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Fish fauna of Uttarakhand, India: Present status, Diversity and Conservation

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Abstract: Extensive Ichthyofaunal survey of various water resources of Uttarkhand was carried out for the period of more than 15 years (2004-2019). The main objective of this paper is to know the district wise status, distribution and to recommend the strategy for the conservation and management of fishes of the state, so that clear-cut idea could be drawn, for further research and policy planning. In the present paper a total of 132 species of fish belonging to 67 genera, 27 families and 8 orders have been reported. The district wise distribution of fish represented a maximum of 101 species from Nainital, followed by 81 species from Dehradun, 75 species from Haridwar, 73 species from Udham Singh Nagar, 59 species from Pauri Garhwal, 37 species from Rudrapryag, 36 species from Almora, 35 species from Chamoli, 34 species from Bageshwar, while 32 species from Pithoragarh and Champawat and 29 species each from Uttarkashi and Tehri Garhwal. Besides these 10 species (7.5%) are in the category of Endangered, while 10 species (7.5%) are exotic in nature and 11 species (8.3%) are endemic to the Uttarakhand state. On the basis of fish catch the dominant species in upper region (hill area) are *Schizothoracine species* (which forms appox. 60% of fish catch) and in the plains dominant species are *Barilius* species (which forms 40% of fish catch) *etc*. Besides this after the careful observation and constant monitoring, some major factors responsible for the depletion of fish resources were listed out which include over exploitation of fish resources, lack of fish policy/laws, deforestation, destruction of spawning ground, shrinkage of water bodies, pollution/weed infestation in water bodies, introduction of exotic fish, construction of dams (which effect fish migration) and lack of awareness among masses. Moreover, the conservation and management strategy for fish has also been discussed in detail.

Keywords: Fish Resources, Diversity, Status, Distribution, Endangered, Endemic, Exotic, Conservation and Management

Introduction

Uttarakhand is rich in its inland water resources as most of the rivers owe their origin from the himalayas. Apart from this the region is blessed with many natural lakes. All these resources are full of indigenous fishes which are economically important to humans. Most of the world inland fish serve as a major source of protein, (Wetzel, 2001). Globally a total of 21,723 species of fish have been recorded from varied ecosystems. In India 2,513 species of fish have been reported which contributes 11.1 % of the world fish population out of which 1,580 are inhabitant to marine and 933 in freshwater ecosystem (Jayram, 1999). Uttarakhand is a newly created hill dominant state of India situated between 28^0 43'-31^0 8' North latitude and 77^0 35'-$81^0$2' East longitudes with geographical area of 53,483 Km ^{2} supported by 13 district with an altitude from 400m-6000m, varying from lesser Himalaya to greater Himalayas, Doons and Shiwalik. Due to its varied geographical set up, Uttarakhand is supported by cold water streams on the one hand whereas by the moderately warm water spring fed streams on the other hand having an abode of several fish species. Mahseer, Schizothoracine and catfishes are among fascinating fish fauna of the region. Apart

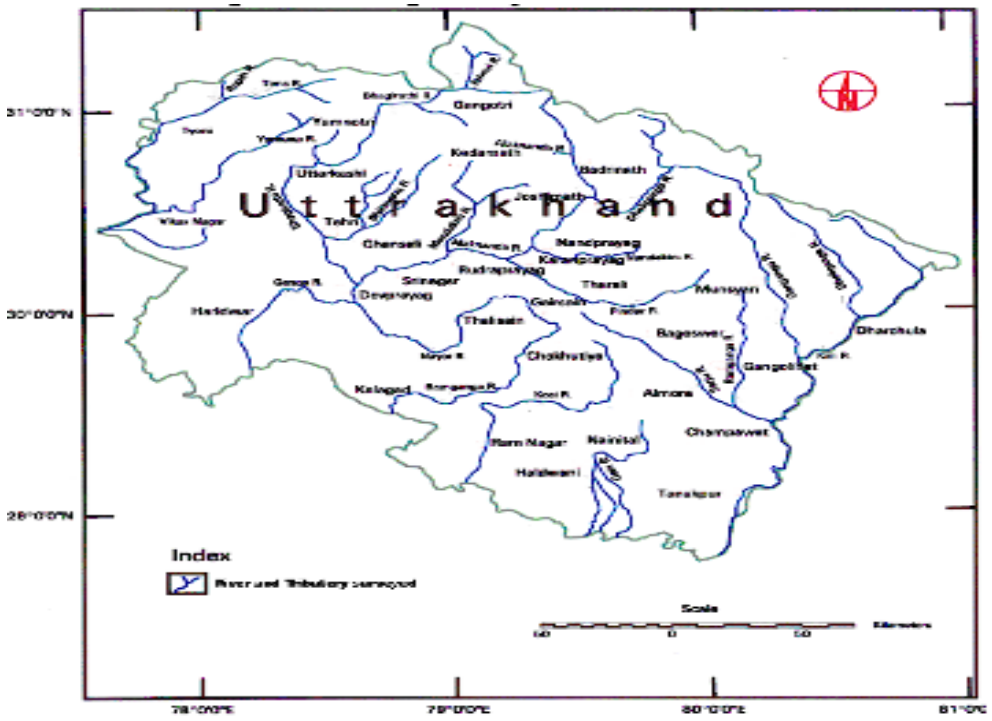
from this there is a history of introduction of exotic trout species in some specific hatcheries in Uttarakhand like Kaldyani in Uttarkashi and Talwari and Bairangana in Chamoli District. Uttarakhand state also harbors a good net work of protected areas and wetland like Tehri reservoir, Asan & Jhimaltal conservation reserves, Bhimgoda , Naini Tal, Dodital, Devaria Tal, Bhimtal, *etc*. where fish fauna is under protection either religiously or by the law of conservation of wetlands. Fishery resources of Uttarakhand are also affected due to increased anthropogenic pressure in the name of development activities like unplanned exploration, power generation, deforestation , shrinkage of water bodies and pollution, etc.

Uttarakhand state is an integral part of Western Himalaya and attracts the attention of Ichthyologists since very beginning. The important contributors are Hora (1937 b, 1952), Menon (1954, 1962, 1974), Atkions (1974), Sehgal (1974,1999), Tilak and Husain (1977), Singh et.al. (1987), Karmakar (2000), Joshi (2000), Johal *et al.* (2002), Johal and Rawal (2005), Mehta & Uniyal (2005) , Nautiyal (2005) and Sharma *et al.* (2007). A review of literature on fish fauna of undivided Uttar Pradesh (Hill region) and Uttarakhand showed enough contributions in this field (Hora and Mukherjee 1936, Hora 1937, Menon 1949, 1999, Chaudhary and Khandelwal 1960, Das 1960, Lal and Chatterjee 1963, Singh 1964, Tilak 1969, Pant 1970, Grover 1970,1979, Badola and Pant, 1973, Tilak and Husain 1974, 1976, 1977a,1977b, 1978, Badola, 1975, 2009, Husain 1976, 1995, 1997, Badola and Singh 1977a, 1977b, 1977c, 1981a, 1981b, Das & Pathania 1978, Singh and Badola 1978, Baloni 1980, Sharma 1983, 1984, 2004, Bhatt *et al.* 1984, Tilak and Baloni 1984, Singh *et al.* 1987, Das and Nath 1988, Dobriyal & Kumar 1988, Nautiyal 1989, 1994,2001, 2005, Khanna & Badola 1990, Sunder 1990, 1995, Dobriyal 1991, Dobriyal *et al*. 1992), Bhatt and Pathak 1992a 1992,b , Joshi *et al*. 1993, Pathak & Bhatt 1993, Rautela *et al.* 1993, Singh *et al*.1993, Grover *et al.* 1994, Joshi 1994, Husain and Tilak 1995, Singh and Sharma 1998, Joshi 1999, Pathania & Rautela 2000, Khan 2000, Chawan 2000, Bahuguna *et al.* 2001, Uniyal *et al*. 2001, 2002 , 2006, 2011, Uniyal 2002, 2008, 2009, 2010, Uniyal and Kumar 2002, 2006, Sharma 2003 Negi and Malik 2005, Uniyal and Mehta 2007, Negi & Negi 2010, Uniyal & Uniyal 2010, Nautiyal *et al.* 2013, Bhatt *et al.* 2016 and Rana *et al.* 2017). The present paper mainly focused on the status, distribution of fish in various district of the state and recommendation for the conservation and management of fishes for state policy planning.

Material and Methods:

The detailed Ichthyofaunal survey of various water resources of Uttarakhand was undertaken for the period of more than 15 years (2004-2019) under different projects (Fig 1). Fish specimens were collected by applying various fishing methods in day and night time to get maximum representation of fishes. The inventory of fish fauna has been

prepared on the bases of material (specimen) identified by authors, available in Zoological Survey of India, Dehradun (U.A.) and also material received from various University/ Institutes of Uttarakhand. Identification was based on the Day (1889), Talwar and Jhingran (1991), and Jayaram (1999), however there is difference of opinion among the taxonomist regarding the classification to be followed , in present study classification given by Nelson (1994) is followed with slight modification.



Map 1: Drainage Pattern of Uttarakhand

Results and Discussion

Fish diversity and status:

A total of 132 species of pisces belonging to 67 genera 27 families and 8 orders have been reported, out of which two species are the new records for the state *i.e. Glossogobius garius*, reported from Haridwar district, while *Bagrius bagrius*, reported from Dehradun and Hardwar districts, while *Garra lamta* is new record for Dehradun district and *Nandus nandus* and *Colisa facitus* has also been reported for the first time from Garhwal Hills (Table 1.).

The family wise distribution of fishes revealed that 55 species belongs to family Cyprinidae, 16 species from Cobitidae, 15 species from Sisoridae, 5 species each from Bagridae and Ailindae, 4 species from Channidae, 3 species each from Siluridae and Salmonidae, 2 species each Notopteridae, Centropomidae, Nandidae , Mugilidae, Gibiindae, Belontiidae and Mastacembelidae, 1 species each from Clupeidae Psilorhynchidae, Balitoridae, Amblycipitidae, Clariidae, Heteropneustidae, Belonidae, Aplocheilidae, Poeciliidae, Synbranchidae, Anabantidae and Osphronemidae, (Fig.1).

The district wise distribution of fish shows that maximum 101 species are reported from Nainital, followed by 81 species from Dehradun, 75 species from Hardwar, 73 species from Udham Singh Nagar and 59 species from Pauri Garhwal. The reason for high fish diversity in these districts is low altitude, moderate water temperature and rich drainage, where cold water as well as warm water fish is found. On the other hand 37 species are reported from Rudrapryag, 36 from Almora, 35 species from Chamoli, 34 species from Bageshwar, 32 species each from Pithoragarh and Champawat and 29 species each in Uttarkashi and Tehri Garhwal. The reason for less diversity of fishes in these districts is the high altitude and low water temperature.

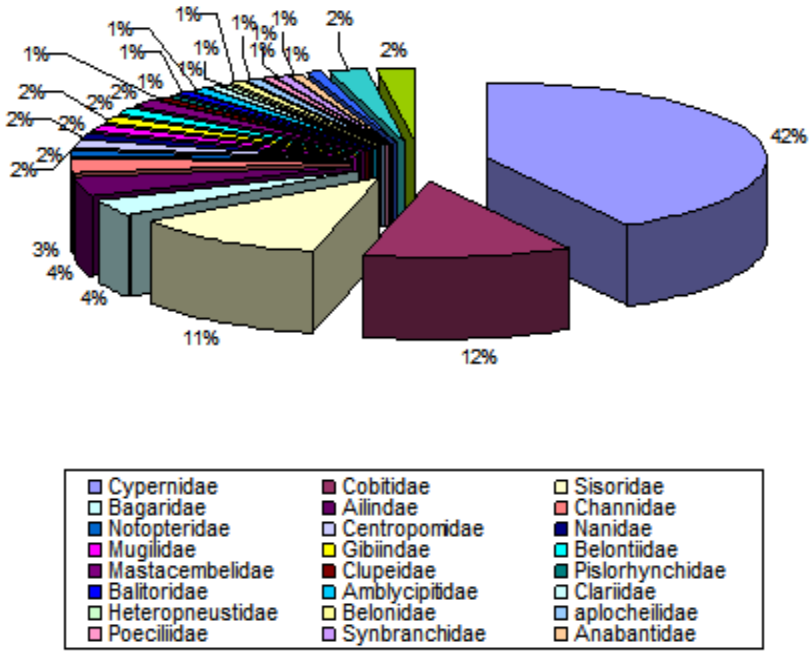


Fig 1: Fish Diversity (Family wise) in Uttarakhand

Fishes inhabiting this region have high adaptive features to survive and stay in fast water current, (Fig.-2). While as per the CAMP -1998, 10 species (7.5%) are in the category of Endangered and need immediate protection and 10 species (7.5%) are exotic species, which were introduced in the state mainly for biological control, game and commercial purpose. While 11 species (8.3%) are endemic to the Uttarakhand state, which act as a flag ship species for balancing the aquatic ecosystem (Table-1).

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Table.1: District wise fish diversity of Uttarakhand

Fish fauna of Uttarakhand													
Districts	**Garhwal**							**Kumaon**					
Taxon	**Dehradun**	**Hardwar**	**Tehri**	**Pauri**	**Uttarakashi**	**Chamoli**	**Rudraprya g**	**Nanital**	**Almora**	**Pithoragarh**	**Champawat**	**Bageshwar**	**Udham Singh Nagar**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
PHYLUM: CHODRATA													
CLASS: ACTINOPTERYGII													
Order: Osteoglossiformes													
Family: Notopteridae													
1. *Notopterus notopterus* (Pallas)	-	+	-	-	-	-	-	+	-	-	-	-	+
2. *N. Chitala* (Ham.-Buch)	-	-	-	-	-	-	-	+	-	-	-	-	+
ORDER: CLUPEIFORMES													
FAMILY: CLUPEIDAE													
3. *Gudsia chapra* (Ham.-Buch)	-	-	-	-	-	-	-	+	-	-	-	-	-
ORDER: CYPRINIFORMES													
FAMILY: CYPRINIDAE													
4. *Chela laubuca* Ham.-Buch.	-	-	-	+	-	-	-	+	-	-	-	-	+
5. *Salmostoma bacaila* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	+
6. *S. Phula phulo* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	+
7. *Hypophthalmichthys moltrix* (Valenciennes) **(EX)**	-	+	-	-	-	-	-	+	-	-	-	+	+
8. *Amblypharyngopodon mola* (Ham.-Buch)	-	-	-	-	-	-	-	+	-	-	-	-	+
9. *Aspidoparia jaya* (Ham.-Buch.)	+	+	-	-	-	-	-	+	-	-	-	-	+
10. *A. morar* (Ham.-Buch)	+	+	-	-	-	-	-	+	-	-	-	-	+
11. *B. barila* (Ham.-Buch)	-	-	+	+	+	-	-	-	-	-	-	+	-
12. *B. barna* (Ham.-Buch)	+	+	+	+	+	+	+	+	+	+	+	+	+
13. *B. bendelisis* (Ham.-Buch)	+	+	+	+	+	+	+	+	+	+	+	+	+
14. *B. dimorphicus* Tilak & Husain **(EN)**	+	+	-	+	-	-	-	-	-	-	-	-	-
15. *B. shacra* (Ham.-Buch)	-	+	-	+	-	+	-	-	-	-	-	-	-
16. *Barilius vagra* (Ham.-Buch)	+	+	+	+	+	+	+	+	+	+	+	+	+
17. *B. pectorilus* Tilak & Husain **(EN)**	+	-	-	-	-	-	-	-	-	-	-	-	-
18. *Raiamas bola* (Ham.-Buch) **(TH)**	+	-	-	+	-	+	+	+	-	+	+	+	-
19. *Brachydanio rerio* (Ham.-Buch)	+	+	-	+	-	-	-	+	+	-	+	-	+
20. *Danio devario* (Ham.-Buch)	+	+	-	+	-	-	-	+	-	-	-	-	+

21. *Esomus danricus* (Ham.-Buch.)	+	+	-	+	-	-	-	+	-	-	+	-	+
22. *Rasbora daniconius* (Ham.- Buch.)	+	+	-	+	-	-	-	+	+	-	+	-	+
23. *Carassius carassius* (Linnaeus) **(EX)**	+	+	-	-	+	+	+	+	-	-	-	+	+
24. *Catla catla* (Ham.-Buch.)	+	+	-	-	-	-	-	+	-	-	-	-	+
25. *Chagunius chagunio* (Ham.-Buch)	+	+	-	+	-	-	-	+	-	-	-	-	-
26. *Cirrhinus mrigala* (Ham.-Buch)	+	+	-	-	-	-	-	+	+	-	-	-	+
27. *C. reba* (Ham.-Buch)	+	+	-	-	-	-	-	+	-	-	-	-	-
28. *Cyprinus carpio* Linnaeus **(EX)**	+	+	-	-	+	+	+	+	+	-	-	+	-
29. *Cyprinus specularis* Lacepeds **(EX)**	+	+	-	-	+	+	+	+	+	-	_	+	-
30. *Labeo boga* (Ham.-Buch)	-	+	-	-	-	-	-	-	-	-	+	-	+
31. *Labeo bata* (Ham.- Buch.)	-	+	-	-	-		-	-	+	-	-	-	+
32. *Labeo calbasu* (Ham.- Buch.)	+	+	+	+	+	-	-	+	-	-	-	-	+
33. *Labeo dero* (Ham.- Buch.)	+	+	+	+	+	+	+	+	+	+	+	+	+
34. *Labeo dycoheilus* (McClelland)	+	+	-	+	-	-	-	+	+	+	+	+	+
35. *Labeo gonius* (Ham.- Buch.)	-	-	-	-	-	-	-	+	+	-	-	-	-
36. *Labeo rohita* (Ham.- Buch.)	+	+	-	-	-	-	-	+	+	+	-	-	+
37. *Osteobrama cotio cotio* (Ham.- Buch.)	-	+	-	-		-	-	+	-	-	-	-	+
38. *Puntius carletoni* Ham.-Buch.	+	-	-	+	-	-	-	+	-	-	-	-	-
39. *P. chola* (Ham.- Buch.)	+	+	-	+	-	-	-	+	-	-	-	-	-
40. *P. conchonius* (Ham.- Buch.)	+	+	-	+	-	+	+	+	+	+	+	+	+
41. *P. gelius* Ham.-Buch.	-	-	-	-	-	-	-	-	+	-	+	-	-
42. *P. sarana sarana* Ham.- Buch.	+	+	-	+	-	-	-	+	-	-	-	-	-
43. *P. Sophore* Ham.-Buch.	+	+	-	+	-	-	-	+	-	-	-	-	+
44. *P. terio* Ham.-Buch.	-	-	-	-	-	-	-	+	-	-	-	-	-
45. *P. ticto* Ham.-Buch.	+	+	-	+	-	+	+	+	+	+	+	+	+
46. *Tor chelynodies* (McClelland) **(TH)**	+	+	+	+	+	+	+	+	+	+	+	+	+
47. *T. putitora* (Ham.-Buch) **(TH)**	+	+	+	+	+	+	+	+	+	+	+	+	+
48. *T. tor* (Ham.-Buch.) **(TH)**	+	+	+	+	+	+	+	+	+	+	+	+	+
49. *Ctenopharygodon idellus* (Valenciennes) **(EX)**	+	+	-	-	-	-	-	-	-	-	-	-	+
50. *Crossocheilus latius* (Ham.-Buch.)	+	+	+	+	+	+	+	+	+	+	+	+	+
51. *Garra gotyla gotyla* (Gray)	+	+	+	+	+	+	+	+	+	+	+	+	+
52. *G. lamta* Ham.-Buch.	+*	-	+	+	+	+	+	+	+	+	+	+	+

53. *Schizothoraichthys progastus* (McClelland)	+	-	+	+	+	+	+	-	-	+	+	+	-
54. *S. esocinus* (Heckle)	-	-	-	+	-	+	+	-	-	-	-	-	-
55. *S. curvifons* (Heckle)	-	-	+	-	-	+	+	-	-	+	-	-	-
56. *S. kumaonensis* Menon **(EN)**	-	-	-	-	-	-	-	+	-	+	-	+	-
57. *S. sinuatus* (Heckel)	-	-	+	+	+	-	+	-	+	+	+	+	-
58. *S. richardsonii* (Gray)	+	+	+	+	+	+	+	+	+	+	+	+	-
FAMILY: PSILORHYNCHIDAE													
59. *Psilorhynchus balitora* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	-
FAMILY: BALITORIDAE													
60. *Balitora brucei* Gray	-	-	-	+	-	-	+	-	+	-	+	-	-
FAMILY: COBITIDAE													
61. *Botia alomrhae* Gray **(EN)**	-	-	-	-	-	-	-	+	+	-	-	-	-
62. *B. dario* (Hamilton- Buchanan)	-	-	+	+	-	-	-	-	-	+	-	+	-
63. *B. lochachata* Chaudhari	-	+	-	-	-	-	-	-	-	-	-	-	+
64. *B. rostrata* Gunter	+	-	+	+	-	+	-	-	-	-	-	-	+
65. *Lepidocephalus annandalei* Chaudhari	+	-	-	-	-	-	-	+	-	-	-	-	-
66. *L. caudofurcatus* Tilak & Husain **(EN)**	+	-	-	-	-	-	-	-	-	-	-	-	-
67. *L. guntea* (Ham.-Buch.)	+	+	-	+	-	-	-	+	-	-	-	-	+
68. *Nemachilus beavani* Gunter	-	+	+	+	+	+	+	+	+	+	+	+	+
69. *N. botia* (Ham.-Buch.)	+	+	+	+	+	+	+	+	+	+	+	+	+
70. *N. corica* (Ham.-Buch.)	+	+	-	+	-	-	-	+	-	-	-	-	+
71. *N. doonensis* (Tilak & Husain) **(TH); (EN)**	+	_	-	+	-	+	+	+	-	+	-	-	-
72. *N. gangeticus* (Menon) **(EN)**	+	-	-	+	-	-	-	-	-	-	-	-	-
73. *N. montanus* (McClelland) **(TH); (EN)**	+	-	+	+	+	+	+	+	+	+	+	+	+
74. *N. rupecola* (McClelland)	+	+	+	+	+	+	+	+	+	+	+	+	+
75. *N. savona* (Ham.-Buch.)	+	-	-	-	-	-	+	+	-	-	-	-	-
76. *N. submontanous* (Tilak & Husain)	+	-	-	-	-	-	-	-	-	-	-	-	-
ORDER: SILURIFORMES **FAMILY: AMBLYCIPITIDAE**													
77. *Amblyceps mongois* (Ham.-Buch.)	+	+	-	+	-	-	-	+	+	-	-	-	+
FAMILY: BAGRIDAE													

78. *Aorichthys seenghala* (Sykes)	+	+	-	-	-	-	-	+	-	-	-	-	+
79. *Mystus bleekri* (Day)	+	+	-	-	-	-	-	+	-	-	-	-	+
80. *M. cavasius* (Bloach)	-	+	-	-	-	-	-	+	-	-	-	-	+
81. *M. vittatus* (Bloch)	+	+	-	+	-	-	-	+	-	-	-	-	+
82. *Pseudeutropius atherinoides* (Bloach)	+	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY: SILURIDAE													
83. *Ompok bimaculatus* (Bloach)	-	+	-	-	-	-	-	+	-	-	-	-	+
84. *O. pabda* (Ham.-Buch.) **(TH)**	+	-	-	-	-	-	-	+	-	-	-	-	+
85. *Wallago attu* (Schneider)	+	+	-	-	-	-	-	+	-	-	-	-	+
FAMILY: AILINDAE													
86. *Ailia coila* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	+
87. *Clupisoma garua* (Ham.-Buch.)	-	+	-	-	-	-	-	+	-	-	-	-	-
88. *C. montana* Hora	+	-	+	-	-	-	-	-	-	-	-	-	-
89. *Eutropiichthys vacha* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	-
90. *Silonia silondia* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	-
FAMILY: SISORIDAE													
91. *Bagarius yarrelli* Sykes	+	+	-	+	-	-	-	+	-	+	+	+	+
92. *B. bagarius* (Ham.-Buch.)	+*	+*	-	+	-	-	-	-	-	-	-	-	-
93. *Euchiloglanis hodgarti* (Hora) **(EN)**	-	-	-	-	-	-	-	+	+	+	-	+	-
94. *Gagta cenia* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	-
95. *Glypthorax cavia* (Ham.-Buch.)	+	-	+	-	+	+	+	+	-	-	-	-	+
96. *G. conirostris* (Steindachner)	-	-	-	+	-	-	-	-	-	-	-	-	-
97. *G. dakapathari* Tilak & Husain **(TH); (EN)**	+	+	-	+	-	-	-	+	-	-	-	-	-
98. *G. garhwali* Tilak **(TH) ; (EN)**	+	-	+	+	-	+	+	-	-	-	-	-	-
99. *G. horai* Shaw & Shebberae	+	-	-	-	-	-	-	+	-	-	-	-	-
100. *G. pectinopterus* (McClelland)	+	+	+	+	+	+	+	+	+	+	+	+	+
101. *G. saisii* (Jenkins)	-	-	-	+	-	-	-	-	-	-	-	-	-
102. *G. telchitta* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	-

103. *G. alakandi* Tilak **(TH); (EN)**	-	-	-	+	-	-	-	-	-	-	-	-	-
104. *Laguvia ribeiroi kapuri* Tilak & Husain	-	-	-	-	-	-	-	+	-	-	-	-	-
105. *Pseudechensis sclcatus* (McClelland)	+	-	+	+	+	+	+	+	+	+	+	+	+
FAMILY: CLARIIDAE													
106. *Clarias batrachus* (Linna.)	+	+	-	-	-	-	-	+	-	-	-	-	+
FAMILY: HETEROPNEUSTIDAE													
107. *Heteropneustes fossilis* (Bloch)	+	+	-	-	-	-	-	+	-	-	-	-	+
ORDER: SALMONIFORMES													
FAMILY: SALMONIDAE													
108. *Salmo gairdnerii gairdnerii* Richardsons **(EX)**	+	-	+	-	+	+	+	+	-	-	-	-	-
109. *S. gairdnerii irideus* Gibbons **(EX)**	-	-	-	-	+	-	+	-	-	-	-	-	-
110. *S. trutta fario* Linn. **(EX)**	+	-	-	-	+	+	+	+	-	-	-	-	-
ORDER: CYPRINODONTIFORMES													
FAMILY: BELONIDAE													
111. *Xenentodon cancilia* (Ham.-Buch.)	+	+	-	-	-	-	-	+	-	-	-	-	+
FAMILY: APLOCHEILIDAE													
112. *Aplocheilus panchax* (Ham.-Buch.)	+	+	-	-	-	-	-	-	-	-	-	-	-
FAMILY: POECILIIDAE													
113. *Gambusia affinis holbrooki* Girard **(EX)**	+	+	-	-	-	-	-	-	-	-	-	-	+
ORDER: SYNBRANCHIFORMES													
FAMILY: SYNBRANCHIDAE													
114. *Monopterus cuchia* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	-
ORDER: PERCIFORMES													
FAMILY: CENTROPOMIDAE													
115. *Chanda nama* Ham.-Buch.	-	+	-	-	-	-	-	+	-	-	-	-	-
116. *C. raga* Ham.-Buch.	-	+	-	-	-	-	-	+	-	-	-	-	-
FAMILY: NANIDAE													
117. *Nandius nandius* (Ham.-Buch.)	+*	+	-	-	-	-	-	+	-	-	-	-	-
118. *Badis badis* (Ham.-Buch.)	+	+	-	+	-	-	-	+	-	+	-	-	+
FAMILY: MUGILIDAE													
119. *Rhinomugil corsula* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	+

120. *Sicamugil cascasia* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	+
FAMILY: GIBIINDAE													
121. *Glossogobius gutum* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	-
122. *G. giuris* (Ham.-Buch.)	-	+*	-	-	-	-	-	-	-	-	-	-	+*
FAMILY: ANABANTIDAE													
123. *Anabas testudineus* (Bloach)	-	+	-	-	-	-	-	+	-	-	-	-	+
FAMILY: BELONTIIDAE													
124. *Colisa fascitus* (Schneider)	+*	+	-	-	-	-	-	+	-	-	-	-	+
125. *C. lalia* (Ham.-Buch.)	-	-	-	-	-	-	-	+	-	-	-	-	+
FAMILY: OSPHRONEMIDAE													
126. *Osphronemus goramy* Lacepede **(EX)**	+	-	-	-	-	-	-	-	-	-	-	-	-
FAMILY: CHANNIDAE													
127. *Channa gachua* Ham.-Buch.	+	+	-	+	-	+	+	+	+	+	+	+	+
128. *C. marilius* Ham.-Buch.	-	+	-	-	-	-	-	+	-	-	-	-	-
129. *C. punctatus* Bloch	+	+	-	+	-	-	-	+	-	-	-	-	+
130. *C. straitus* Bloch	-	+	-	-	-	-	-	+	-	-	-	-	+
ORDER: SYNBRANCHIFORMES													
FAMILY: MASTACEMBELIDAE													
131. *Macroganathus pancalus* Ham.-Buch.	+	+	-	+*	-	-	-	+	-	-	-	-	+
132. *Mastacemblus armatus* (Laceped)	+	+	+	+	+	+	+	+	+	+	+	+	+
TOTAL	**81**	**75**	**29**	**59**	**29**	**35**	**37**	**101**	**36**	**32**	**32**	**34**	**73**

+: PRESENT; -: ABSENT; *: NEW RECORD
TH: THREATENED (Endangered; As per CAMP, Assesment-1998; 10 Species; 7.5%)
EN: ENDEMIC (11 Species; 8.3%)
EX: EXOTIC (10 Species; 7.5%)

On the basis of fish catch the dominant species in upper region (hill area) are *Schizothorax* spp. (which forms appox. 60% of fish catch) followed by *Glypotothorax* spp., *Noemachilus* spp., *Garra* spp. and allied species *etc*. While in plain areas dominant species are *Barilius* spp. (which form 40% of fish catch) *Puntius* spp., *Lepidocephalus* spp., (which forms 60% of fish catch) followed by *Tor* spp., *Puntius* spp., *Channa* spp., *Labeo* spp and allied species spp., *etc*., (Table-2).

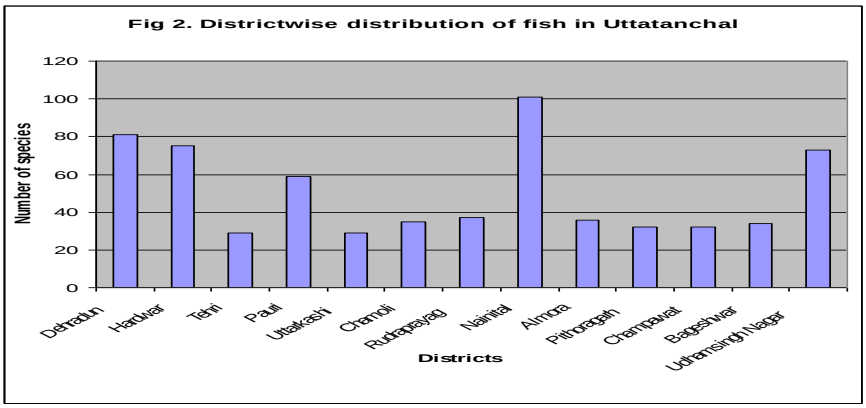

Table. 2. Fish catch Percentage in Uttarakhand (Calculated on the bases of catch and interviewing the local fisher men)

S.No.	Species	Percentage (%)	
		Hills	Plains
1	*Barilius spp*	05	40
2	*Schizothorax spp.*	60	-
3	*Tor spp.*	05	10
4	*Puntius spp.*	02	10
5	*Garra spp.*	05	02
6	*Labeo spp.*	01	05
7	*Neomachils spp.*	05	02
8	*Glypothorax spp.*	10	02
9	*Channa spp.*	-	05
10	*Mystus spp.*	-	02
11	*Mastercembalus spp.*	01	05
12	*Allied Species (Clarius, Ompok, Heteropneustes, Wallago, Xenentodon, Lepidocephalus, Badis etc.)*	06	17
	Total Catch in Percentage (%)	**100**	**100**

The present observation is in agreement with the findings of Nautiyal *et al*. (1990), Johal (2002), Uniyal (2002, 2009) and Uniyal and Kumar (2006). The altitudinal and longitudinal zonation of rivers reveal that the fish assemblage is more at the confluence of river as the water is more at that point and less at the origin as water velocity is fast there. The present finding is supported by the Pardhasaradhi *et al*. (1984), Edds (1989, 1993), Nautiyal (2001), Johal and Rawal (2005), Mehta & Uniyal (2005), Uniyal (2010) and Nautiyal *et al.* (2013). Fish culture is an important aspect for the economic development of the area. In Uttarakhand also fishery can be developed as it harbors good commercially important fishes. As per catch percentage the fish which can be propogated at

high altitude is *Schizothorax* spp., and *Glyopothorax* spp.) and in plain area the fishes like *Barilius* spp., *Tor* spp., *Channa* spp., and *Clarius* spp. can be cultured. Although exotic species can also be used for this purpose but it should not be mixed with natural water body , as it grows at very fast rate and adversely affect the native fish, the same observations has been made by Sharma (1993), Sunder (1995), Gadgil *et al.* (2001) Uniyal (2006) and Uniyal and Mehta (2006), Uniyal & Uniyal (2010). Fishery can be developed only when the fish are well conserved. In Uttarakhand suitable steps should be taken to conserve the fish (most of the fishes are in endangered category like *Tor* spp., *Raiamas bola*) by involving the locals as well as Government and Non Government organizations. The similar observations has been made by Das and Nath (1988), Nautiyal *et al.* (1990), Bahuguna et al. (2001), Sharma (2003), Johnsingh *et al.* (2006), Uniyal *et al.* (2006) , Bhatt *et al.* (2016), Rana *et al.* (2017) from different parts of the Uttarakhand.

Conservation and Management of fish resource of Uttarakhand:

Conservation and management is an important tool to preserve the nature for maintaining the ecological balance, which is foremost essential for the survival of human kind. In past, the reference of animal and plant conservation is found in Vedas and linked with Hindu religion and culture (Hora1952, Krishna 2000, Gadgil et al. 2001, Kothari 2001, Kothari & Singh 1994, Maitland 1993, Uniyal 2002, Johnsingh *et al.* 2006, Sarkar *et al.* 2008, Agrawal and Singh 2009 and Uniyal & Uniyal 2010). After the careful observation and constant monitoring of water bodies and fish fauna of Uttarakhand, some major factors responsible for the depletion of fish resources has been listed out as follows:

Factors affecting (Threats) fish resources of Uttarakhand:

1. Over exploitation of fish fauna: It was observed that main reason of over exploitation of fishes was extensive use of unscientific methods of fishing *i.e.* Dynamiting, hammering, bleaching powder and Ichthyotoxic plants. These methods adversely effect the population of Juvenile as well as brooder fishes, aquatic biota, water quality and human health (by consuming polluted water and fish). Now the situation is alarming as the catch percentage, size and diameter of fishes is decreasing drastically. These methods are also affecting the breeding of fishes, which are resulting the decreasing fecundity rate.

2. Lack of policy/law implementation: In Uttarakhand state fishing activities are not well organized and it is required that time to time checking should be done, yet no license have been issued to the villagers, and law is not strictly followed which result in the destruction of fish and their habitat. There is no check on daily catch, size of fish and mesh size of nets, by which even the Juvenile fishes get killed which adversely affect the population.

3. Deforestation, soil erosion and siltation: Due to excessive deforestation on the bank of

river the problem of soil erosion and siltation is increasing as a result water level is decreasing, which adversely affect the fish population.

4. Destruction of spawning ground: Usually the game fishes *i.e. Tor* spp. and *Labeo* spp. *etc*. migrate into the small stream or tributary for breeding purpose, so that young ones can grow in safe place. Big boulder or pebbles act as a breeding ground for them, but indiscriminate extraction of building material , as well as big logs thrown in the river results in destruction of breeding ground, which adversely affect the population and create a threat for future generation .

5. Pollution in water bodies: In one and half decade, Uttarakhand attracted a good numbers of industries mainly in (Dehradun, Udham Singh Nagar and Hardwar), which adversely effecting the water quality of the rivers, as industrial effluents is mostly introduced in the riverine ecosystem either directly or indirectly. Secondly the domestic garbage, solid waste, sewage disposal, pesticides and insecticides used in agriculture fields are thrown into the rivers. All these waste carry non-biodegradable component, which result in the decreased oxygen percentage and cause mass mortality of fishes, which is another serious threat to the fish fauna of the state.

6. Weed infestation: The weed infestation (unwanted plants and animals) in water bodies (mainly in Asan Conservation Reserve (Ram sar Site) & Jhilmal tal Conservation Reserve, Bhimgoda *etc*.) is another serious problem. It increases the turbidity and decreases the oxygen percentage of the river, resulting in the fish mass mortality, which creates an imbalance in the population structure of the fishes.

7. Introduction of the exotic species: The exotic fishes (fishes introduced form outside the country) are introduced for various purposes. Usually exotic species grow faster than native species and adversely effect their population and growth.

8. Migration problem due to River Valley Projects (Construction of dams): The construction of dam adversely effects the migration of fishes which result in destruction in breeding and spawning. In Uttarakhand number of mega river valley projects have been proposed (Tehri, Dhauli and Gauri ganga, Chibbro, Chila *etc*.).Due to construction of these dams the migration route of migratory fishes (*Tor* spp.and Labeo spp.) gets adversely affected, which decrease their fecundity rate and population dynamics, which is a big challenge for their survival. And due to this reason the famous game fish Mahseer listed as endangered. These dams also result in destruction of habitat of fishes, however the effective fish ladder / path to be constructed in every dams, so that migratory fish can freely migrate for spawning.

9. The fishing festival - Maund: Maund - fishing festival celebrated in various region of Garhwal Himalaya. It is celebrated onset of monsoon when fishes migrate for breeding. In this festival male of near by villages gather on the bank of river and throw quintals of "Timur powder" (*Zanthoxylum armatum*) which carry

toxic substance, Bhatt and Fraswan (1992) in the river and kill number of fishes (Juvenile and brooders) aquatic insect and plants. It is practiced in Garhwal region every year due to which a lot of fishes die. It is important to find out the eco-friendly path to celebrate the festival (Uniyal, 2002).

10. Climate Change (Cloud-burst & Flash-flood): Cloud burst and flash flood is quite common in hill regions of Uttarakhand, which increases the siltation and wipe out the aquatic life, due to which fishes get adversely affected.

11. Unawareness among masses: The most important cause of destruction of fishes of Uttarakhand state is unawareness among masses and unplanned developmental activities on rover banks, which adversely effects the habit and habitat of fishes.

The above-mentioned points are the important factors for the destruction of fish fauna of Uttarakhand. Some mitigation measures have been suggested, which are as follows

Mitigation measures for the Conservation and Management of fish fauna in Uttarakhand:

1. Reforms in Laws and strict implementation: Uttarakhand state, it is necessary revive the policies/laws for the conservation of fishes in light of current situation, the laws made previously were ineffective. It is important to make strict laws by state fishery department/Forest department and their implementation should be done seriously to avoid illegal fishing. Daily catch should be fixed along with the size of fish and nets (traps) so that indiscriminate killing of fishes can be stopped.

2. Fishery status: For proper planning and management, it is foremost important to know the exact fishery status of concerned area on the bases of IUCN guidelines (1994), (extinct, critically endangered, venerable, rare, low risk, data deficit) for the formation of action plan to check the depletion of fish. It has been observed that the catch percentage, size, length and weight of *Tor* spp., *Labeo* spp., *Raiamas bola etc*. are decreasing at alarming rate, therefore, it is necessary to check the status of these species.

3. Fishes should be included in Acts: Conservation programmes can not be successful until endangered fishes are not included in the acts *i.e*. Wildlife Protection Act 1972, Amended 1995, Fishery Act of India 1897 (Modified 1957) and Red Data Book (ZSI, 1994). Fishes are not included in any of the acts. For conservation of fishes on the verge of extinction, they should be included, in the acts so that nationwide campaign could be launched to check there further depletion.

4.Unscientific methods should be banned : All unscientific methods of fishing *i.e.* (indiscriminate killing of large number of fishes, Juvenile as well as brooder fish, which adversely affect the population of fish as well as water quality)i.e. Dynamiting, Ichthyotoxic plant, Electric current, Hammering, Bleaching powder, should be banned and fine should be imposed on the guilty.

5. Planning and policy for sustainable use of fish resources: Proper scientific planning and

policy should be adopted for the sustainable development of fish resources of the state, so that fishery activities can be linked with economic benefits of the people of the state.

6. Pre and post impoundment study of river valley projects: It is necessary to study the pre and post impoundment study of river valley projects. So that clear cut measure can be taken for sustainable development of fisheries. Due to river valley projects the migration phenomena of migratory fish get adversely affected. Although the concept of the fish path and fish ladder is used but it was observed that with thorough experiments and trails the migration problem can be minimized.

7. Paddy culture or sera culture: In hilly area of state the paddy fields are called "sera", these are situated on the bank of river/hillstream and receive constant water supply. In these seras fish fauna can be cultured. It can be an alternative source of economy to people.

8. Afforestation along river side: Afforestation should be done on the river banks, so that problem of soil erosion, siltation can be solved. Trees like *Oak, Rhododendron, Shoria, Dalbergia* etc. having high water retaining capacity should be planted, in order to increase the water level, oxygen level and it also provides an ideal habitat for fishes to flourish.

9. Conservation of spawning ground: For the development of fishery, it is important to protect the spawning ground of fishes, so that fish can breed freely. Constant vigilance should be done by Fishery department/Forest department by deputing guard.

10. Weed control: Another important aspect for fish conservation is to control the weed (unwanted plants), which cause mass mortality. A routine cleaning of different water bodies is required, so that fishes may grow.

11. Pathology centre: Author came across fish *i.e. Schizothorax richardsonii* suffering from "Black spot" diseases number of times, which shows the presence of disease among fishes. It is important to monitor the fish stock routinely so that mass mortality may not occur. Fish pathology centre should be established at district level for monitoring of water bodies of the state.

12. Water quality assessment laboratory: It is very important to establish Water quality assessment laboratory in every district, so that regularly water quality assessment can be done and proper measure can be taken to monitor the health of particular aquatic ecosystem.

13. Introduction of exotic fishes: Exotic fishes should be introduced only after thorough assessment. If found suitable with minimum ecological risk, than only it should be introduced otherwise exotic fishes grow at faster rate then native species and adversely effect their abundance.

14. Close season: During breeding season, fishing activity should be banned (July - October) so that fishes can breed freely and the brooder fish can be protected.

14. Aquaculture, establishment of hatcheries and training centers: For economic development of newly formed state

Uttarakhand it is necessary to exploit the fishery resources (aquaculture), which can generate employment for people of the region. For this it is foremost important to establish the hatcheries and train the people about new methods of fish culture. In this direction important fishery research centre like Pant Nagar Agriculture University, Pant Nagar and Cold Water Fishery Research Institute, Bhimtal can play an important role.

15. *In situ* conservation: It refers to conserve the animals and plants in their natural habitat by providing ideal habitat to grow. In case of fishes *in situ* conservation can be done by establishing fish sanctuaries/reserve area. In Uttarakhand various fish sanctuary can be established in Protected Areas (PA'S) for the protection of fishes.

16. *Ex situ* conservation: It refers to conservation of plants and animal in laboratory by storing genetical material by establishing "Gene Bank". The methods adopted for this is cryopreservation of sperms, eggs or embryos and storage of cells cultures. In Uttarakhand, presently, Cold Water Fishery Research Institute, Bhimtal has done efforts for the conservation of endangered Mahseer fish and good results have been achieved. Such laboratory can be established in other place also.

17. Eco-tourism by angling: Angling can be of immense help in promoting tourism in the state. As it attracts lot of foreigners (angling activity like catch and released should be encouraged) and area like Dakpathar, Corbet Tiger Reserve (CTR), Nayar valley, Biyas ghat are suitable for this purpose. As these activities increases the understanding of conservation among masses and also generates the revenue.

18. Mass awareness : The most effective way to conserve the fish fauna of both the rivers is to educate the masses at different levels *i.e.* village, block, school, College etc. by organizing seminars, video show, distributing poster, sticker with slogan for conservation, folks songs and excursion. So that they can understand the importance of fish conservation.

Above mentioned recommendations are useful for the development of aquaculture and conservation of fishes in Uttarakhand state.

In order to strengthen the further research in Fishery Science the modern tools and technology like Remote Sensing and Geographical Information Studies can be integrated with basic research, so that habitat suitability modeling can be develop for better management and effective policy planning . The long term monitoring projects should be incited (Multi-intuitional) to understand the impact of climate change on aquatic ecosystems. It is equally important to monitor / revisit the various aquatic ecosystem to understand the health of water resources and to know the status of fishes. Besides this taxonomy and ecological studies of fragile ecosystem to be conducted on regular bases to have current update baseline data up to species level for proper management.

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