal life, which influence the growth of the fish. Eroded streams smother bottom life in streams, reduce plant growth, interfere with gills of fishes and the development of eggs (MacAllister et al, 1985). It converts a natural environment replete with vegetation cover and food organisms into an artificial environment with few of these essential requirements for maintenance of fish populations (Coad, 1980-81) Further, the water body is subject to high summer temperatures rarely beneficial to the fish life. These factors changes environmental scenario and resulting habitat shrinkage have made the mahseers endangered. Further, the over-fishing and changes in stream ecology have also contributed to their decline.

BACKGROUND TO THE CRITERIA PROCESS

The threatened species categories now used in Red Data Books and Red Lists have been in place with some modification for almost 30 years. Since their introduction these categories have become widely recognized internationally and they are used in whole range of publications and listing produced by the IUCN as well as by numerous governmental and non-governmental organizations. The need to revise the categories has been recognized for some time. In 1984 the SSC (Species Survival Commission) held a

symposium. 'The Road to Extinction' (Fitter & Fitter, 1987) which examined the issues in some detail and at which a number of options were considered of the revised system. However no single proposal resulted. The current phase of development began in 1989 with a request from the SSC Steering Committee to develop a new approach that would provide the conservation community with useful information for action planning. Several versions were proposed as listed below :

Version 1.0 : Mace & Lande (1991). The first paper discussed new basis for the categories and presenting numerical criteria especially relevant for large vertebrates.

Version 2.0 : Mace et al (1992). A major revision of Version 1.0 including numerical criteria appropriate to all organisms and introducing the non-threatened categories.

Version 2.1 : (IUCN 1993). Following an extensive consultation process within SSC a number of changes were made to the details of the criteria and fuller explanation of basic principles was included. A more explicit structure clarified the significance of the non-threatened categories.

Version 2.2 : Mace & Stuart (1994). Following further comments received and additional validation exercises some more changes to the criteria were made. In addition the susceptible category present in versions 2.0 and 2.1 was subsumed into the Vulnerable category. A precautionary application of the system was emphasized.

Current version. 3.1 : The IUCN adopted this final version in 2001, which incorporates changes as a result of comments from the IUCN and SSC memberships and from a final meting of the Criteria Review working Group (CRWG) in February 2000. All new assessments after January 2001 are expected to use the latest adopted version and cite the year of publication and version number. The final version is published as a document.

"IUCN (2001). *IUCN Red list Categories and Criteria : Version 3.1.IUCN* Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK. ii + 30 pp." (see Annexure 1). This is now used for assessing extinction risks to species and these are now used for evaluation of species for inclusion in the IUCN Red List of Threatened species (2002). In Actinopterygii (Bony fishes) alone, a total of 1156 major taxonomic groups have been found threatened. Of these 80 have been assessed as Extinct (EX), 11 Extinct in the Wild (EW), 152 as Critically Endangered (CR) and 421 as Vulnerable (VU). The new method has attracted great interest from many agencies and management authorities since it is an excellent tool for observing changes in the status of animals over time and providing a more systematic and transparent approach to listing (Sally Walker and Sanjay Molur, 1997, Anon *Species* Nos. **31, 32,** 1999).

India is committed to the convention to assess sites and species and develop strategies for conservation of Biodiversity. The Endangered Species Prioritization Working Group on Biodiversity Conservation Prioritization Project (BCPP) in a workshop in May 1997 recognized the need to assess the status of all taxa in seven major groups of which freshwater fishes also formed a part of national assessment. As a first step I took up the case of the Deccan Mahseers as a measurable segment.

The IUCN 2001 criteria (Version 3.1) for assessing extinction risks to species are used here for evaluating the Deccan Mahseer species. Categorization has been done wih a view to verify all wild populations inside their natural range as in the case of the Deccan Mahseers. Populations introduced in new areas as in the case of *Tor khudree* are not assessed. The various categories now adopted (current version 3.1) and recommended are presented Fig. 1 in Annexure. The Taxon Data Sheet Categories used in the CAMP process is adopted. The Conservation Assessment and Management Plan (CAMP) organize workshops to provide strategic guidance for application of intensive management and information collection techniques to threatened taxa. CAMPs provide a rational and comprehensive means of assessing priorities for intensive management within the context of the broader conservation needs of threatened taxa. For this process the CAMP assembles a broad spectrum of expertise on wild and captive management of the taxa under review. In our country CAMPs are conducted as collaborative ventures of CBSG, (Conservation Breeding Specialist Group) with Indian Governmental and non-governmental agencies, institutions, organizations and individuals with the technical support from CBSG, CBSG India members and IUCN/SSC specialist group members from India and others. About 10-40 experts are brought together from the academic community and/or private sector to evuluate the threat status of all taxa in a broad group (e.g. an order or family), country, or geographic region to set conservation action and information gathering priorities. The CAMP process also provides an opportunity to test the applicability of the new IUCN Red List Categories (see Text-fig. 8)

With the above background and adopting the IUCN current version the eco-status of the three species has been assessed individually.

Before undertaking this exercise it is necessary to highlight the habitat in the Western Ghats where these fishes are living.

The Western Ghat range of Mountains (Text-Fig. 9) run for a distance of 1600 km from Surat Dangs in Gujarat to the mouth of the river Tapi, as a chain of continuous mountains, unbroken except at Palghat Gap, which is 13 km wide at its narrowest point. The mountains rise 170 m above sea level, running parallel to the west coast of India and the Arabian Sea from 21°N estuary of Tapi to Mahendragiri 8°N near Kanyakumari. They have an elevation of 900-1500m on average above sea level with Anaimalai at a height of 2965m. In width the hill ranges average 100 km, its heighest peak is around 1500m to the north and 2600 m in the south, the rainfall range from 3000 mm on the coast to 7500 mm on the crest-line declining rapidly to the east. (Promod et al. 1997). These ranges intercept the monsoon winds to the southwest creating a rain shadow in the region to their east. The Western Ghats is one of the 25 hotspots of Biodiversity spreading to 1,40,000 km^2 in the five southern states Maharashtra, Karnataka, Kerala, Andhra Pradesh and Tamil Nadu. As many as 35 million people live in these states and 17 rivers drain from the hills most of them joining the Arabian Sea. Only Cauvery, Krishna and Godavari originate in the Western Ghats but flow eastwards joining the Bay of Bengal. The entire Western Ghats

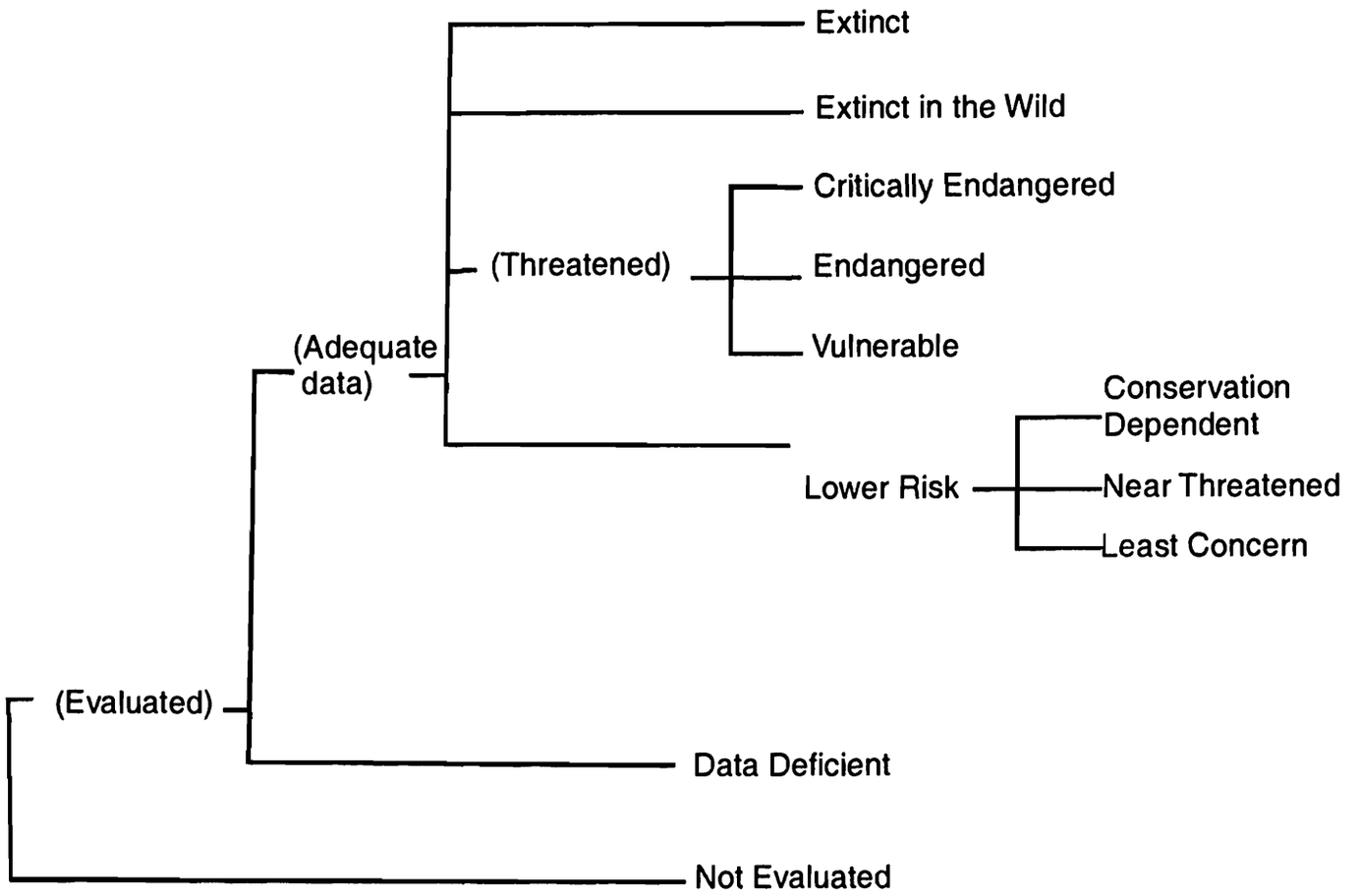

Fig. 8. Structure of Categories. Current version (After Sally Walker & Molur, S. 1997)

region may be divided into three bio-geographic provinces, a Northern (Gujarat, Maharashtra, Goa), Central (Karnataka) and southern (Kerala, and Tamil Nadu).

It is well known that extensive deforestation has taken place in the Western Ghats during the last 100 years. The pattern and magnitude of these changes remain unknown. The forest fragmentation that resulted as a consequence of deforestation affects the distribution of animal species by reducing their core habitats. River courses have changed and some of them have been shrunk with less flow of water and dischage. Channelisation for irrigation purposes, loss of thick vegetation and want of foliage cover has resulted in greater evaporation and loss of prime habitats for fish survival. Harmful fragmentation accelerates extinction besides demographic pressures. Deforestation in the catchments is responsible for soil erosion, siltation and turbidity. Due to these factors fish do not breed and even if they breed the eggs do not survive. Such environmental degradation decreases genetic diversity also. Considering the above factors the eco-status of the deccan Mahseer fishes as discussed appears to be justified. I shall illustrate the case of *Tor mussullah* in Maharashtra.

The main reason of depletion of Mahseer fishes is due to destruction of brood fishes and juveniles by use of explosives, spears and swords during monsoon when the fish ascends upstream for breeding purposes (Ogale, 1994).

Figure **Rough extent of the Western Ghats range.**

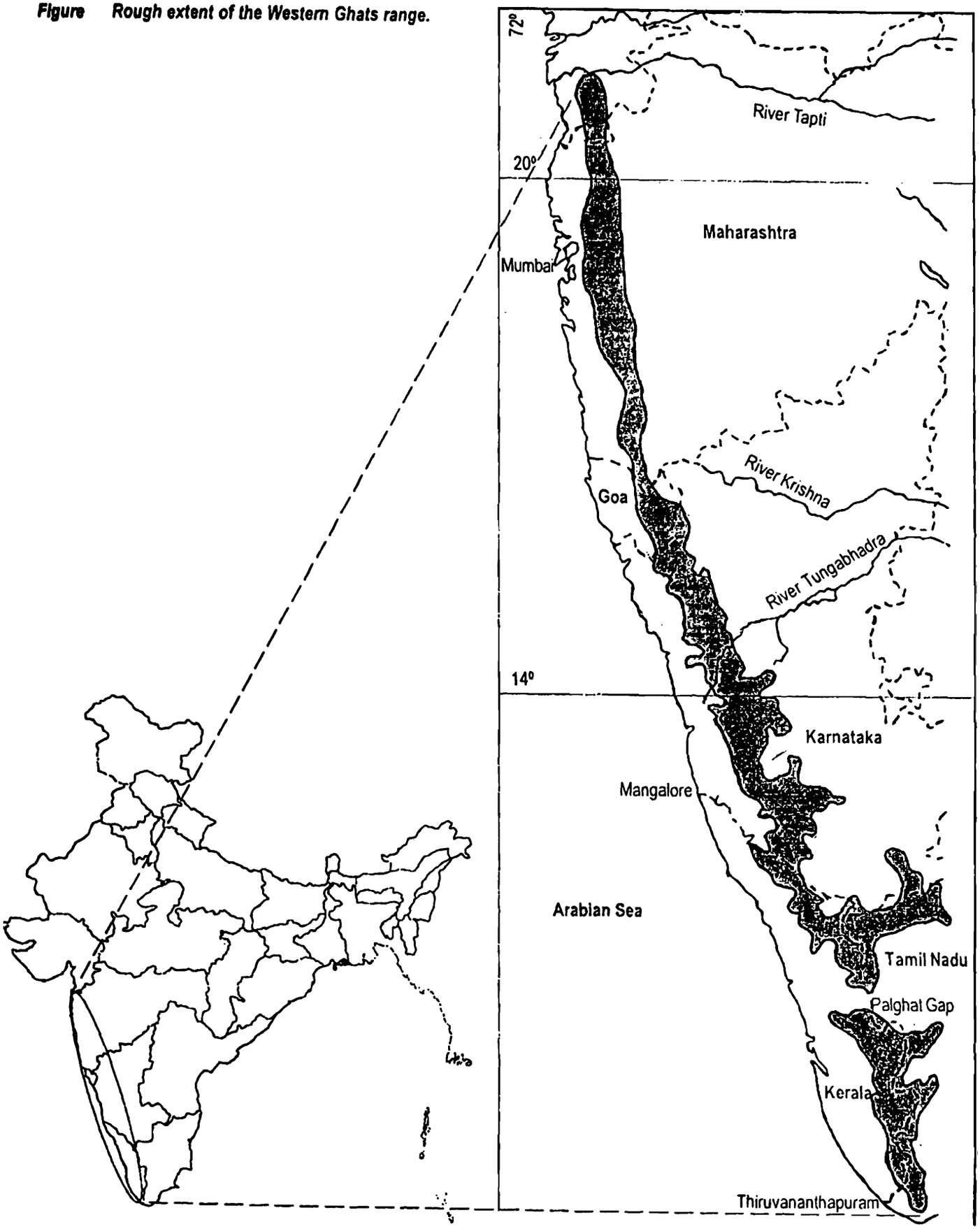

Fig. 9. Rough extent of Western Ghat mountains (Nameer *et al Zoo's Print J* 16(1) 2001).

Criteria for determining the exact status of Mahseer fishes have been attempted by many workers. Menon(1994) opined that determining the status Endangered, Vulnerable and Rare especially of fishes is extremely difficult, the term 'extinct' should be used very very carefully in respect of freshwater fishes unlike fossills. The IUCN present categorization outdates this limitation and is not as such valid anymore.

ASSESSMENT AND DETERMINATION OF THREATENED STATUS

This assessment has been done for each of the three Deccan Mahseer species as per standards formulated by IUCN Version 3.1 (February 2000) which document is attached as an annexure 1. (All letterings and numbers are as per Chapter V in above document).

Criteria for Critically Endangered, Endangered and Vulnerable species

Species ***Tor neilli*** (Day)

B. Geographic range in the form of either B1 (Extent of occurrence) or B2 (area of occupancy) or both

1. Extent of occurrence estimated to be less than 100 km^2 and estimates indicating at least two of a-c.

   a. *Severely fragmented* : known so far only from Thungabhadra river at Kurnool (Andhra Pradesh) and Bhadra river at Bhadravati (Karnataka).

   b. *Continuing decline, observed, inferred or projected, in any of the following*

      (i) *extent of occurrence* : Kurnool about 10 sq.km; Bhadravati about 10 sq.km

      (ii) *area of occupancey* : Less than 10 sq.km. Small distribution.

      (iii) *Area extent and or quality of habitat* : At Kurnool the area of occupancy is less than 10 sq km as already indicated. The species was described from River Thungabhadra at Kurnool, the type locality, by Francis Day in 1868. This area is highly polluted due to effluents from the Rayalaseema Paper & Pulp Mills, ferry services, washing of cattle, automobiles, besides defecation along the banks during dry months when the water flow is meager. When the river swells up in monsoon months no fishing is done, but ferry services, water extraction and human discharge of waste products continue. At Bhadravati the canal bed is completely concreted to carry the submerged power lines thereby destroying the original habitat.

      (iv) *Number of locations or subpopulations* : Only two locations are so far known. No subpopulations are present.

      (v) *Number of mature individuals* : Excepting the specimen present and preserved in the Natural History Museum, London which is 22 "long no other mature individuals are known or reported. Other specimens mentioned in the text are juveniles. Further no recods or catch statistics are available.

2. **Area of occupancy** estimated to be less than 10 km^2, and estimates indicating at least two of a-c.

   a. *Severely fragmented:* Yes, known only from two locations.

   b. Continuing decline, observed, inferred or projected in any of the following :

      (i) *extent of occurrence :* Limited to two areas as cited above. Record at Kurnool was made in 1868 and at Bhadravati in 1956. For the last 49 years no further records or sightings are known.

      (ii) *area of occupancy* : Less than 10 km^2; in this also the decline is very severe since no fish is available and not even known.

      (iii) *area, extent and/or quality of habitat* : Increasing human habitations, detrimental activites and anthropogenic factors demographic pressures are on increase accelearating decline which is 80%.

      (iv) *number of locations or subpopulations :* Two as already stated. No subpopulations.

      (v) *number of mature individuals :* See B 1 b (v) above.

Assessment Status : CRITICALLY ENDANGERED (CR). Could even be EXTINCT (EX). CR B 1 ab + 2ab

Species ***Tor mussullah*** (Sykes) (In Maharashtra)

A. Reduction in population size based on the following :

1. (a) *As observed, estimated, inferred or suspected population size reduction.* There are about 25 reservoirs in Maharashtra alone extending to about one lakh ha in area. The Bhima river system has about 25 major reservoirs having a water spread of 60,000 ha. *Tor mussullah* is available in these waters.

   Increased dam construction, consequent reservoir formations as on Ghod River at Sirur, the type locality of *T mussulah,* the fish catch has become decimated. The species was described in 1839 and now its habitat has become altered and it is caught sporadically. Because of this the decline has been estimated now more than 50%.

   (d) *Actual or potential levels of exploitation.* With the construction of a dam across a river, a new reservoir comes into existence. The vast expanse of water spread area submerges the rich fertile land adjoining both sides and also the river bed and its original course. Initially there is a population explosion in any new reservoir, but it does not last long and decline starts in fish catches after a crest is reached in 20 years. Ultimately a relative stabilization in production takes place with a minimal fish production.

3. *Population size reduction :* As an example the case of Vasant Sagar (Warna reservoir) can be cited. The reservoir came into existence in 1982. The maximum production was achieved in 1996 (four generations). Now decline has started. Similar is the case Koyana reservoir where the fish production is on the decline.

B. Geographic range in the form of either B1 (extent of occurrence) or B2 (area of occupation) OR both.

1. *Extent of occurrence estimated to be less than 20,000 km^2, and estimates indicating at least two of a-c.*

a. *Severely fragmented :* Yes. Found in Koyana and Warna reservoirs.

b. (iv). *Number of locations or subpopulations.* not more than 10 locations.

D. Population very small or restricted in the form of either of the following.

1. *Population size estimated to number fewer than 1000 mature individuals :*

The number of mature individuals is fewer than 1000 (300 to 400 only).

2. *Population with a very restricted area of occupancy (less than 20 km^2) or number of locations (typically five or fewer) such that it is prone to effects of human activities.*

The above cited mature individuals occupy a total area of typically less than 20km^2 in each location. Because of the increased fishing pressure in these limited area a possibility exists of an uncertain future for these naturally occuring populations. The causes of decline are over fishing, water extraction, demographic changes, anthropogenic factors causing habitat decimation and gradual siltation of the reservoir after some years. If protective measures are not taken the species may become Critically Endangered in the course of few years.

Assessment Status : VULNERABLE (VU) VU A1A, d + A3, VU B1a, b(iv), VU D1, 2

Species ***Tor mussullah*** (Sykes) (In Kerala)

A. Reduction in population size on any of the following :

2. As observed. estimated, inferred or suspected population size reduction of ≥ 80% over the last 10 years or three generations whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood Or may not be reversible, based on (and specifying) any of (a) to (c) under A1.

1(c) *a decline in area of occupancy, extent of occurrence and or/quality of habitat. Tor mussullah* is found in isolated pockets as Meenmutty in Malappuram district, Maanchery river in Kerala which are hill streams. The number of mature individuals caught are far less than what was about 10 years ago in view of the degradation of the habitat due to rail, road construction, human habitations, dynamiting, poisoning etc. This trend may not be reversible since no fish sanctuary or protective measures have been

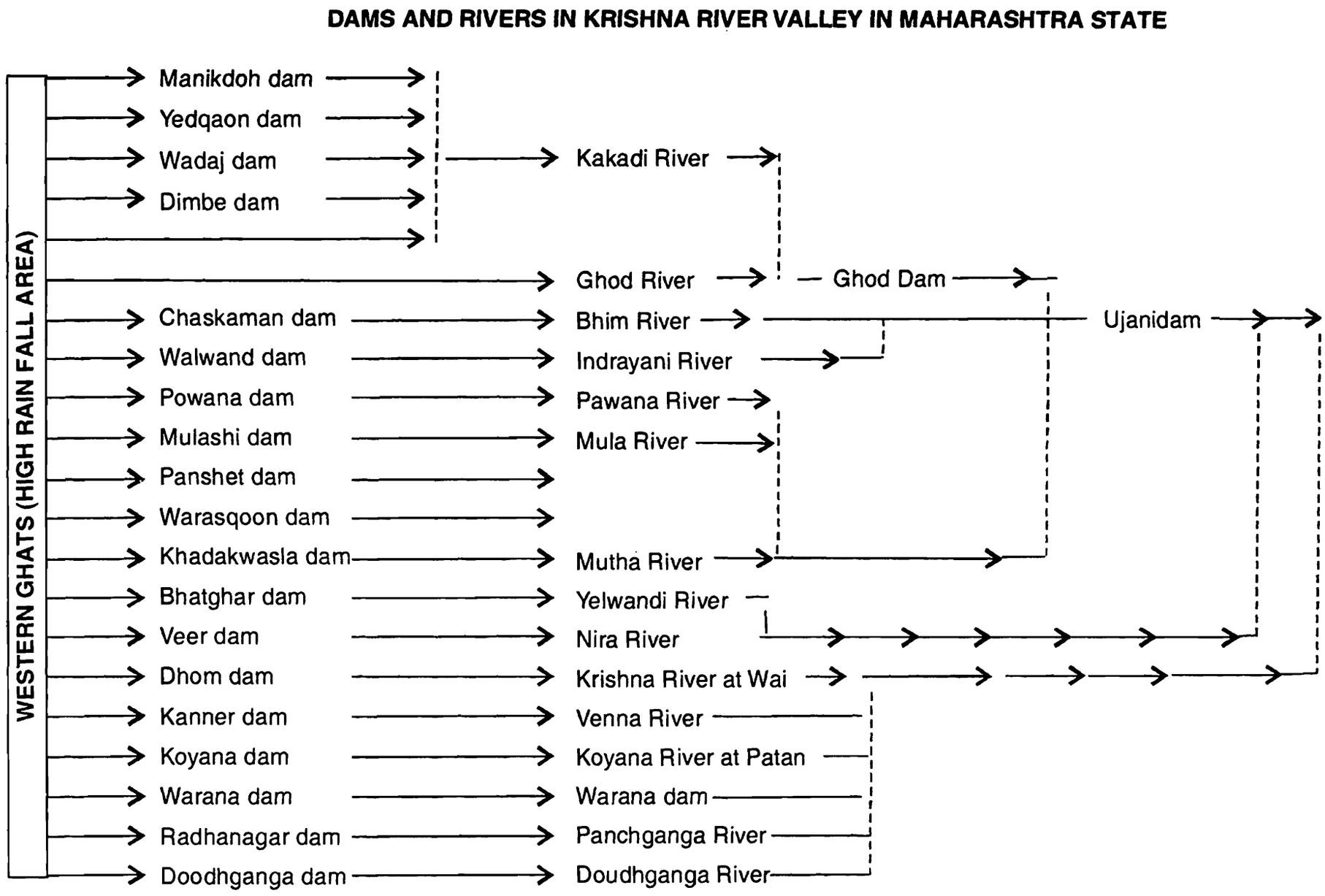

Fig. 10. Distribution of *Tor mussullah* in Maharashtra (Map courtesy S. V. Valaangkar).

taken. Hora and Law (1941) recorded 13 examples of this species from Travancore (11 from Pampadampara, Western Ghats, North Travancore and two from Kallar stream at the foot of Ponmudi hills, Western Ghats, South Travancore). This area is completely changed and no *mussullah* available. It is confined only to Meenmutty as stated above. Estimates of population size is less than ≥ 80% over the last 10 years or even more than three generations.

(d) *actual or potential levels of exploitation* : Tribals, construction workers possess dynamites for constructing roads, bridges etc in a hilly terrain and this easy availability has rendered their access to kill the hill stream fishes of which *Tor mussullah* is a part. Unlike other hill fishes as loaches, the mahseer mature individuals grow to a good size of more than 30 cm and fall as attractive prey. Even in monsoon months when the stream is in full floods and when the mature fish migrate upstream for spawning purposes they are killed, both the spawners as well as the spent fish. This merciless killing prevents further new recruitment of the species and the population gets diminished. The level of exploitation thus is high over ≥ 80%

Assessment Status : ENDANGERED (EN). EN A2 1cd

Species ***Tor khudree*** (Sykes)

As outlined in detail in the main text this species is widely cultivated and introduced in water bodies along the Western Ghat states as Karnataka, Kerala, Maharashtra and Tamil Nadu. Its abundance can be seen from the list of specimens studied which indicates the wide extent of its occurrence.

For instance in Kerala the habitat of *Tor khudree* in Periyar lake is very congenial with no disturbances noted in the Reserve area. During a period of five years (1996-2001) sampling of the lake has shown the abundance index rise from 0.52 in 1996 to 0.93 in 2001. Other river systems in Kerala where *Tor khudree* are observed are given below with the percentage of abundance.

Achankoil river, Chalakudy river (4.3%), Pambar river (7.83%), Kabini river (2.75%), Payaswinipuzha (7.69%) and Parambikulam reservoir (7.23%).

In Maharashtra *Tor khudree* is extensively found in all tributary rivers of Godavari and Bhima, besides the many reservoirs the state has constructed. For instance Bhandara reservoir on Pravana river, a tributary of Godavari. *Tor khudree* exists in natural conditions. In the 25 major reservoirs extending to about 1 lakh ha the fish is found abundantly. (Text-Fig. 10). The mahseer get matured by the end of second year of its growth (+ 1 age group). Normally fish weighting 1.5 to 15 kg do breed in nature profusely. Gravid mahseer weighing more than 15 kg female are rare. Both male and female within range of 35 cm size group are of 2 years class. Fish measuring above 80 cm are 15 years old and are found in gonodially mature condition.

In Maharashtra, Karnataka and Tamil Nadu the species is extensively stocked by obtaining fry and fingerlings from the Tata Electric Company's Fish Farm at Lonavla. The hypophysation and rearing techniques are detailed elsewhere.

The major threats to this species is over abundance of introduced alien species as Tilapia and gold fish.

Assessment status : Not threatened

THREAT PERCEPTS

We shall discuss the threat aspects in respect of the three Deccan Mahseer fishes. At the outset it may be stated that only a few factors are applicable to our fishes. Those mainly responsible individually and or collectively are discussed in the following pages.

Disease. Pilgrims infested some specimens of *Tor mussullah* at Sringeri with fungus over their fins mainly due to indiscriminate throwing of plastic bags containing remnants and left over of eateries, and non-degradable waste material into the river. This is a common practice in most pilgrim centers where mahseers are kept protected in river sanctuaries as at Sringeri, Ramanathapura, Alandi, Dehu (on river Indrayani) in Maharashtra etc. Though the infection is not severe and no mortality has been reported from our country (see Klinger & Francis-Floyd, 1996) though the diseased fish when consumed may create complications. Early preventive measures of strict enforcement by the state fishery departments are necessary.

2. *Decline in prey species.* An erroneous impression is prevalent that the mahseers are all carnivorous and rapacious. But careful perusal of accounts given by earlier authors like Thomas (1897), McDonald (1948) would indicate that they are omnivorous in their feeding habits and take almost anything occurring in water. Khudree mahseer have been observed in the lakes near Lonavla that the feeding habits change seasonally. During early monsoon when there is ample growth of soft weeds, the guts are gorged with remnants of vegetation. During early monsoon when there is ample growth of soft weeds, the guts are gorged with remnants of vegetation. During spawning period i.e. July, August guts are almost empty. September and October show a mixture of vegetative matter, mollusks, small fish and insects in the ratio of 60 : 10 : 10 : 20. In November and December fish proportion increases whereas in the remaining months algal incrustations (over growth of epiphyton) on submerged structures, rocks, fruit remains, crabs, beetles, insect larvae appear to form a common menu (Kulkarni, 1990). Khudree mahseers feed on small fish like *Danio, Rasbora, Chela, Puntius, Oxygaster* etc. which are their prey populations. Because of such omnivorous feeding habits Mahseers thrive where such food is available as in reservoirs, and other closed water bodies. The present practice of concreting the bottom of reservoirs as in Bhadravati, heavy silting renders fish life difficult, to survive and the above noted prey population for the mahseers are much reduced if not completely depleted. Thus the food chain is disrupted and the mahseers are endangered.

3. *Submergence.* Often times heavy discharge of excess rainwater from reservoirs wash away the mahseers; being unable to swim against the fast ferocious current. Such an instance did take place in the unprecedented floods in the Cauvery in (!993) Karnataka headwaters and the release of water from their reservoirs as Kabini and Krishnarajasagar, which carried the excess flow downstream at Muthathi where many large sized mahseers of *Tor mussullah* and *T khudree* perished, and were washed away.

4. *Edaphic factors (change due to fertilizer. Pesticides etc).* Most of the lacustrine or lentic water bodies in which Mahseers thrive are amongst agrarian lands, which are subjected to heavy dose of fertilizers and pesticides. Chlorinated pesticides such as DDT, Dieldrin, BHC and Endosulfan and Carbamates as Carbofuran, Organophophorus insecticides as Phosphamidon have ability to remain intact for a long period in the environment and find their way into living organisms. Pesticides, microorganisms, soil, water and air interact with one another in a closed net work system. Various factors are involved in the bio-activation/detoxification of pesticides in the above network (Venkataraman & Rajyalakshmi, 1971). Most pesticudes end up in soil and spread in the environment at relatively low concentrations. Soil and aquatic sediments are generally loaded with microorganisms and many are volatile (Matsumara, 1982). In mountainous areas as Kodagu etc the plantations are constantly sprayed with many harmful pesticides, which ultimately run down the slopes and are washed away during rains into the river systems.

5. *Pollution.* In the Cauvery basin alone as many as 146 industries are located (135 in Tamil Nadu and 11 in Karnataka (source : Karnataka and Tamil Nadu Pollution Boards reports). Major industries polluting the river are Chemical and Food, Pulp and Paper, Engineering Units. Tanneries, Textiles and Dyeing units, Distilleries, Sugar factories, besides thermal power generation (MSF, 2000). These cause considerable effect on the growth of these fishes in their natural habitat. In Maharashtra cane fields are burnt the effects of which not only affect the soil but also the rain-washes the remnants into the river systems. Ecological deterioration caused by the soil erosion, siltation and turbidity due to deforestation in catchment areas inhibits the breeding instinct of mahseer, which are known to breed in clear streams.

6. *Fishing and 7. Dynamiting.* One of the major causes of the decline in the Mahseers stocks is the indiscriminate fishing by tribals, villagers and fishermen. Even brood fishes are not spared and in mountainous areas as Kerala, fishing is done illegally by poisoning, dynamites and grenades. Thoughtless destruction of brood fish and juveniles by military persons, construction contractors with the help of explosives is a cause for decline. The effect of road building in these areas for habitations and also for defense purposes has given the easy access for these people to get the dynamites etc. It is an open fact accepted by fishermen when contacted; many have no patience to cast a net or line The setting up of Wildlife associations in Kerala, Karnataka who have marked river sanctuaries for holiday fishing where Mahseers are caught live but immediately released into the stream is a welcome step.

8. *Hunting/Harvesting for food.* Because of the heavy decline in catches of mahseer fishes the yield is poor; moreover since these fishes are inhabitants of not very hospitable terrains as in Maancherry, Meenmutty in Kerala the catches are not much. In Koyana reservoir also the fishing is only seasonal. When the reservoirs are full after monsoon rains fishing is not much. The expanse of water spread in the reservoirs is very vast and deeper portions are inaccessible for fishermen who do not have proper nets in adequate number for exploiting the resource. Moreover most of them operate native nets as cast nets, dragnets of small size and entangle nets in shallow peripheral areas of the reservoir. Since the mahseers are denizens of deep waters they are protected. Bhatghar reservoir (about 50 km from Pune, Maharashtra) *Tor khudree* and *T mussullah* were dominating species (15.12%) in the fish landing of the reservoir a few years ago. But in recent years the fishery has come down to 4.09% (Pisolkar, 1994). *T mussullah* is rarely caught since as a general practice water is periodically released after every three years to undertake repairs of tunnels to power turbines. At these times the catch are good; but such type of dewatering without taking any precutions or making any arrangements to stop escape of fish results in depletion of the indigenous stock.

9. *Human interference/persecution/disturbance* and *10. Poisoning.* In many river sanctuaries the presence of a large stock of active, swimming Mahseer fishes is really an enjoyable sight. The villagers and local men zealously protect these fishes and no fishing is ever allowed. In spite of this often times poaching takes place and many are taken away stealthily. On some occasions out of vengeance in not being allowed to harvest, mass scale poisoning and destruction of the entire stock takes place. On May 6, 1996, at Shesheela near a village in Chikmagalur district, Karnataka the entire stock of mahseer fish was poisoned and killed. This report was published in a Kannada Magazine "Sudha" of June 30, 1996, under the title 'Fish World has fallen prey to the human anger' (page 2). The local villagers by the side of the river Kapila flowing near Sheshileshwar temple were shocked to see on a morning all their pet fishes dead. The river was poisoned with toxic compounds for the simple reason that four fishermen were reprimanded for fishing illegally in the night. This tragedy highlights the socio-economic compulsions of the end users who are fishermen and villagers whose livelihood and sustenance should be kept in view. A regulated exploitation may serve both ends of compensation and conservation (see Jayaram 1997).

11. *Loss of habitat and its quality.* The mahseer fishes which are the noblest sport fish of India is also of considerable importance as food fish because of its large size and better keeping quality during the transport. They are of unparalleled recreation to innumerable sportsman of India as well as abroad. In large lakes, they serve as biological control agents utilizing aquatic weeds and small trash fish. In the past the number of streams unfrequented by men was large; a greater number of mature mahseers had the opportunity to spawn unmolested and hence the critical quiescent stage in their life history did not matter very much. But with the increasing number of streams being used for reservoirs for multi-purpose development schemes, the traditional breeding grounds of the mahseer

are lost to them. On top of this adverse situation, many of the streams that are excluded from the development activites are affected by harmful industrial effluents, which kill the fish fauna and especially the tiny fry or the hatchlings in enormous numbers. All these handicaps combined are working adversely on the mahseers in peninsular India. It is well known that mahseers migrate upstream into shallow running waters for spawning. At this time unscrupulous fishermen kill the brood with sticks, swords, spears and other implements. Where some escape the onslaught they fall prey to fishermen's nets or wickerwork baskets when they are on their downstream march. The present day extensive transport facilities enable fishermen to penetrate deeper into the otherwise secluded forest streams for their destructive fishing activities. Thus the loss of their habitat is alarming.

12. *Loss of habitat due to fragmentation.* The Western Ghats as already stated is a chain of mountains, which are in the six states of peninsular India. The pristine riverine systems have been tampered with anthropogenic measures such as dam constructions, road building, railways as the Konkan railway project etc which have affected the ecology and habitat of these fishes. Many dams and embankments have come up the tributaries making the fish to adopt and thrive in the newfound lacustrine habitat as in Koyana, Bhatgar, Bhavani and Mettur reservoirs. The original riverine areas have become obliterated making the loss of their prime habitat. From a fast flowing river the fish has to adapt itself to deep water with little flow and changed substratum, food availability and breeding grounds. Such fragmentation has in a way done well to the fishery because catches are easily obtained and hatcheries on the reservoir banks are assisted by the water availability. A good example is the Walwahn Lake and the hatcheries of the Tata Electric Company at Lonavla, Maharashtra, Harangi nursery on the banks of Harangi reservoir, Karnataka.

13. *Construction of dams.* Most thermal power stations as in Bhadravati, Mettur and Shivasamudram, Koyana impound and divert the river/reservoir waters for power generation through turbines. At these places the bottom of the canals taking the water are lined up with concrete and rendered unfit for any plant or animal life. At Bhadravati the Bhadra River has been thus concretized thereby killing the entire life of *Tor neilli*, which was reported earlier. I have discussed elsewhere the harmful effects of channelisation of rivers and the resulting harm.

14. *Demographic changes.* The Western Ghat region that is the prime centre for the mahseers, like other parts of the tropics is undergoing rapid transformation. The deforestation rate is high and forests are being transformed into agriculture and monoculture plantations. Hydroelectric projects, mining and extraction of forest products are also altering the landscape. Furthermore forest fragmentation affects the distribution of large animal species by reducing their core habitat. Tilaman et al (1994) demonstrated the negative effects of even a slight increase in habitat fragmentation, which accelerates extinction due to factors such as demographic and environmental stochasticity, decrease in genetic heterozygosity, edge effects and human disturbance (Burkey, 1995). Moreover the reservoirs in the Western Ghats are mostly established inside protected areas or

sometimes protected areas are delineated after the reservoir is built. Because the reservoirs are built within the protected areas there is an increase in deforestation as distance from reservoirs increased (Menon & Bawa, 1997).

Besides the above, other major threats for the depletion of the mahseers are as below :

1. Thoughtless destruction of brood fish and juveniles by military persons, construction workers with the help of explosives (dynamites).

2. Mahseers migrating upstream in shallow waters for spawning are killed unscrupulously with sticks, swords, spears etc. Some escape the onslaught and breed in available waters but the resultant fry and fingerlings after being the victim of depredation by other fish fall prey to fishermen's nets and baskets during their downward journey.

3. Ecological deterioration caused by the soil erosion, siltation and turbidity due to deforestation in catchment areas inhibits the breeding instinct of mahseer which are known to breed in clear streams. Pollution due to different types of effluents has also good share in the toll.

4. Fecundity being low in these fishes, the eggs being demersal sink to the bottom get mixed with mud and die being choked. The result is recruitment to new class is poor.

CONSERVATION STRATEGIES

Ecologists are now beginning to talk of the merits of a new regime management termed adaptive management. For decades ecologists and natural resources managers thought that like physicists and engineers they would be able to predict and control the behavior of systems of their interest. To this end they developed models of fish and forest stocks and prescribed how the resources were to be managed over the periods. The behavior of ecosystems is best understood on the terms of observation of their past behavior, since they vary tremendously from place to place and time to time. It is the local people who above all others, possess the pertinent knowledge of ecological history. They are the most appropriate agents to serve as stewards of local ecosystems for they are ones to suffer most by the degradation and have therefore the greatest stake in its well being (Gadgil, 1998). As stated earlier in any environment, be it aerial, aquatic or terrestrial if anything is available or remains unhindered and is of easy and free access, it is immediately exploited by human agencies because no monetary capital outlay is involved, no laws or statutes exist from operating it and because it is free for all. This is the "Law of the Commons" without any Law. The mahseer fishes lived in calm, clear waters in thick jungles, in remote inaccessible valleys and narrow gorges with oxygen rich rapids. Most of these were not easily accessible or for that matter not even known to many save a few devoted anglers, fishermen, villagers and tribals. With the opening of the jungles under the pretext of land development, forest cultivation, land use for power projects and factories, access has been provided by building of roads, rail and pathways. As a follow up human

invasion has taken place who have started utilizing the water sources for their consumption and along with it the fish, irrespective whether it is a mahseer or an ordinary carp. Moreover these roads and pathways are mostly built along the alignment of the river and its banks. The river stretches became vulnerable to everyone. Even the ordinary road worker, daily wage earner who would have never seen such prime jungle streams became tempted to catch the fishes by whatever means available to him since there was none to prohibit him. The innocent and illiterate tribals and even villagers started to get easy access to dynamites, used for building roads and bridges and discovered that the easiest way to get his fish is to kill them by dynamitting or poisoning. Instead of spending long hours casting nets and rods, he found these implements easy and time saving besides involving no cost. Many resorted to this simply for the joy of killing. Even for vengeance people have massacred mahseer as in river Kapila, Karnataka (Jayaram 1997). The mahseer fishes are unfortunately victims of such derogatory practices and anthropogenic pressures because of which they have become endangered. The important stresses are industrial, domestic and pesticide, habitat destruction due to multipurpose river valley projects, land development and erosion, increased water extraction and over exploitation.

CONSERVATION STRATEGIES FOR THE DECCAN MAHSEERS

Having thus fixed the eco-status of the three Deccan mahseers it is worth considering the conservation measures adopted so far and whether they can be further developed.

Need for active conservation. Active conservation for the Deccan mahseers is indispensable in view of the prevalent endangerment situation of their habitats. While a possibility exists of self regeneration of the natural flowing river for improving the habitats, in our densely populated and fast growing industrialisation of the country, the most varied, direct and indirect, short mediam term conservation measures are needed. Priorities are indispensable for these fishes but at the same time the helping measures should not give room to problems for other existing and competing species. Before adopting concrete species conservation measures, exact understanding of the concerned species in question is essential. These have been investigated and the status of each of the three species has been outlined under the earlier Chapter "Assessment and determination of Threatened Status"

Cause of endangerment. An important measure for an endangered species is the protection and regeneration of their living area. Measures for water conservation and improvement of the habitat, freeing it from pollution and maintaining sustainable water quality for fish life are essential. Unfortunately some of the areas as in Sringeri (Thunga River) where *T mussullah* thrive, are visited by pilgrims who pollute it by indiscriminate feeds and throwing of non-degradable wastes. A most demanding factor for survival of any fish stock is first the water in which they live and as such their living space cleanings affect favourably not only the target species but also the remaining biotic community. In this sense the most endangered fish species is the mahseer, which serve as an important indicator of the

quality condition of the entire water stretch and at the same time serve as a driving force for the reconciliation and preventive measures to be adopted by human influence in that area. Besides water pollution and water spoilage other factors play a part. In some instances such as certain methods of fishing, the craze for landing a big sized mahseer as in Muthathi (on Cauvery) may lead to ultimate depletion because of over fishing by the professional and leisure time anglers.

Quality of water and steam structure. For fishes the elements of habitat that be considered are : (a) water clarity (b) water temperature (c) oxygen (d) absence of toxic chemicals (e) vegetation (f) shelter (g) type of bottom, boulders, gravel, sand or mud (h) seasonal water flow as in monsoon months (i) depth (j) absence of obstructions (k) presence of pools or rifles (l) shade, leaf falls (m) competition (n) absence of parasites and predators (o) food supply and spawing substrate (McAllister & Gruichy, 1976).

Besides water pollution that affects the quality of the riverine habitat, certain other causes of the river structure closely need attention. Deterioration of stream flow has greatly shortened the ranges of many species and others have been denied access to large segments of their original distribution. Linear flow of a river is important not only for the known long distance wandering of the fish and for mahseers for their spawning upstream migration. The strong binding of the river to its bed with its attendant fall out of the natural flow dynamics, the non existence of the gravel and the course of the current, disappearance of convenient gradient which serve as steps, refuge and strong exposure to wavering climatic conditions, absence of flood water which assist in migration for spawning which influence the living space of mahseers have all contributed to their endangerment.

Indigenous or Native species : Native species are those, which appear naturally in the area and are autochthonous. Many species of *Puntius, Barilius, Danio, Rasbora, Garra, Noemacheilus* perches and cichlids often coexist with the mahseers. Wild species naturalized by man as at the Lonavla fish farm, introductions as in Sringeri, Ramanathafura are not evaluated as Native species even if they thrive in free nature as they do so presently. However homlaopterids, loaches, *Barilius* indicate clean water quality unlike catfishes, murrels, eels which indicate foul waters.

Exotic species. Profound modifications of the pristine environment has restricted habitable waters and the introduction and establishment of a host of exotic species have brought about replacement as well as reduction of native forms through competition, predation and hybridization. Some species and subspecies have become extinct and many are endangered (Maththiessen, 1959).

MEASURES OF PROCTECTION

The impoundment of certain waters as in Koyana, Venna and Warna in Maharashtra for protection of mahseers is a welcome measure. The importance of such areas lies in the

fact that the existing ecosystem is protected though certain changes in the stream structure comes into play, such as from lotic to a lentic pattern. The infringement especially of the upper reaches such as in Krishna where the original course itself has been diverted (Jayaram, 1995) is best avoided. It is better to protect the entire catchment area and not interfere the upper reaches, which may constrict the storage and flow stretches. The case of Cauvery is an example where many upper reaches tributaries have been impounded with resultant poor flow in the Delta areas (MSF, 2000). In such natural ecosystems as outlined above no further helpful measures can be mooted. However, fish culture methods have to be taken up for replenishing the unproductive areas and where the populations have become rare; it often happens that it may not be possible for fishes like the Deccan mahseers which have become rare and occur in limited numbers to succeed in creating new types of living habitats in a natural way in such newly created water bodies as the new reservoirs and artifical lakes. Artificial first settlement of species in such areas has to be installed not only on general ecological grounds but also for conservation. An example is the cultivation and stocking of mahseers in Walwahn Lake, Lonavla, Maharashtra.

Resettlement, Ranching Re-naturalization or resettlement of such species into their normal and usual habitats should be the penultimate means and aim in any conservation measure. The first installment in the newly created areas or habitat should be carefully monitored and protected against harmful influences. What is to be ranched in a certain water-face must be worked out well in advance. Exotic species present there should be removed so also weed fishes, which interfere with the food availability. These have to be eradicated throughly and completely. In case of artificial water bodies, unlike natural lakes, management would be easier. All animal organisms settle by themselves. Settling endangered species as the mahseers cannot be done without human assistance. To come to near natural conditions as in artifical lakes, settlement of many endangered species can also be considered. In such instances natural species already known from that areas are to be selected.

MAHSEER CONSERVATION

Biological observations on mahseers have attracted the attention of anglers and scientists since last century but anglers had their own limitations. After the recommendations of Agricultural Commission (1976) studies on the biology of the mahseer fishes commenced at different centers mainly in north India such as on Kumaun Lakes (Nainital) and Garhwal areas by different universities and institutions. The cold water fisheries center of Central Inland fisheries commenced studies on *Tor putitora* and *Tor tor* mostly on their biology. In respect of the Deccan Mahseers the Lonavla Fish farm of the Tata Electric Company initiated work, developed definite methodology and perfected the techniques.

Methods of Conservation. In respect of sport fish as that of the Deccan mahseers that are endangered obtaining quantitative data of catches in regular sequence for comparison is

not easy. It is necessary therefore to analyze the situation objectively from the information available and work out strategies for conservation of existing natural stocks and take steps for continued propagation of the concerned species. An extensive technique used in Europe and North America is the construction of fish ladders and passes especially for Salmon. This is not practicable in the case of the Deccan mahseers because of the very same passes or ladders may become traps for capture of the brooders by unscrupulous fishermen and locals. Moreover the Deccan mahseers species are yet to be found widely distributed.

The Indian Fisheries Act, 1897 (modified in 1956) is a landmark for the conservation of fishes in India. According to this, among other things the use of explosives or poison in any water body is liable for punishment including fine and imprisonment. The Wild Life Act 1972 does not include fish. The FAO (1980) proposed essential and complimentary criteria for aquatic resources. These are *in situ* and *ex situ* conservation measures.

In situ conservation Mahseers being large sized fish and is capable of getting accustomed to taking artificial feeds thrive well in lakes and reservoirs. As such *in situ* conservation is recommended. *In situ* conservation is useful where genetic diversity exist and where wild forms are present. This is done through their maintenance within natural or man made eco-systems in which they occur. The many advantages of such conservation are (i) continued evolution of the wild populations along with other forms (ii) natural parks and biosphere reserves may provide less expensive protection for the wild relatives than in *ex situ* practics. Further *in situ* conservation allows the adaptation to the changed environment, which is not feasible in *ex situ* conservation. In our country several places exist where such *in situ* conservation of *T khudree* and *T mussullah* in Fish refugia or sanctuaries exist. These are :

In Karnataka : Sringeri (Tunga River); Srirangapatnam, Ramanathapura (Cauvery), Chiplagudde, Hariharapura (Thunga River) and Shimsha (Sharvati River). Subrahmanya (Netravati River). Hunmari near Shimoga (Thunga River). Shesheela near Dharmasthala, Sullia, Sampange (Kapila River system).

In Maharashtra : Alandi, Dehu (Indrayani River). Pandarpur (Bhima River)

Ex situ conservation. Conservation of genetic resoruces. It is indisputable fact that our biological resources constitute a capital asset with great potential for yielding sustainable benefits. Despite mounting efforts over the past 20 years, loss of biological diversity is mainly due to habitat destruction, over harvesting, pollution and introduction of exotic fishes. Since the origin of earth, species diversity has increased regularly to produce a fantastic array of living forms. No one knows for certain how many species exist at present but the number has recently estimated to be between ten and thirty million. Of this about one million are predicted to become extinct by the turn of the century. We need criteria for recognizing the biological boundary limits for identifying species or ecosystems in trouble and for distinguishing critical ecological processes and keystone species. Urgent

and decisive action is needed to conserve and maintain genes, species and ecosystems with a view to have sustainable management and use of these fish resources.

Effective national action is required for *in situ* protection of ecosystem, for *ex situ* conservation of fish genetic resources and the enhancement of the ecosystem functions. For such an approach, needless to emphasize that the participation of support and the local communities are essential elements for its success.

Ex situ conservation involves conservation of the fishes outside their original habitat. River ranching, establishment of hatcheries in aquaria, and germ-plasm banks where cryo-preservation of gametes is adopted can do this. This type of *ex situ* conservation compliments *in situ* techniques and serve in maintaining viable populations of threatened species as the Deccan mahseers, provides education and public awareness services besides remaining as sites for basic and applied research and experimentation. Survival of species as *Tor neilli* seems to be so severe that *in situ* maintenance will have very little prospect. *Ex situ* conservation is being practiced in case of the Deccan mahseer fishes in locations listed elsewhere.

These fish sanctuaries like those of wildlife serve useful purpose in protecting its fishes in fair weather but they being in the upper courses of rivers, movement of fish are not restricted when the river is in spate. The gravid fish by their instinct leave the sanctuaries and migrate to shallow waters for spawning. Though they are protected in the fair season, they are subject to poaching and destruction by fishermen during the flood season. This results survival of the young ones hazardous, with recruitment for the new generation being much affected.

Aquaria. Besides the role of river sanctuaries the role of aquaria has not been much thought of in our country. For endangered species as the Deccan mahseers captive propagation is worth a trial in aquaria though attempts should be made to evolve a natural habitat as far as possible.

Germ plasm and seed banks. On going research has already led to significant advances in technologies for captive propagation. Germ-plasm storage techniques include long-term storage of embryos. Embryo transfer has tremendous potential for use in captive propagation since it allows the introduction of new bloodlines in the captive population and transport of adults. The role of transfer of disease in the adults has diminished. Long-term cryogenic storage of embryos has become routine. Storage at extremely low temperature below–130° C extends the storage life for a longer time. The National Bureau of Fish Genetic Resources, Lucknow has done pioneering work in this direction. However some problems in such storage cannot be overlooked. Inadvertent selection, wrong identification, unintentional crossing with other varieties may occur. Moreover under *ex situ* storage conditions, the evolution of the species is frozen so no further adaptation to environmental changes can take place. The chief benefit in *ex situ* conservation is in providing breeders with ready access to wide range of genetic material already screened

for useful trial. *Ex situ* conservation represents last resort for species as the Deccan mahseers, which have died out in their natural habitats.

CONSERVATION AND REHABILITATION OF THE DECCAN MAHSEERS

The *in situ* and *ex situ* conservation techniques need a basic requirement of adult brooders and fish from their natural environment. To keep a sustained and continued availiability of seeds is a prerequisite, more so when the chances of availability in nature of threatened species is remote. Towards this direction the efforts of the late Dr. C. V. Kulkarni and his team in the Fish Farm of the Tata Electric Company at Lonavla needs elaboration. The procedures they developed are simple and unsophisticated so that even junior scientists working in remote centre can follow them easily.

In August 1986, a workshop was organized where several fishery scientists of the country participated and were demonstrated different farm practices and actual artificial breeding operations. A set of recommendations for the conservation and propagation of mahseers were drawn up and forwarded to different states. Again in August 1987, a training program was arranged for middle level scientists where the participants individially took part in actual hands on fishing operations under the guidance of the experts.

Breeding habits. Close studies of different biological aspects and behavioral patterns of mahseers in recent years have contributed to an understanding of the shortcomings in their life cycle and also as to the methods of conservation, which can be effectively practised (Kulkarni, 1986). It has been found that raising large number of fly and fingerlings in fish farm for restocking the depleted waters, preventing illegal fishing and improvement of the habitat are major criteria. These have been done at Lonavla.

Determination of the extent of the breeding season is an essential factor in knowing the capacity of the mahseer to propagate its race. It has been found that July to September is the commonest peak period for most of the mahseer species. At Lonavla *T khudree* mahseer were found to breed on a small scale near the out gate of adjoining stream into the lakes. This covered a period from the middle of July to end of August particularly when the temperature of water was 21 to 22°C and rain swelled the stream. In order to avoid natural mortality at different stages and obtain a large number of eggs, ripe fish, which congregated at the surface of stream, were carefully collected and the selected ones were stripped of their eggs and milt by exerting pressure on the caudal portion in a particular manner (Plate XIV, Fig. A). It was found that *Tor khudree* has three sizes of eggs in the ovary. If stripping was done in the early monsoon period only the ripe eggs were obtained. On opening the ovary however two other size groups of immature ova were seen which mature and spawn out in the lake partly in monsoon season. The stripped eggs were then collected in enamel trays and the milt of the male spread over it as is usually done in the case of trout and salmon for the fertilizing the eggs. The fertilized eggs are demersal, lemon yellow or brownish golden in colour. They measure 2.8 to

3.2mm in diameter and if kept in proper hatching trays with a direct water sprinkling arrangement take 60 to 80 hours to hatch out depending on water temperature, which may vary from 24 to 28°C (Kulkarni & Ogale, 1978). The early hatchlings of *khudree* mahseer are golden yellow and pass through a semi-quiescent stage during which they remain huddled in corners and crevices with their heads tucked away from light as if they are negatively phototropic. This condition continues for about six days and forms the most critical period of its early life cycle. At Lonavla fish firm hatchings are grown into fry and fingerlings stage in nursery and rearing ponds, the grown-up fingerlings are released into the hydel lakes of the Tata Electric Company. About five lakh eggs are obtained in the above manner every year. Thousands of fry and fingerlings have also been supplied gratis for many years to different state and angling associations in the country where they have been rehabilitated. Live eggs of *Tor khudree* are kept in moist cotton wool for 48 hours in the laboratory at normal monsoon temperature of 22°. After the fertilized eggs were hardened for 24 hours they are packed in moist cotton wool, placed in a plastic basket within an outer container and sent unattended by air cargo from Bombay to Bangalore. The mortality was 8% in the first consignment and 5% later (Kulkarni & Ogale, 1979).

The fish has a very low fecundity of barely 15,000 per kg of body weight though Desai (1970) estimated a figure ranging from 7000 to 1,05,500 from the oval count depending on the size of the fish.

Hatchery arrangement. Though several systems are in vogue, the one in Lonavla is the simplest. It involves cement cisterns, wooden floating trays and perforated pipes. The pipes have been specially punctured at regular intervals to provide oxygenated water directly into the trays and on the eggs.

The wooden hatchery trays used are 56 x 56 x 10cm deep, with a suitable (1 mm) plastic or veilon mesh properly stretched and fixed to form the bottom of the tray. Eight such trays can be arranged and kept floating in a rectangular cement tank (hatchery) 2.5 x 1.2 x 0.76 m deep. About 30,000 eggs can be conveniently accommodated in each tray thus making a total of 2,40,000 for each hatchery tank. According to requirements and space available these can be increased or decreased. The water that is sprinkled over the eggs in the hatchery tanks through the perforated pipes fall at the rate of one litter per minute per day. Thus if eight trays are used at a time 460 litters water will be required per hour and 11,520 litters per day, the total quantity depending on the number of hatching trays being used. The overhead tank supplying clean silt free water can be about three meters high with a capacity of 10,000 litters. Water should be drawn from a convenient depth to avoid silt and the tank should be kept full to maintain pressure of water for the sprinkling jets. The outflow from the hatching tank is so arranged that only the bottom water be removed first by a siphon system commencing near the bottom. Adjustments can be made depending on the local conditions prevailing at a given place. The quality of water is the most important criteria. A pipette or ordinary ink filler having a wide

aperture constantly removed dead and defective eggs.

Limitations of the stripping method. Stripping the spawners (male and female), artificial fertilization of eggs and their rearing afterwards as outlined have some limitations. The collection of ripe and oozing specimens is the crux of the problem. Unlike in Walwahn and Shirwada lake, Lonavla, in many mahseer streams favorable conditions as in the above lakes do not prevail and gravid fish keep on migrating into remote streams which are very much dispersed in the forest area resulting in dispersal rather than concentration of breeding population. Collection of specimens for stripping then becomes a problem and sometimes disappointing. Breeding of fish in farm ponds therefore assumes greater importance (Ogale & Kulkarni, 1987). In some areas the configuration of the lake or the river and its surrounding land itself may not be conducive for collection of spawners for stripping and artificial fertilization as detailed above. In such cases recourse has to be taken by breeding the fish by hormone injections. Efforts made in this direction at Lonavla on *Tor khudree* indicate that the pond-raised fish can be bred in the third year when the female is about 900 gms or more in body weight. In this case stripping is done after administering a second dose to the female, the male requiring only one dose. The dosages are 6 and 12 mgs per kg of body weight. In some cases the pair breed normally without stripping in the cloth happa. In this type of breeding, diet and oxygenation of water play important roles. Food should contain more protein than usual and oxygenation effected by running water or by mechanical means.

Inherent biological constraints in Natural Breeding. The mahseers require specialized biological conditions for its breeding and juvenile development. Kulkarni (1971) during the course of several observations at Lonavla focused attention to the several handicaps the fish faces in its natural breeding. With a low fecundity and a long hatching period (80 hours) the extended semi quiescent state after hatching (3 days) are all inherent obstacles for its easy breeding and development. In Nature mahseer spawners try to reach their favoured spawning grounds, which may be in the vicinity, or far away traversing smoothly or enduring the overflowing monsoon streams. The actual spawning area has to be comparatively calm, having well oxygenated water and a bed of sand or gravel. The journey to these grounds may be safe or fraught with risks and dangers but their inner instinct drives the spawners to meet the challenges in order to breed and propagate their race.

SUMMARY

1. Three species of Deccan Mahseer *Tor khudree, Tor mussullah* and *Tor neilli* are endangered due to habitat destruction, pollution, anthropogenic activities as road, rail, constructions and human habitations etc.

2. The etymology of the name mahseer has been analysed and the various usages discussed.

3. Description of *Tor khudree* and *Tor mussullah* based on a series of large first time hand collection is presented and of *Tor neilli* on the syntype present in the Leiden Museum.

4. The generic and specific status of *Tor mussullah* and *Tor neilli* has been clarified. Statistical and cytogenetic studies have proved the separate identity of *Tor mussullah* and its individual status.

5. Location and distribution of the Deccan mahseers in peninsular India have been identified and details presented with photographs where needed.

6. *Tor mussullah* lives in isolated pockets in discontinuous patches particularly in the Western Ghats.

7. The causative factors for their decimation, the threat percepts have been examined.

8. Criteria for detemining the endangered status as per IUCN versions, the inhibiting dangers and the precise eco status have been presented.

9. An attempt is made to portray the present taxonomic status of the three Deccan mahseer species. Their threat percepts, conservation measures have been elaborated.

10. Possible *in situ* and *ex situ* conservation measures, the advantages and disadvantages of the systems and the locations where *in situ* conservation are practised are elaborately described.

11. The artificial breeding, hatching and rearing of *Tor khudree* in particular at Lonavla fish farm are detailed.

12. Advantages and inherent constraints in artificial breeding have been detailed.

13. Rehabilitation possibilities of the mahser species are outlined.

RECOMMENDATIONS

1. Intense efforts should be made to locate the populations of the near extinct *Tor neilli* by organizing specific location survey in the Tungabhadra river system where it has been previously reported. Fish refugia, river sanctuaries in probable areas should be created, besides those that are in existence.

2. Environmental awareness of the importance and value of these fishes should be created amongst the user agencies as fishermen, workers who encroach on their prime habitats for human habitation and construction activities.

3. The knowledge and expertise of the rural people must be collated and their cooperation ensured in all conservation measures.

4. Habitat improvement and restoration of the damaged ones should be undertaken for the continued viability of these species.

5. Channelisation of river courses must be restricted but where necessary, concreting the bottom and sides of the feeder canals should be avoided.

6. A green belt of at-least one or two meters on either side of the channels and on the banks should be built at the time of construction of the canals. These areas ensure a degree of food supply to the fishes and other aquatic biota.

7. In any conservation measure, involvement of the local communities is absolutely essential for they are the stewards and have greater stake than any one else

8. *In situ* and *ex situ* conservation measures have their own limitations and advantages. For species as *Tor neilli* survival in *in situ* situations, maintenance has very little prospects. On the other hand for *ex situ* mature breeders are needed which are now available for *Tor khudree* and *Tor mussullah.*

9. Germ plasm storage techniques and embryo transfer have tremendous potential in captive breeding.

10. *Ex situ* conservation provides breeders with ready access to a wide range of genetic material already screened for user trial.

11. *Ex situ* conservation represents the last resort for species as Deccan mahseers, which have died out in the natural habitats.

12. The model set up at Lonavla fish farm is time tested and could be adopted with simple modifications to suit local conditions.

13. Just as *Tor mussullah* and *Tor khudree* have been relocated efforts should be made for *Tor neilli* also after adequate samples, particularly brooders are found.

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PLATE- I. *Tor khudree malabaricus* (Jerdon) from Kallada river, Kulathupuzha, Kerala (Photo A. Gopalakrishnan).

PLATE-II. *Tor mussullah* specimens from the Koyana reservoir (29-05-1997). Photo (KCJ).

PLATE-III. A. Close up view of head and anterior portion of *Tor musullah* from Koyana reservoir to show the hump and 4½ scales between the dorsal fin base and lateral line. The hump is well seen in top fig. pp. II. B. *Tor mussullah* from Walwahn Lake, Lonavla (30-05-1997. Photo KCJ).

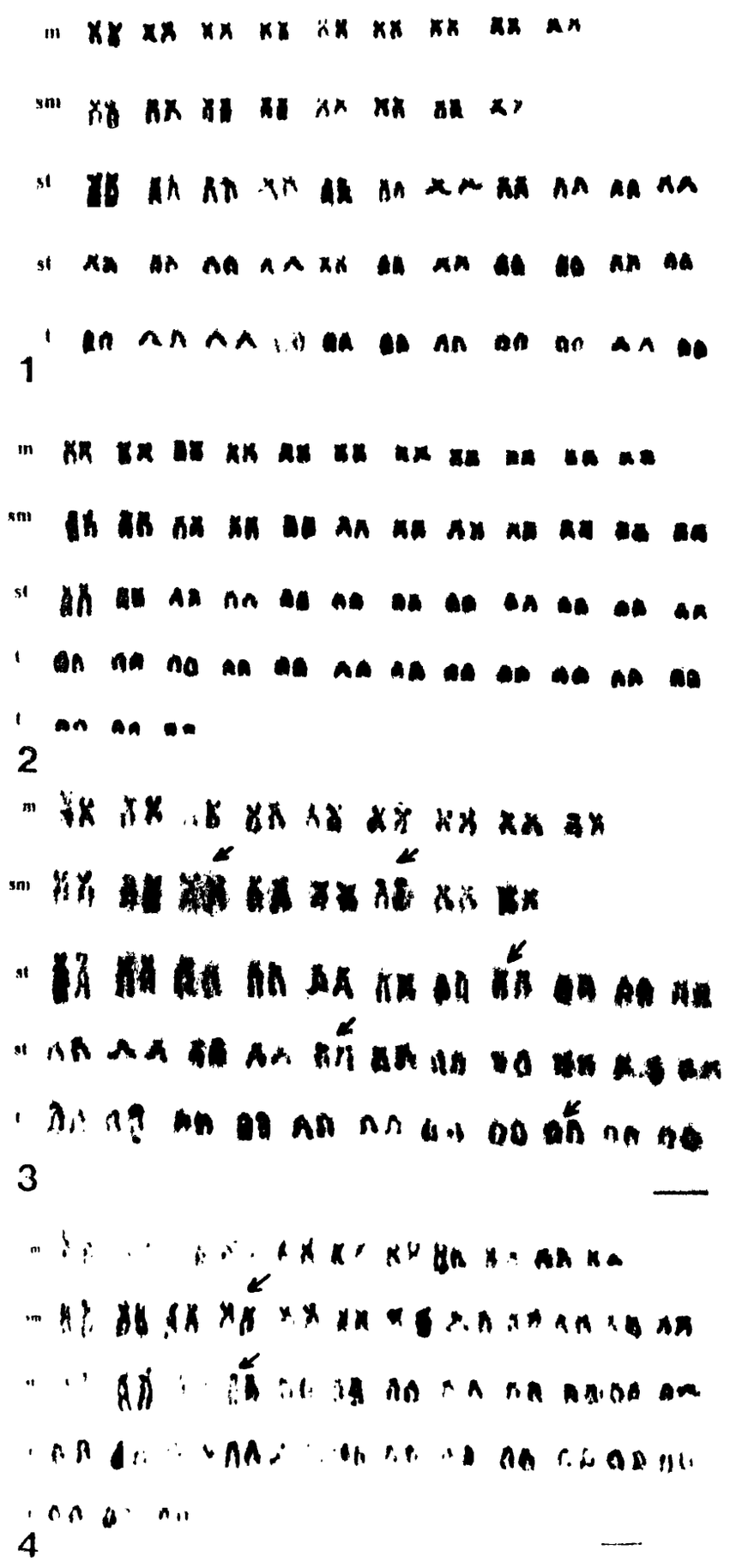

PLATE -IV. Cytogenetics of two species of mahseers in India

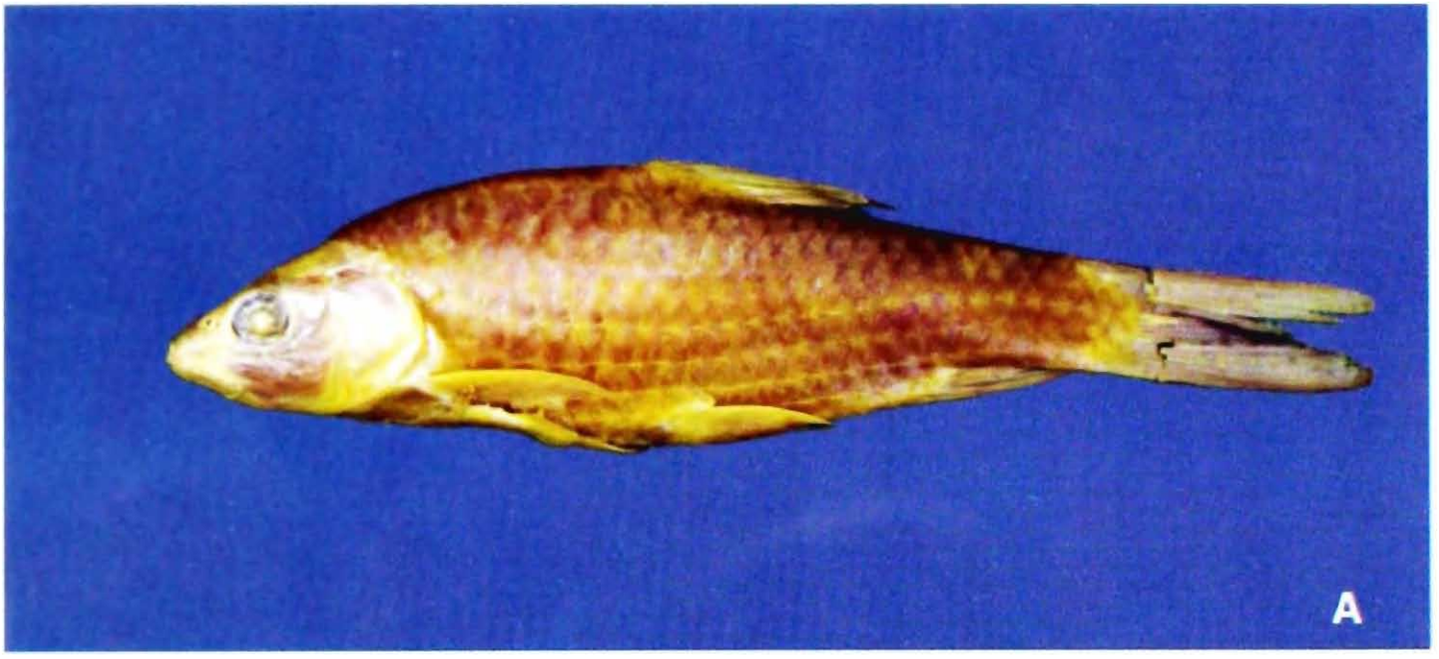

PLATE-V. A. Lateral view of *Tor neilli* (Day) from Leiden Museum, Leiden. B. Anterior view of same to show the scale rows and dorsal fin. (Photo ZSI/SRS Sri Margabandhu).

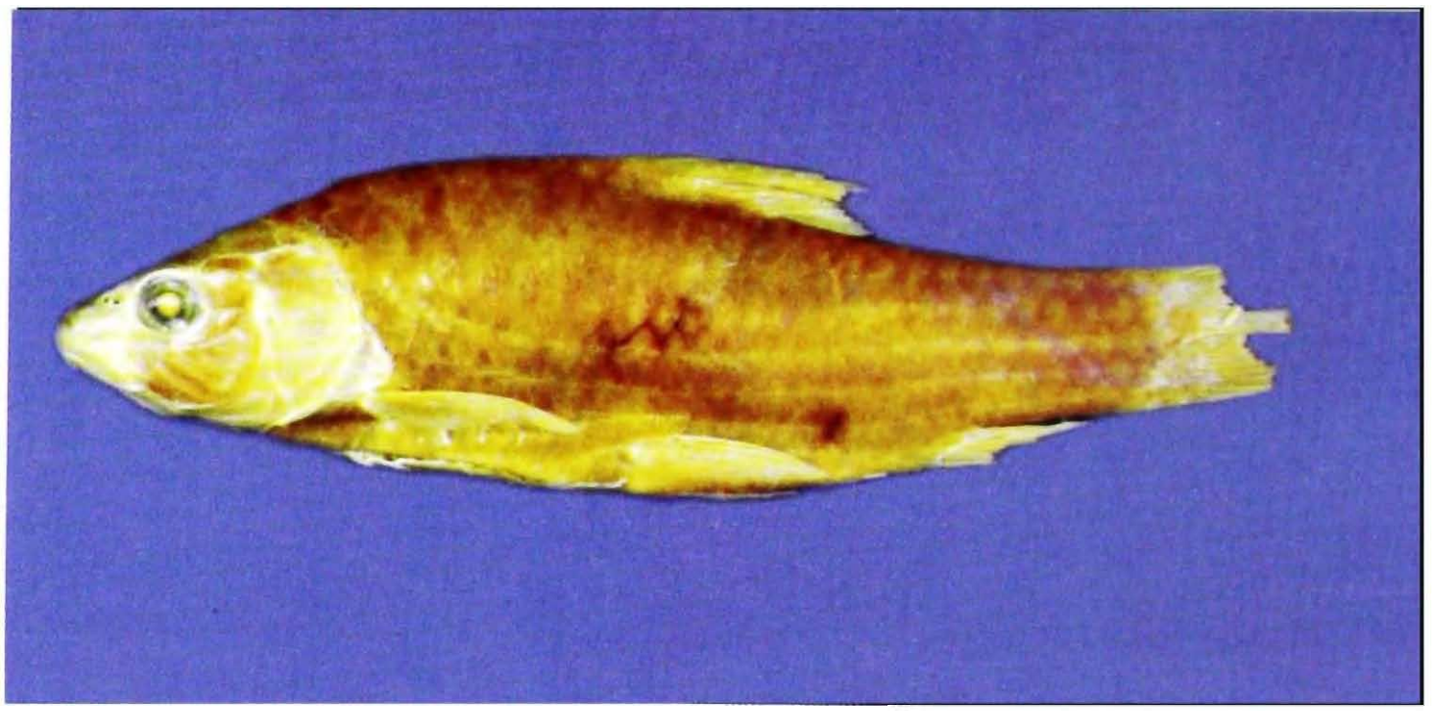

PLATE-VI. Lateral view of specimen AMS B 7870 in Australian Museum, Sydney wrongly identified as *Barbus neilli* (Coutesy Dr. McGrowther, Sydney. Photo S. Humphreys, Sydney).

PLATE-VII. Ghod river downstream view (Nov. 1998. Photo KCJ)

PLATE-VIII. A. Thunga river at Chiplagudde. Fish congregating mean the bank. B. At Teerthahalli (11-02-1999. Photo KCJ).

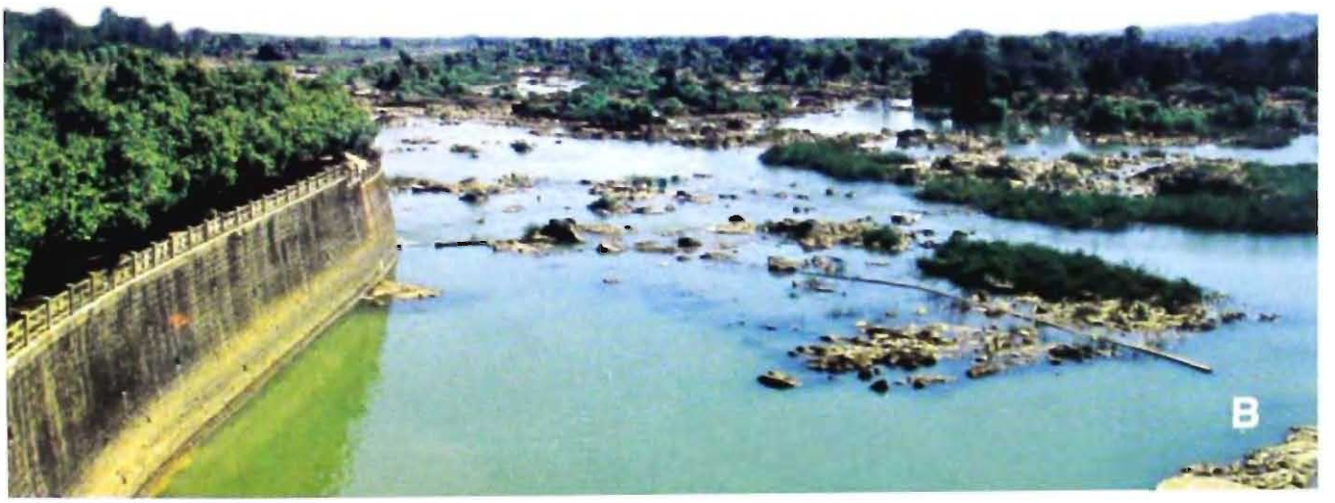

PLATE- IX. A. Thunga river at Hariharapura. Mahseers swimming as a shoal. B. Thunga river at Gajnur dam at Koppa near Sringeri (12-2-1999) (Photo A. Johnson).

PLATE-X. Thunga river at Sringeri. (09-02-1996. Photo KCJ).

PLATE-XI. *Tor mussullah* specimens congregating on the shore to take offerings from pilgrims at Sringeri, Thunga river. (Photo KCJ).

PLATE-XII. Lower Aganashini river at Kirtigedde site (Teerthahalli 01-6-1996). (Photo KCJ)

PLATE-XIII. Moyar river at Thengumarahada upstream view. (23 11-1994. Photo M. Bhaskaran, TN Fisheries).

PLATE-XIV. *Tor khudree* male milt oozing out on stripping. B. Female eggs coming out on stripping. (Phot courtesy S. N. Ogale, Lonavla).

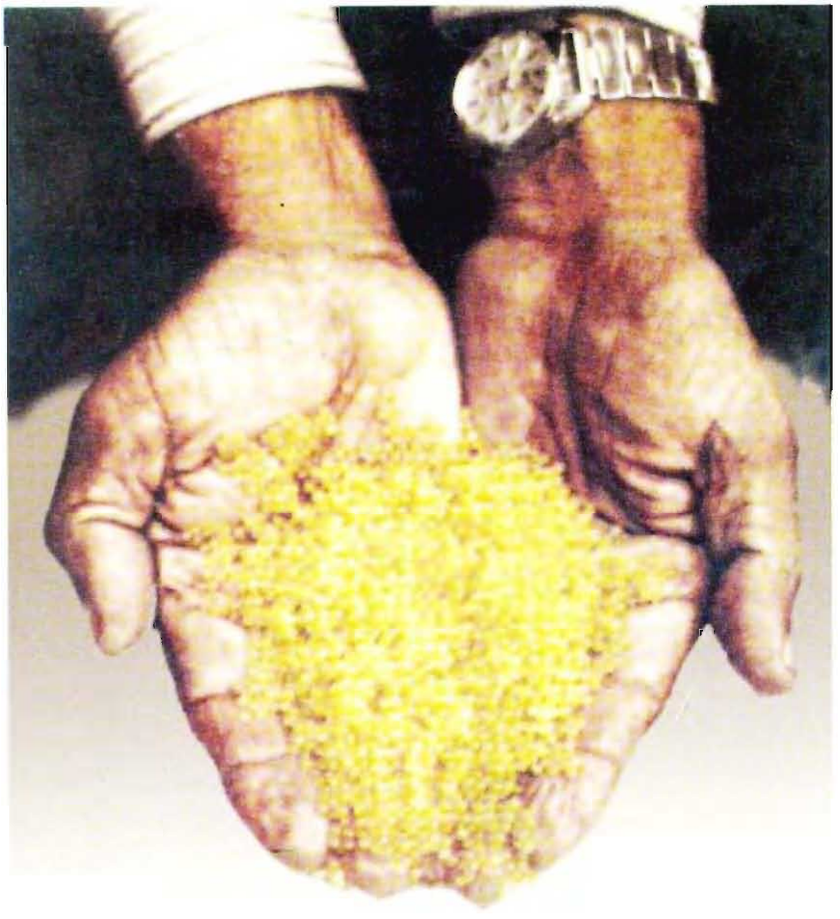

PLATE-XV. Fertilized eggs of *Tor khudree* (phot courtesy S. N. Ogale, Lonavla).

ANNEXURE I

IUCN Red List Categories and Criteria Version 3.1

Prepared by the IUCN Species Survival Commission

As approved by the
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Gland, Switzerland

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The work of the CRWG and the hosting of the review workshops were made possible through generous financial support from the Canadian Wildlife Service; Federal Ministry for Economic Cooperation and Development, Germany (BMZ); Global Guardian Trust; New South Wales National Parks and Wildlife Service, Australia; New South Wales Scientific Committee, Australia; Ministry of the Environment, Finland; Ministry of the Environment, Sweden; Swedish Species Information Centre; and WWF Sweden. The review process was coordinated by the IUCN Red List Programme Officer funded by the UK Department for the Environment, Food and Rural Affairs (DEFRA); the Center for Applied Bio-diversity Science at Conservation International; and WWF UK.

IUCN is indebted to the hundreds of scientists who participated in the criteria review workshops or who submitted comments and suggestions during the review process. This combined input has resulted in a far more robust, user friendly and widely applicable system.

As a result of the review process, several new topics have become the focus of active research and publication in the academic community. As greater clarity emerges on tricky and unresolved issues, these will be addressed in a comprehensive set of user guidelines. The intention is to keep this revised system stable to enable genuine changes in the status of species to be detected rather than to have such changes obscured by the constant modification of the criteria.

The Red List Categories and Criteria, Version 3.1 are available in booklet form in the following language versions : English, French and Spanish from the IUCN Publications Services Unit (see address on inside front cover).

They are also available on the SSC website in English, French and Spanish, at: http://www.iucn.org/themes/ssc/red-lists.htm.

I. INTRODUCTION

1. The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk. However, while the Red List may focus attention on those taxa at the highest risk, it is not the sole means of setting priorities for conservation measures for their protection.

Extensive consultation and testing in the development of the system strongly suggest that it is robust across most organisms. However, it should be noted that although the system places species into the threatened categories with a high degree of consistency, the criteria do not take into account the life histories of every species. Hence, in certain individual cases, the risk of extinction may be under-or over-estimated.

2. Before 1994 the more subjective threatened species categories used in IUCN Red Data Books and Red Lists had been in place, with some modification, for almost 30 years. Although the need to revise the categories had long been recognized (Fitter and Fitter 1987), the current phase of development only began in 1980 following a request from the IUCN Species Survival Communion (SSC) Steering Committee to develop a more objective approach. The IUCN council adopted the new Red List system in 1994.

The IUCN Red List Categories and Criteria have several specific aims :

- to provide a system that can be applied consistently by different people;
- to improve objectivity by providing users with clear guidance on how to evaluate different factors which affect the risk of extinction;
- to provide a system which will facilitate comparisons across widely different taxa;
- to give people using threatened species lists a better understanding of how individual species were classified.

3. Since their adoption by IUCN Council in 1994, the IUCN Red List Categories have become widely recognized internationally, and they are now used in a range of publications and listings produced by IUCN, as well as by numerous governmental and non-governmental organizations. Such broad and extensive use revealed the need for a number of improvements, and SSC was mandated by the 1996 World Conservation Congress (WCC Res. 1.4) to conduct a review of the system (IUCN 1996). This document presents the revisions accepted by the IUCN Council.

The proposals presented in this document result from a continuing process of drafting, consultation and validation. The production of a large number of draft proposals has led to some confusion, expecially as each draft has been used for classifying some set of

species for conservation purposcs. To clarify matters, and to open the way for modifications as and when they become necessary, a system for version numbering has been adopted as follows :

Version 1.0 : Mace and Lande (1991)

The first paper discussing a new basis for the categories, and presenting numerical criteria especially relevant for large vertebrates.

Version 2.0 : Mace *et al.* (1992)

A major revision of Version 1.0, including numerical criteria appropriate to all organisms and introducing the non-threatened categories.

Version 2.1 : IUCN (1993)

Following an extensive consultation process within SSC, a number of changes were made to the details of the criteria, and fuller explanation of basic principles was included. A more explicit structure clarified the significance of the non-threatened categories.

Version 2.2 : Mace and Stuart (1994)

Following further comments received and additional validation exercises, some minor changes to the criteria were made. In addition, the Susceptible category present in Versions 2.0 and 2.1 was subsumed into the Vulnerable category. A precautionary application of the system was emphasised.

Version 2.3 : IUCN (1994)

IUCN Council adopted this version, which incorporated changes as a result of comments from IUCN members, in December 1994. The initial version of this document was published without the necessary bibliographic details, such as date of publication and ISBN number, but these were included in the subsequent reprints in 1998 and 1999. This version was used for the *1996 IUCN Red List of Threatened Animals* (Baillie and Groombridge 1996), *The World List of Threatened Trees* (Oldfield *et al.* 1998) and the *2000 IUCN Red List of Threatened Species* (Hilton-Taylor 2000).

Version 3.0 : IUCN/SSC Criteria Review Working Group (!999)

Following comments received, a series of workshops were convened to look at the IUCN Red List Criteria following which, changes were proposed affecting the criteria, the definitions of some key terms and the handling of uncertainty.

Version 3.1 : (IUCN (2001)

The IUCN Council adopted this latest version, which incorporated changes as a result of comments from the IUCN and SSC memberships and from a final meeting of the Criteria Review Working Group, in February 2000.

All new assessments from January 2001 should use the latest adopted version and cite the year of publication and version number.

4. In the rest of this document, the proposed system is outlined in several sections. Section II, the preamble, presents basic information about the context and structure of the system, and the procedures that are to be followed in applying the criteria to species. Section III provides definitions of key terms used. Section IV presents the categories, while Section V details the quantitative criteria used for classification within the threatened categories. Annex I provides guidance on how to deal with uncertainty when applying the criteria; Annex II suggests a standard format for citing the Red List Categories and Criteria; and Annex III outlines the documentation requirements for taxa to be included on IUCN's global Red Lists. It is important for the effective functioning of the system that all sections are read and understood to ensure that the definitions and rules are followed. (**Note:** Annexes I, II and III will be updated on a regular basis.)

II. PREAMBLE

The information in this section is intended to direct and facilitate the use and interpretation of the categories (Critically Endangered, Endangered, etc.), criteria (A to E), and subcriteria (1, 2, etc.; a, b etc.; i, ii, etc.).

1. Taxonomic level and Scope of the categorization process

The criteria can be applied to any taxonomic unit at or below the species level. In the following information, definitions and criteria the term 'taxon' is used for convenience, and may represent species or lower taxonomic levels, including forms that are not yet formally described. There is sufficient range among the different criteria to enable the appropriate listing of taxa from the complete taxonomic spectrum, with the exception of micro-organisms. The criteria may also be applied within any specified geographical or political area, although in such cases special notice should be taken of point 14. In presenting the results of applying the criteria, the taxonomic unit and area under consideration should be specified in accordance with the documentation guidelines (see Annex 3). The categorization process should only be applied to wild populations inside their natural range, and to populations resulting from benign introductions. The latter are defined in the IUCN *Guidelines for Re-introductions* (IUCN 1998) as ....an attempt to establish a species, for the purpose of conservation, outside its recorded distribution, but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range'

2. Nature of the categories

Extinction is a chance process. Thus, a listing in a higher extinction risk category implies a higher expectation of extinction, and over the time-frames specified more taxa listed in an higher category are expected to go extinct than those in a lower one (without

effective conservation action). However, the persistence of some taxa in high-risk categories does not necessarily mean their initial assessment was inaccurate.

All taxa listed as Critically Endangered qualify for Vulnerable and Endangered, and all listed as Endangered qualify for Vulnerable. Together these categories are described as 'threatened' The threatened categories form a part of the overall scheme. It will be possible to place all taxa into one of the categories (see Figure 1).

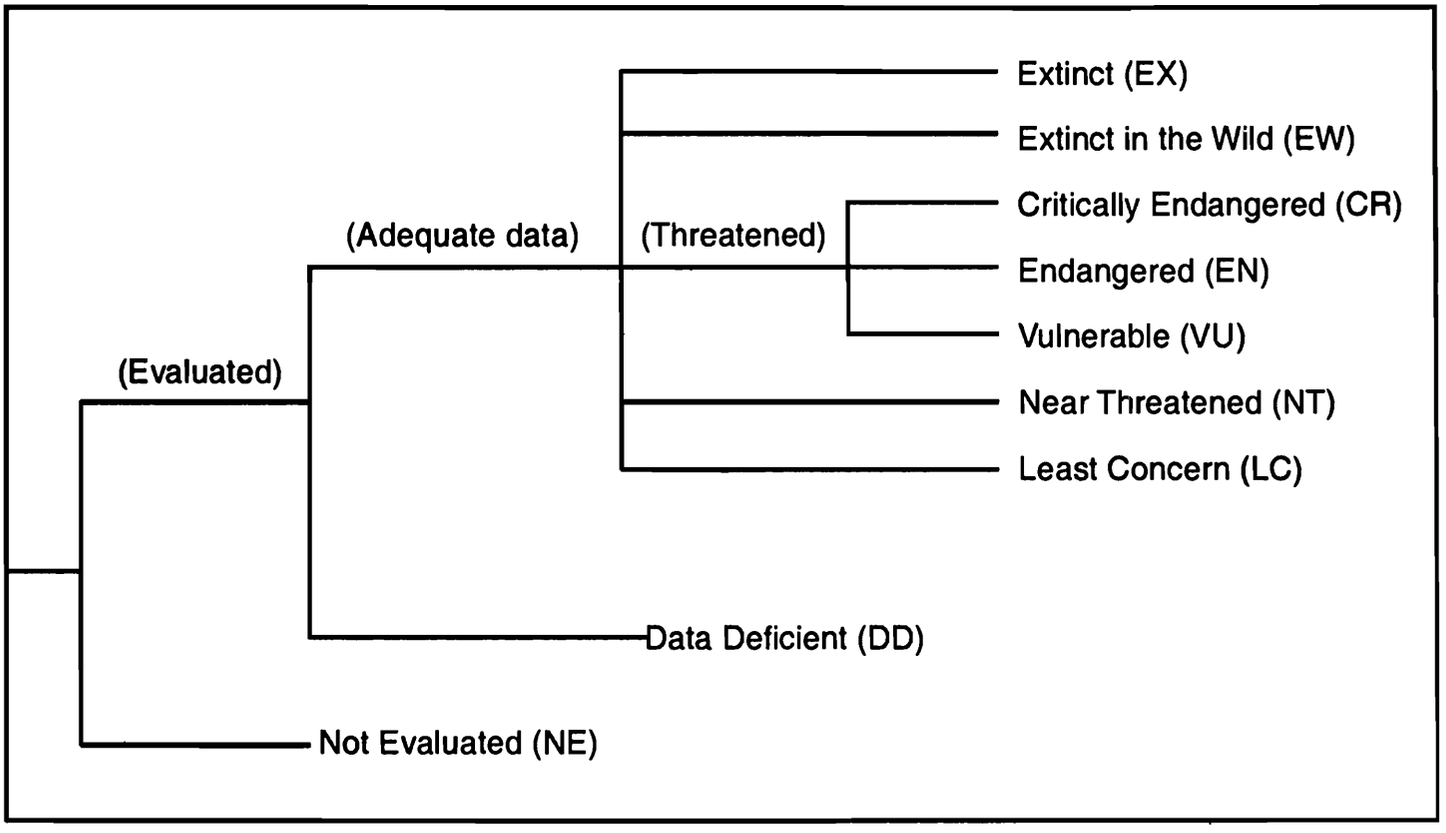

Fig. 1. Structure of the categories

3. Role of the different criteria

For listing as Critically Endangered, Endangered or Vulnerable there is a range of quantitative criteria; meeting any one of these criteria qualifies a taxon for listing at that level of threat. Each taxon should be evaluated against all the criteria. Even though some criteria will be inappropriate for certain taxa (some taxa will never qualify under these however close to extinction they come), there should be criteria appropriate for assessing threat levels for any taxon. The relevant factor is whether *any one* criterion is met, not whether all are appropriate or all are met. Because it will never be clear in advance which criteria are appropriate for a particular taxon, each taxon should be evaluated against all the criteria, and all criteria met at the highest threat category must be listed.

4. Derivation of quantitative criteria

The different criteria (A-E) are derived from a wide review aimed at detecting risk factors across the broad range of organisms and the diverse life histories they exhibit. The

quantiative values presented in the various criteria associated with threatened categories were developed through wide consultation, and they are set at what are generally judged to be appropriate levels, even if no formal justification for these values exists. The levels for different criteria within categories were set independently but against a common standard. Broad consistency between them was sought.

5. Conservation actions in the listing process

The Criteria for the threatened categories are to be applied to a taxon whatever the level of conservation action affecting it. It is important to emphasise here that a taxon may require conservation action even if it is not listed as threatened. Conservation actions which may benefit the taxon are included as part of the documentation requirements (see Annex 3).

6. Data quality and the importance of inference and projection

The criteria are clearly quantitative in nature. However, the absence of high-quality data should not deter attempts at applying the criteria, as methods involving estimation, inference and projection are emphasised as being acceptable throughout. Inference and projection may be based on extrapolation of current or potential threats into the future (including their rate of change), or of factors related to population abundance or distribution (including dependence on other taxa), so long as these can reasonably be supported. Suspected or inferred patterns in the recent past, present or near future can be based on any of a series or related factors, and these factors should be specified as part of the documentation.

Taxa at risk from threats posed by future events of low probability but with severe consequences (catastrophies) should be identified by the criteria (e.g. small distributions, few locations). Some threats need to be identified particularly early, and appropriate actions taken, because their effects are irreversible or nearly so (e.g., pathogens, invasive organisms, hybridization).

7. Problems of Scale

Classification based on the sizes of geographic ranges or the patterns of habitat occupancy is complicated by problems of spatial scale. The finer the scale at which the distributions or habitats of taxa are mapped, the smaller the area will be that they are found to occupy, and the less likely it will be that range estimates (at least for 'area of occupancy' : see Definitions, point 10) exceed the thresholds specified in the criteria. Mapping at finer scales reveals more areas in which the taxon is unrecorded. Conversely, coarse-scale mapping reveals fewer unoccupied areas, resulting in range estimates that are more likely to exceed the thresholds for the threatened categories. The choice of scale at which range is estimated may thus, itself, influence the outcome of Red List assessments and could be a source of inconsistency and bias. It is impossible to provide any strict but general rules for mapping taxa or habitats; the most appropriate scale will depend on the taxon in question, and the origin and comprehensiveness of the distribution data.

8. Uncertainty

The data used to evaluate taxa against the criteria are often estimated with considerable uncertainty. Such uncertainty can arise from any one or all of the following three factors: natural variations, vagueness in the terms and definition used, and measurement error. The way in which this uncertainty is handled can have a strong influence on the the results of an evaluation. Details of methods recommended for handling uncertainty are included in Annex 1, and assessors are encouraged to read and follow these principles.

In general, when uncertainty leads to wide variation in the results of assessments, the range of possible outcomes should be specified. A single category must be chosen and the basis for the decision should be documented; it should be both precautionary and credible.

When data are very uncertain, the category of 'Data Deficient' may be assigned. However, in this case the assessor must provide documentation showing that this category has been assigned because data are inadequate to determine a threat category. It is important to recognize that taxa that are poorly known can often be assigned a threat category on the basis of background information concerning the deterioration of their habitat and/or other factors; therefore the liberal use of 'Data Deficient' is discouraged.

9. Implications of listing

Listing in the categories of Not Evaluated and Data Deficient indicates that no assessment of extinction risk has been made, though for different reasons. Until such time as an assessment is made, taxa listed in these categories should not be treated as if they were non-threatened. It may be appropriate (especially for Data Deficient forms) to give them the same degree of attention as threatened taxa, at least until their status can be assessed.

10. Documentation

All assessments should be documented. Threatened classifications should state the criteria and subcriteria that were met. No assessment can be accepted for the IUCN Red List as valid unless at least one criterion is given. If more than one criteiron or subcriterion is met, then each should be listed. If a re-evaluation indicates that the documented criterion is no longer met, this should not result in automatic reassignment to a lower category of threat (downlisting). Instead, the taxon should be re-evaluated against all the criteria to clarify its status. The factors responsible for qualifying the taxon against the criteria, especially where inference and projection are used, should be documented (see Annexes 2 and 3). The documentation requirements for other categories are also specified in Annex 3.

11. Threats and priorities

The category of threat is not necessarily sufficient to determine priorities for conservation action. The category of threat simply provided an assessment of the extinction risk under current circumstances, whereas a system for assessing priorities for action will include

numerous other factors concerning conservation action such as costs, logistics, chances of success, and other biological characteristics of the subject.

12. Re-evaluation

Re-evaluation of taxa against the criteria should be carried out at appropriate intervals. This is especially important for taxa listed under Near Threatened, Data Deficient and for threatened taxa whose status is known or suspected to be deteriorating.

13. Transfer between categories

The following rules govern the movement of taxa between categories :

A. A taxon may be moved from a category of higher threat to a category of lower threat if none of the criteria of the higher category has been met for five years or more.

B. If the original classification is found to have been erroneous, the taxon may be transferred to the appropriate category or removed from the threatened categories altogether, without delay (but see Point 10 above).

C. Transfer from categories of lower to higher risk should be made without delay.

14. Use at regional level

The IUCN Red List Categories and Criteria were designed for global taxon assessments. However, many people are interested in applying them to subsets of global data, especially at regional, national or local levels. To do this it is important to refer to guidelines prepared by the IUCN/SSC Regional Applications Working Group (e.g., Gardenfors et al. 2001). When applied at national or regional levels it must be recognized that a global category may not be the same as a national or regional category for a particular taxon. For example, taxa classified as Least Concern globally might be Critically Endangered within a particular region where numbers are very small or declining, perhaps only because they are at the margins of their global range. Conversely, taxa classified as Vulnerable on the basis of their global declines in numbers or range might be Least Concern within a particular region where their populations are stable. It is also important to note that taxa endemic to regions or nations will be assessed globally in any regional or national applications of the criteria, and in these cases great care must be taken to check that an assessment has not already been undertaken by a Red List Authority (RLA), and that the categorization is agreed with the relevant RLA (e.g., an SSC Specialist Group known to cover the taxon).

III. DEFINITIONS

1. Population and Population Size (Criteria A, C and D)

The term 'population' is used in a specific sense in the Red List Criteria that is different to its common biological usage. Population is here defined as the total number of individuals of the taxon. For functional reasons, primarily owing to differences between

life forms, population size is measured as numbers of mature individuals only. In the case of taxa obligately dependent on other taxa for all or part of their life cycles biologically appropriate values for the host taxon should be used.

2. Subpopulations (Criteria B and C)

Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less).

3. Mature individuals (Criteria A, B, C and D)

The number of mature individuals is the number of individuals known estimated or inferred to be capable of reproduction. When estimating this quantity the following points should be borne in mind :

- Mature individuals that will never produce new recruits should not be counted (e.g. densities are too low for fertilization).
- In the case of populations with biased adult or breeding sex ratios, it is appropriate to use lower estimates for the number of mature individuals, which take this into account.
- Where the population size fluctuates, use a lower estimate. In most cases this will be much less than the mean.
- Reproducing units within a clone should be counted as individuals, except where such units are unable to survive alone (e.g. corals).
- In the case of taxa that naturally loose all or a subset of mature individuals at some point in their life cycle, the estimate should be made at the appropriate time, when mature individuals are available for breeding.
- Re-introduced individuals must have produced viable offspring before they are counted as mature individuals.

4. Generation (Criteria A, C and E)

Generation length is the average age of parents of the current cohort (i.e. newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once. Where generation length varies under threat, the more natural, i.e. pre-disturbance, generation length should be used.

5. Reduction (Criteria A)

A reduction is a decline in the number of mature individuals of at least the amount (%) stated under the criterion over the time period (years) specified, although the decline need not be continuing. A reduction should not be interpreted as part of a fluctuation unless there is good evidence for this. The downward phase of a fluctuation will not normally count as a reduction.

6. Continuing decline (Criteria B and C)

A continuing decline is a recent, current or projected future decline (which may be smooth, irregular or sporadic) which is liable to continue unless remedial measures are taken. Fluctuations will not normally count as continuing declines, but an observed decline should not be considered as a fluctuation unless there is evidence for this.

7. Extreme fluctuations (Criteria B and C)

Extreme fluctuations can be said to occur in a number of taxa when population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (i.e. a tenfold increase or decrease).

8. Severely fragmented (Criterion B)

The phrase 'severely fragmented' refers to the situation in which increased extinction risk to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations may go extinct, with a reduced probability of recolonization.

9. Extent of occurrence (Criteria A and B)

Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy (see Figure 2). This measure may exclude discontinuities or disjunctions within the overall distributions of taxa (e.g. large areas of obviously unsuitable habitat) (but see 'area of occupancy', point 10 below). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).

10. Area occupancy (Criteria A, B and D)

Area of occupancy is defined as the area within its 'extent of occurrence' (see point 9 above) which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. In some cases (e.g. irreplaceable colonial nesting sites, crucial feeding sites for migratory taxa) the area of occupance is the smallest area essential at any stage to the survival of existing populations of a taxon. The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats and the available data (see point 7 in the Preamble). To avoid inconsistencies and bias in assessments caused by estimating area of occupancy at different scales, it may be necessary to standardize estimates by applying a scale-correction factor. It is difficult to give strict guidance on how standardization should be done because different types of taxa have different scale-area relationships.

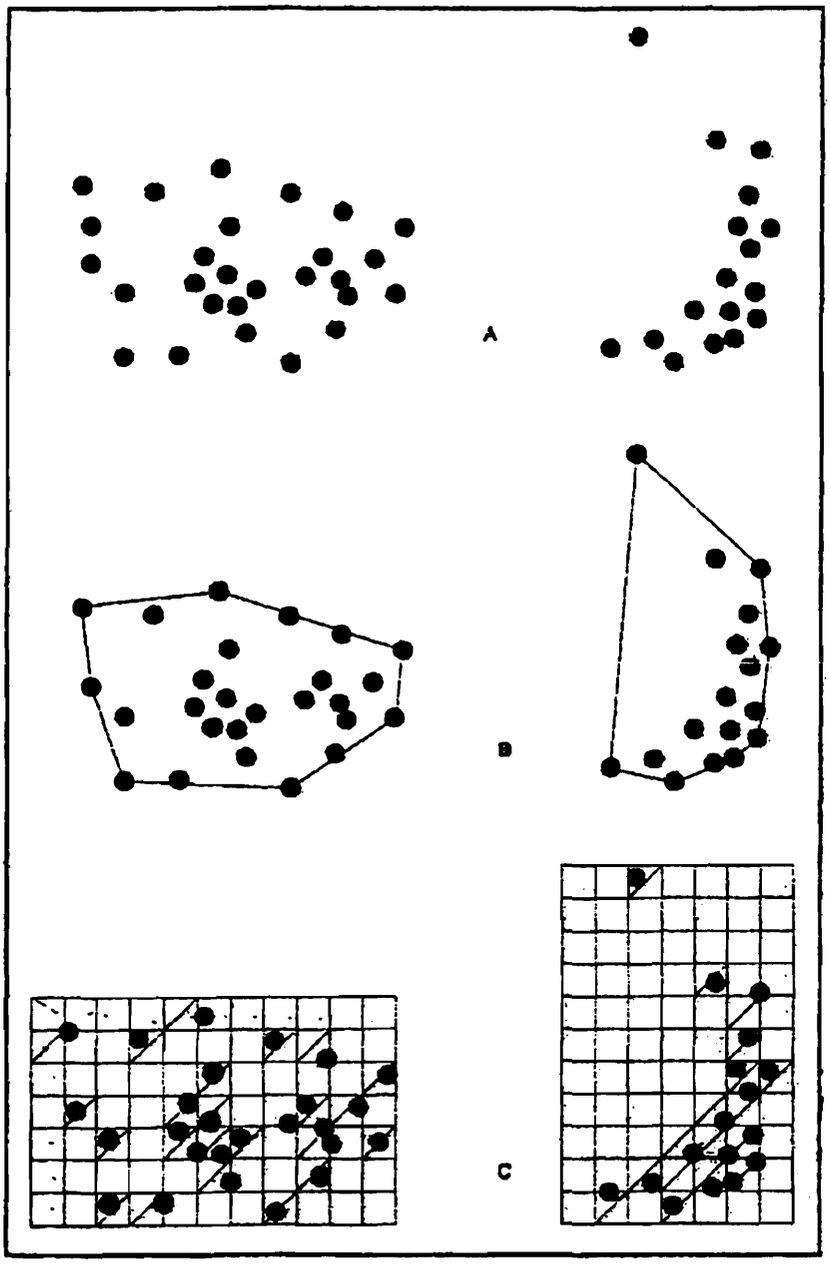

Fig. 2. Two examples of the distinction between extent of occurrence and area of occupancy. (A) is the spatial distribution of known, inferred or projected sites of present occurrence. (B) Shows one possible boundary to the extent of occurrence, which is the measured area within this boundary. (C) Shows one measure of area of occupancy which can be achieved by the sum of the occupied grid squares.

11. Location (Criteria B and D)

The term 'location defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat.

12. Quantitative analysis (Criterion E)

A quantitative analysis is defined here as any form of analysis which estimates the extinction probability of a taxon based on known life history, habitat requirements, threats and any specified management options. Population viability analysis (PVA) is one such technique. Quantitative analyses should make full use of all relevant available data. In a situation in which there is limited information, such data as are available can be used to provide an estimate of extinction risk (for instance, estimating the impact of stochastic events on habitat). In presenting the results of quantiative analyses, the assumptions (which must be appropriate and defensible), the data used and the uncertainty in the data or quantitative model must be documented.

IV. THE CATEGORIES[1]

A representation of the relationships between the categories is shown in Figure 1.

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for critically Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (See Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

[1]*Note : As in previous IUCN categories, the abbreviation of each category (in parenthesis) follows the English denominations when translated into other languages (see Annex 2).*

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see SectionV), and it is therefore considered to be facing a high risk of extinction in the wild.

NEAR THREATENED (NT)

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC)

A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has lapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE)

A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

V. THE CRITERIA FOR CRITICALLY ENDANGERED, ENDANGERED AND VULNERABLE

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing an extremely high risk or extinction in the wild :

A. Reduction in population size on any of the following

1. An observed, estimated, inferred or suspected population ≥ 90% over the last 10 years or three generations, whichever is the longer where the causes of the reduction are

clearly reversible AND understood AND ceased, based on (and specifying) any of the following

(a) direct observation

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred, suspected population size reduction of ≥ 80% over the last 10 years or three generations whichever is the longer where the reduction or its causes may not have ceased OR may not be understood OR may not be based on (and specifying) any of (a) to under A 1.

3. A population size reduction of ≥80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any or (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥ 80% over any 10 years or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupance) OR both :

1. Extent of occurrence estimated to be less than 100 km^2, and estimates indicating at least two of a-c :

a. Severely fragmented or known to exist at only a single location.

b. Continuing decline, observed, inferred or projected, in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) area, extent and/or quality of habitat

(iv) number of locations or subpopulations

(v) number of mature individuals.

C. Extreme fluctuations in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) number of locations or subpopulations

(iv) number of mature individuals.

2. Area of occupancy estimated to be less than 10 km^2, and estimates indicating at least two of a-c :

a. Severely fragmented or known to exist at only a single location.

b. Continuing decline, observed, inferred or projected, in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) area, extent and/or quality of habitat

(iv) number of locations or subpopulations

(v) number of mature individuals.

c. Extreme fluctuations in any of the following :

(i) Extent of occurrence

(ii) area of occupancy

(iii) number of locations or subpopulations

(iv) number of mature individuals.

C. Population size estimated to number fewer than 250 mature individuals and either :

1. An estimated continuing decline of at least 25% within three years or one generation, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a-b) :

a. Population structure in the form of one of the following :

(i) no subpopulation estimated to contain more than 50 mature individuals, OR

(ii) at least 90% of mature individuals in one subpopulation.

b. Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 50 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 100 years).

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild :

A. Reduction in population size based on any of the following :

1. An observed, estimated, inferred or suspected population size reduction of ≥70% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following :

(a) direct observation

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasties.

2. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (c) under A1.

3. A population size reduction of ≥50%, projected or suspected to be met within the next 10 years of three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥ 50% over any 10 years or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both :

1. Extent of occurrence estimated to be less than 5000 km^2, and estimates indicating at least two of a-c:

a. Severely fragmented or known to exist at no more than five locations.

b. Continuing decline, observed, inferred or projected, in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) area, extent and/or quality of habitat

(iv) number of locations or subpopulations

(v) number of mature individuals.

c. Extreme fluctuations in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) number of locations or subpopulations

(iv) number of mature individuals.

2. Area of occupancy estimated to be less than 500 km^2, and estimates indicating at least two of a–c :

a. Severely fragmented or known to exist at no more than five locations.

b. Continuing decline, observed, inferred or projected, in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) area, extent and/or quality of habitat

(iv) number of locations or subpopulations

(v) number of mature individuals.

c. Extreme fluctuations in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) number of locations or subpopulations

(v) number of mature individuals.

C. Population size estimated to number fewer than 2500 mature individuals and either :

1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred in numbers of mature individuals AND at least one of the following (a–b) :

a. Population structure in the form of one of the following :

(i) no subpopulation estimated to contain more than 250 mature individuals, OR

(ii) at least 95% of mature individuals in one subpopulation.

b. Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 250 mature individuals.

E. Quantiative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years).

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild :

A. Reduction in population size based on any of the following :

1. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are : clearly reversible AND understood AND ceased, based on (and specifying) any of the following :

(a) direct observation

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥30% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (c) under A1.

3. A population size reduction of ≥30%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥ 30% over any 10 years or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (c) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) Or B2 (area of occupancy) OR both :

1. Extent of occurrence estimated to be less than 20,000 km^2, and estimates indicating at least two of a–c :

a. Severely fragmented or known to exist at no more than 10 locations.

b. Continuing decline, observed, inferred or projected, in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) area, extent and/or quality of habitat

(iv) number of locations or subpopulations

(v) number of mature individuals.

c. Extreme fluctuations in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) number of locations or subpopulations

(iv) number of mature individuals.

2. Area of occupancy estimated to be less than 2000 km^2, and estimates indicating at least two of a-c:

a. Severely fragmented or known to exist at no more than 10 locations.

b. Continuing decline, observed, inferred or projected, in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) area, extent and/or quality of habitat

(iv) number of locations or subpopulations

(iv) number of mature individuals.

c. Extreme fluctuations in any of the following :

(i) extent of occurrence

(ii) area of occupancy

(iii) number of locations or subpopulations

(iv) number of mature individuals.

C. Population size estimated to number fewer than 10,000 mature individuals and either :

1. An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a–b) :

a. Population structure in the form of one of the following :

(i) no subpopulation estimated to contain more than 1000 mature individuals, OR

(ii) all mature individuals are in one subpopulation.

b. Extreme fluctuations in number of mature individuals.

D. Population very small or restricted in the form of either of the following :

1. Population size estimated to number fewer than 1000 mature individuals.

2. Population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.

E. Quantiative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

Annex 1 : Uncertainty

The Red List Criteria should be applied to a taxon based on the available evidence concerning its numbers, trend and distribution. In cases where there are evident threats to a taxon through, for example, deterioration of its only known habitat, a threatened listing may be justified, even though there may be little direct information on the biological status of the taxon itself. In all these instances there are uncertainties associated with the available information and how it was obtained. These uncertainties may be categorized as natural variability, semantic uncertainty and measurement error (Akeakaya *et al.* 2000.) This section provides guidance on how to recognize and deal with these uncertainties when using the criteria.

Natural variability results from the fact that species life histories and the environments in which they live change over time and space. The effect of this variation on the criteria is limited, because each parameter refers to a specific time or spatial scale. Semantic uncertainty arises from vagueness in the definition of terms or lack of consistency in different assessors' usage of them. Despite attempts to make the definitions of the terms used in the criteria exact, in some cases this is not possible without the loss of generality. Measurement error is often the largest source of uncertainty; it arises from the lack of precise information about the parameters used in the criteria. This may be due to inaccuracies in estimating the values or a lack of knowledge. Measurement error may be reduced or eliminated by acquiring additional data. For further details, see Akeakaya *et al.* (2000) and Burgman *et al.* (1999).

One of the simplest ways to represent uncertainty is to specify a best estimate and a range of plausible values. The best estimate itself might be a range, but in any case the best estimate should always be included in the range of plausible values. When data are very uncertain, the range for the best estimate might be the range of plausible values. There are various methods that can be used to establish the plausible range. It may be based on confidence intervals, the opinion of a single expert, or the consensus opinion of a group of experts. Whichever method is used should be stated and justified in the documentation.

When interpreting and using uncertain data, attitudes toward risk and uncertainty may play an important role. Attitudes have two components. First, assessors need to consider whether they will include the full range of plausible values in assessments, or whether they will exclude extreme values from consideration (known as dispute tolerance). As assessor with a low dispute tolerance would include all values, thereby increasing the uncertainty, whereas an assessor with a high dispute tolerance would exclude extremes, reducing the uncertainty. Second, assessors need to consider whether they have a precautionary or evidentiary attitude to risk (known as risk tolerance). A precautionary attitude will classify a taxon as threatened unless it is certain that it is not threatened, whereas an evidentiary attitude will classify a taxon as threatened only when there is strong evidence to support a threatened classification. Assessors should resize an evidentiary attitude and adopt a precautionary but realistic attitude to uncertainty when applying the criteria, for example, by using plausible lower bounds, rather than best estimates, in determining population size, especially if it is fluctuating. All attitudes should be explicitly documented.

As assessment using a point estimate (i.e. single numerical value) will lead to a single Red List Category. However, when a plausible range for each parameter is used to evaluate the criteria, a range of categories may be obtained, reflecting the uncertainties in the data. A single category, based on a specific attitude to uncertainty, should always be listed along with the criteria met, while the range of plausible categories should be indicated in the documentation (see Annex 3).

Where data are so uncertain that any category is plausible, the category of 'Data Deficient' should be assigned. However, it is important to recognize that this category indicated that the data are inadequate to determine the degree of threat faced by a taxon, not necessarily that the taxon is poorly known or indeed not threatened. Although Data Deficient is not a threatened category, it indicates a need to obtain more information on a taxon to determine the appropriate listing; moreover, it requires documentation with whatever available information there is.

Annex 2 : Citation of the IUCN Red List Categories and Criteria

In order to promote the use of a standard format for citing the Red List Categories and Criteria the following forms of citation are recommended :

1. The Red List Category may be written out in full or abbreviated as follows (when translated into other languages, the abbreviations should follow the English denominations) :

Extinct, EX	Near Threatened, NT
Extinct in the Wild, EW	Least Concern, LC
Critically Endangered, CR	Data Deficient, DD
Endangered, EN	Not Evaluated, NE
Vulnerable, VU	

2. Under Section V (the criteria for Critically Endangered, Endangered and Vulnerable) there is a hierachical alphanumeric numbering system of criteria and subcriteria. These criteria and subcriteria (all three levels) form an integral part of the Red List assessment and all those that result in the assignment of a threatened category must be specified after the Category. Under the criteria A to C and D under Vulnerable, the first level of the hierachy is indicated by the use of numbers (1-4) and if more than one is met, they are separated by means of the '+' symbol. The second level is indicated by the use of the lower-case alphabet characters (a-e). These are listed without any punctuation. A third level of the hierarchy under Criteria B and C involves the use of lower case roman numerals (i-v). These are placed in parentheses (with no space between the preceeding alphabet character and start of the parenthesis) and separated by the use of commas if more than one is listed. Where more than one criterion is met, they should be separated by semicolons. The following are examples of such usage :

EX	CR A1cd	VU A2c+3c
EN B1ac(i,ii,iii)	EN A2c; D	VU D1+2
CR A2c+3c; B1ab(iii)	CR D	VU D2
EN B2ab(i,ii,iii)	VU C2a(ii)	
EN A1c; B1ab(iii); C2a(i)	EN B2b(iii)c(ii)	
EN B1ab(i,ii,v)c(iii,iv)+2b(i)c(ii,v)	VU B1ab(iii) + 2ab(iii)	

EN A2abc+3bc+4abc; B1b(iii,iv,v)c(ii,iii,iv) + 2b(iii, iv, v)c(ii,iii,iv)

Annex 3 : Documentation Requirements for Taxa Included on the IUCN Red List

The following is the **minimum** set of information , which should accompany every assement submitted for incorporation into the *IUCN Red List of Threatened Species*^{TM} :

- Scientific name including authority details
- English common name/s and any other widely used common names (specify the language of each name supplied)

- Red List Category and Criteria.

- Countries of occurrence (including country subdivisions for large nations, e.g. states within the USA, and overseas territories, e.g. islands far from the mainland country)

- For marine species, the Fisheries Areas in which they occur should be recorded (see http//www.iucn.org/themes/ssc/sis/faomap.htm for the Fisheries Areas as delimited by FAO, the Food and Agriculture Organization of the United Nations)

- For inland water species, the names of the river systems, lakes, etc. to which they are confined

- A map showing the geographic distribution (extent of occurrence)

- A rationale for the listing (including any numerical data, inferences or uncertainty that relate to the criteria and their thresholds)

- Current population trends (increasing, decreasing, stable or unknown)

- Habitat preferences (using a modified version of the Global Land Cover Characterization (GLCC) classification which is available electronically from http://www/iucn.org/themes/ssc/sis/authority.htm or on request from redlist@ssc-uk.org)

- Major threats (indicating past, current and future threats using a standard classification which is available from the SSC web site or e-mail address as shown above)

- Conservation measures, (indicating both current and proposed measures using a standard classification which is available from the SSC web site or e-mail address as shown above)

- Information or any changes in the Red List Status of the taxon and why the status has changed.

- Data sources (cited in full; including unpublished sources and personal communications)

- Name/s and contact details of the assessor/s

- Before inclusion on the IUCN Red List, all assessments will be evaluated by at least two members of a Red List Authority. The Red List Authority is appointed by the Chair of the IUCN Species Survival Commission and is usually a sub-group a Specialist Group. The names of the evaluators will appear with each assessment.

In addition to the minimum documentation, the following information should also be supplied where appropriate :

- If a quantitative analysis is used for the assessment (i.e. Criterion E), the data, assumptions and structural equations (e.g., in the case of a Population Viability Analysis) should be included as part of the documentation.

- For Extinct or Extinct in the Wild taxa, extra documentation is required indicating

the effective date of extinction, possible causes of the extinction and the details of surveys which have been conducted to search for the taxon.

- For taxa listed as Near Threatened, the rationale for listing should include a discussion of the criteria that are nearly met or the reasons for highlighting the taxon (e.g., they are dependent on ongoing conservation measures).

- For taxa listed as Data Deficient, the documentation should include what little information is available.

Assessments may be made using version 2.0 of the software package RAMAS® Red List (Akeakaya and Ferson 2001). This program assigns taxa to Red List Categories according to the rules of the IUCN Red List Criteria and has the advantage of being able to explicitly handle uncertainty in the data. The software captures most of the information required for the documentation above, but in some cases the information will be reported differently. The following points should be noted :

- If RAMAS® Red List is used to obtain a listing, this should be stated.

- Uncertain values should be entered into the program as a best estimate and a plausible range, or as an interval (see the RAMAS® Red List manual or help files for further details).

- The settings for attitude towards risk and uncertainty (i.e. dispute tolerance, risk tolerance and burden of proof) are all pre-set at a mid-point. If any of these settings are changed this should be documented and fully justified, especially if a less precautionary position is adopted.

- Depending on the uncertainties, the resulting classification can be a single category and/or a range of plausible categories. In such instances, the following approach should be adopted (the program will usually indicate this automatically in the Results window) :

– If the range of plausible categories extends across two or more of the threatened categories (e.g. Critically Endangered to Vulnerable) and no preferred category is indicated, the precautionary approach is to take the highest category shown, i.e. CR in the above example. In such cases, the range of plausible categories should be documented under the rationale including a note that a precautionary approach was followed in order to distinguish it from the situation in the next point. The following notation has been suggested e.g. CR* (CR-VU).

– If a range of plausible categories is given and a preferred category is indicated, the rationale should indicate the range of plausible categories met e.g. EN (CR-VU).

- The program specifies the criteria that contributed to the listing (see Status window). However, when data are uncertain, the listing criteria are approximate, and in some cases may not be determined at all. In such cases, the assessor should use the Text results to

determine or verify the criteria and sub-criteria met. Listing criteria derived in this way must be clearly indicated in the rationale (refer to the RAMAS® Red List Help menu for further guidance on this issue).

- If the preferred category is indicated as Least Concern, but the plausible range extends into the threatened categories, a listing of 'Near Threatened' (NT) should be used. The criteria, which triggered the extension into the threatened range, should be recorded under the rationale.

- Any assessments made using this software must be submitted with the RAMAS® Red List input files (i.e. the *.RED files).

New global assessments or reassessments of taxa currently on the IUCN Red List, may be submitted to the IUCN/SSC Red List Programme Officer for incorporation (subject to peer review) in a future edition of the *IUCN Red List of Threatened Species*™. Submissions from within the SSC network should preferably be made using the Species Information Services (SIS) database. Other submissions may be submitted electronically; these should preferably be as files produced using RAMAS® Red List or any of the programs in Microsoft Office 97 (or earlier versions) e.g. Word, Excel or Access. Submissions should be sent to :

IUCN/SSC Red List Programme, IUCN/SSC UK Office, 219c Huntingdon Road, Cambridge, CB3 0DL, United Kindgom. Fax: +44 (0)1223-277845; Email: redlist@ssc-uk.org.

For further clarification or information about the IUCN Red List Criteria, documentation requirements(including the standards used) or submission of assessments, please contact the IUCN/SSC Red List Programme Officer at the address shown above.

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Action Plans assess the conservation status of species and their habitats, and specify conservation priorities. The series (over 60 published to date) is one of the world's most authoritative sources of species conservation information available to natural resource managers, conservationists and government officials around the world.

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The IUCN Red List includes species that have been assessed according to the IUCN Red List Categories and Criteria. For each species, the category of threat and relevant criteria are shown, together with other documentation about distribution range, habitats, threats, conservation measures, etc.

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IUCN Species Survival Commission

The Species Survival Commission (SSC) is one of six volunteer commissions of IUCN–The World Conservation Union, a union of sovereign states, government agencies and non-governmental organisations. IUCN has three basic conservation objectives : to secure the conservation of nature, and especially of biological diversity, as an essential foundation for the future; to ensure that where the earth's natural resources are used this is done in a wise equitable and sustainable way; and to guide the development of human communities towards ways of life that are both of good quality and in enduring harmony with other components of the biosphere.

The SSC's mission is to conserve biological diversity by developing and executing programmes to save, restore and wisely manage species and their habitats. A volunteer network comprises of nearly 7,000 scientists, field researchers, government officials and conservation leaders from almost every country of the world, the SSC membership is an unmatched source of information about biological diversity and its conservation. As such, SSC members provide technical and scientific counsel for conservation projects throughout the world and serve as resources to governments, international conventions and conservation organisations.

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