



Distribution, endemism and threat status of freshwater fishes in the Western Ghats of India

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ABSTRACT

Aim To study (1) the large-scale distribution patterns of freshwater fishes in the Western Ghats of India; (2) the endemism and uniqueness of the fishes in various zones; and (3) the threat status of fishes by categorizing them under low risk (LR), vulnerable (VU), endangered (EN) and critically endangered (CR).

Location The Western Ghats of India.

Methods The scientific literature describing the freshwater fishes of the Western Ghats was reviewed. Data describing the lists of the species were extracted and compiled. The species accumulation curve was plotted using Michaelis–Menten-like equation. The Western Ghats was divided into six zones and similarity of the species was calculated using Jacquard's index.

Results Literature to date records 288 species belonging to 12 orders, 41 families and 109 genera, of which 118 species are endemic and 51 are unique. However, the species accumulation curve shows that there might be 345 species in this region, indicating that 16% species have not been recorded to date. An analysis of the distribution pattern of fishes in the Western Ghats suggests that the southern region is more diverse than the northern and central regions. The southern region shows high endemism and high uniqueness while the northern region shows high endemism but less uniqueness. The similarity index between the zones indicates that as the distance between the zones increases similarity decreases. The status of 105 of 288 species was not known due to data deficiency but among the remaining 183 species, 58 species were categorized as LR, 41 as VU, 54 as EN, 24 as CR while the remaining six species were introduced.

Conclusions The distribution patterns of fishes in the Western Ghats are discussed in accordance with the geography of Western Ghats, its climatic conditions and 'Satpura Hypothesis'. The threat status of fishes found in Western Ghats suggests that at least 41% of fish fauna is threatened by either being VU, EN or CR. Implication of potent conservation measures is necessary to conserve the fish fauna of Western Ghats.

Keywords

Western Ghats, fish fauna, diversity, distribution, endemism, threat status, conservation.

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INTRODUCTION

Approaches for setting conservation priorities are becoming a matter of concern as the accelerating and potentially catastrophic loss of biotic diversity, unlike other environmental threats, is irreversible (Mittermeier *et al.*, 1998). The Western Ghats of

India is considered as one of the 25 global biodiversity hotspots owing to its concentration of endemism (Myers *et al.*, 2000). The biodiversity of the Western Ghats is under threat owing to deforestation (Myers, 1990), which not only contributes to loss of timber but also has a severe environmental impact on soil water quality and even local climate (Repetto, 1990).

It is difficult to select a precise site for planning and policy-making aimed at biodiversity conservation. As biodiversity is rooted in place, the task of conserving biodiversity should target places for conservation, and as it is impracticable to conserve everything, prioritization is essential. Without a precise measure of biodiversity, relative estimates of similarity or differences, derived using partial measures, can be used for area prioritization (Sahotra & Margules, 2002). Effective action in this context calls for an understanding of how biodiversity is distributed and maintained, in particular, within the species-rich tropical forest region that are being rapidly depleted (Daniels *et al.*, 1992). Limited information is available on these issues, much of it from investigation in a few localities on only a few taxa.

In a recent investigation Myers *et al.* (2000) have suggested conservation priorities based on plant and animal species endemism deliberately excluding fishes owing to poor data. The present study deals with latitudinal distribution, diversity, endemism and threat status of freshwater fishes in the Western Ghats. Such studies will help understand the large-scale distribution patterns over these mountain ranges and the processes underlying ongoing changes in these patterns.

Western Ghats

The Western Ghats is a mountain chain running north–south parallel to the western coast of India. It runs rather continuously between 8 and 21° N latitudes, covering a distance of *c.* 1600 km, being interrupted just once by a 30-km wide Palghat gap at around 11° N (Fig. 1). The narrow coastal strip that separates the hill chain from the Arabian Sea in the west varies in width from 30 to 60 km, the narrowest being between 14 and 15° N. Hills are generally of elevations between 600 and 1000 m. However, there are higher hills of 1000–2000 m between 8 and 13° N and 18–19° N. Peaks over 2000 m are found only in the Nilgiris, Palanis and Anamalais. The Nilgiris and Palanis are spurs from the main hill chain, which extend the Western Ghats eastwards to *c.* 78° E.

From the Western Ghats originate *c.* 38 east-flowing and 27 west-flowing major rivers. The west-flowing rivers originate in the Western Ghats and drain into the Arabian Sea while the east-flowing rivers merge into one of the three major river systems – Cauvery, Krishna or Godavari – before they drain into the Bay of Bengal. Annual rainfall on the Western Ghats averages 2500 mm. (In certain places like Agumbe, between 13 and 14° N, rainfall exceeds 7600 mm.) The Western Ghats receives much of its rain from the south-west monsoon. Hence the wettest season generally lies between June and October. The rainy season in the southern latitude is however often prolonged locally due to pre-monsoon and winter showers. Thus the dry periods in parts of the Western Ghats south of 13° N are the shortest (2–5 months) while in the north it varies from 5 to 8 months. Mean temperature ranges between 20 and 24 °C. However, it frequently shoots beyond 30 °C during April–May (summer) and sometimes falls to 0 °C during winter in the higher hills.

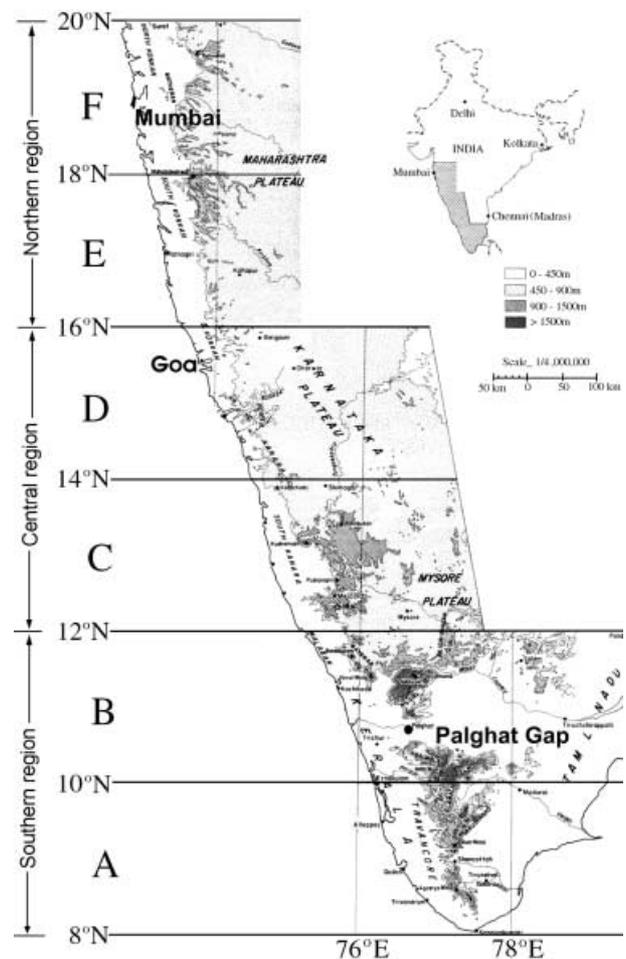


Figure 1 Major physiographical units of the Western Ghats. Map adapted from Samant *et al.* (1996).

METHODOLOGY

Data on the fish fauna of the Western Ghats are quite scattered in the literature. Our study makes use of the work by Ajitkumar *et al.* (2000), Annandale (1919), Bhat (2002), Bhimachar (1945), Bhimachar & Subbarau (1941), Easa & Shaji (1996, 1997), Frazer (1942a,b), Ghate & Wagh (1991, 1995, 2003), Hora (1921, 1937, 1942), Hora & Misra (1937, 1938, 1942), Indra & Rema Devi (1981), Jayaram (1981a,b), John (1936), Johnsingh (2001), Kalawar & Kelkar (1956), Kharat *et al.* (2000, 2003), Menon & Rema Devi (1992), Mukerjee (1931), Perthiyagoda & Kottelat (1994), Rajan (1955), Rao & Shachar (1927), Rema Devi & Indra (1984, 1986), Samant (1990), Sarkar & Yadav (1996), Shaji & Easa (1995a,b, 1996–97, 1998), Shaji *et al.* (1995, 1996), Silas (1950, 1951, 1952, 1953), Singh & Yazdani (1988, 1991), Spence & Prater (1932), Suter (1944), Tilak (1972), Tilak & Tiwari (1976), Tonapi & Mulherkar (1963), Wagh (1999), Yadav (1996, 1997, 2000a), Yazdani & Mahabal (1978), Yazdani & Singh (1990) and Yazdani & Yadav (1995). The taxonomic status of the fishes has been adopted mostly from Talwar & Jhingran (1991).

To estimate the number of species that are yet to be recorded from Western Ghats, we plotted a species accumulation curve. We considered one paper as one sample unit. Papers were selected randomly and the cumulative number of species was plotted against each sampling unit. This procedure was repeated nine times, each being randomized independently. To the scatter of points thus obtained, we fitted a Michaelis–Menten-like equation,

$$S = S_{\max}N/(K_m + N),$$

where S is the number of species, N the sampling unit, S_{\max} the maximum number of species that could be present and K_m the Michaelis–Menten constant.

We divided Western Ghats into divisions of 2° latitude (c. 222 km) to study the distribution patterns of fishes (Fig. 1). The number of species in each zone, their endemism at Western Ghat level and uniqueness at zonal level was determined by preparing the table containing species and its presence in zone (Appendix). We grouped the $8\text{--}12^\circ$ N extent of the Western Ghats as the southern region, $12\text{--}16^\circ$ N as the central region and $16\text{--}20^\circ$ N as the northern region (Fig. 1).

Endemism was considered at two levels: fishes endemic to Western Ghat were termed as endemic species while species confined to any of the six zones were identified as being unique, i.e. found only in concerned zone.

Similarity of the species in the zones was calculated using Jacquard's index:

$$S_j = j/(x + y - j),$$

where S_j is the similarity between any two zones X and Y , j the number of species common to both the zones X and Y , x the total number of species in zone X and y the total number of species in zone Y .

The threat status of fish was adapted from Ajitkumar *et al.* (2000), BCPP Camp workshop on freshwater fishes of India (1997) and Shaji & Easa (1998).

RESULTS

Literature to date records 288 species from the Western Ghats. The species accumulation curve (Fig. 2), however, shows that there might be 345 species in this region.

Species diversity

The recorded 288 fish species belong to 12 orders, 41 families and 109 genera (Appendix and Table 1). Cyprinidae is the most abundant family, contributing 45% of the fish fauna of the Western Ghats. Loaches, of the family Balitoridae, are second most abundant with 9% of the total species.

Cypriniformes is the most predominant order, contributing to 57% of fish species, followed by Siluriformes with 18% (Table 1).

Forty-two of 288 species (15% of the total) are secondary freshwater fishes (capable of adapting to both fresh and marine habitats) of which 15 (5% of the total) are diadromous (having

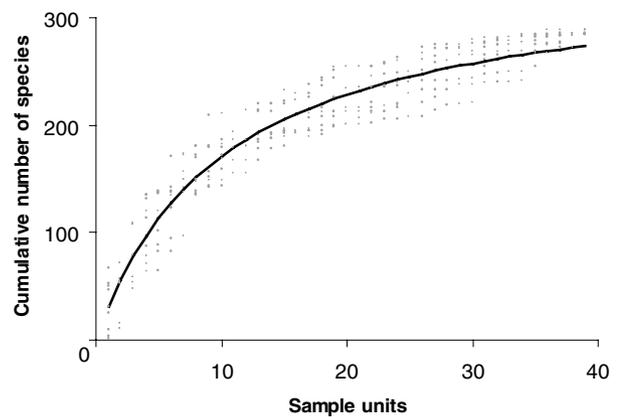


Figure 2 Species individual curves for Western Ghat freshwater fish species. A Michaelis–Menten equation $S = S_{\max}N/(K_m + N)$, where S is the number of species, N the year, S_{\max} the maximum number of species that could be present and K_m the Michaelis–Menten constant, was fitted to the data. Estimated parameters for best fit Michaelis–Menten equation in this case were: $S_{\max} = 345.1$, $K_m = 10.2$ ($r = 0.9595$, $P < 0.001$).

part of their life cycle in the marine and part in freshwater habitats).

Distribution, endemism and uniqueness

Appendix suggests that 22 species are distributed all over the range of Western Ghats of which three are endemic. Of 288 species 118 are endemic, which includes 51 unique species.

Endemism and uniqueness is very high in zone B. The southern region is high in endemism and uniqueness; the northern region is comparatively low, while the central region is the least (Table 2).

The dendrogram (Fig. 3) suggests that similarity between fish species decreases as the distance between the zones increases. Figure 3 also depicts that there is more similarity between zones C, E and F while zones A and B are less similar to others. Zone D is quite isolated from the remaining zones.

Threat status

We have divided the threat status of fish species in the Western Ghats into four categories: low risk (LR), vulnerable (VU), endangered (EN) and critically endangered (CR) (Appendix). The status of 105 species was not known due to data deficiency (DD) but among the remaining 183 species, 58 species were categorized as LR, 41 as VU, 54 as EN, 24 as CR while the remaining six species were introduced (Appendix).

DISCUSSION

Data on the fish fauna of the Western Ghats are limited and subject to different sampling efforts. From the species accumulation curve (Fig. 2) we predict that 345 species may be present in the Western Ghats. The major

Table 1 Fish diversity in the Western Ghats.

Order	Family	Genera	Species	
Osteoglossiformes	Notopteridae	1	2	
Elopiformes	Megalopidae	1	1	
Anguiliformes	Anguillidae	1	2	
Clupeiformes	Clupeidae	2	3	
Cypriniformes	Cyprinidae	27	129	
	Parapsilorhynchidae	1	3	
	Balitorinae	5	26	
Siluriformes	Cobitidae	3	5	
	Bagridae	6	20	
	Siluridae	3	6	
Cyprinodontiformes	Schilbeidae	5	7	
	Pangasidae	1	1	
	Sisoridae	4	13	
	Clariidae	2	4	
	Heteropneustidae	1	1	
	Hemiramphidae	2	3	
	Belontiidae	1	1	
	Oryziatidae	1	1	
	Horachthyidae	1	1	
	Cyprinodontidae	1	1	
Syngnathiformes	Aplocheilidae	1	3	
	Poeciliidae	3	3	
Syngnathidae	2	2		
Synbranchiformes	Synbranchidae	1	3	
Perciformes	Ambassidae	4	8	
	Lutjanidae	1	1	
	Haenulidae	1	1	
	Sciaenidae	1	1	
	Scatophagidae	1	1	
	Nandidae	3	4	
	Cichlidae	2	3	
	Mugilidae	4	4	
	Bleniidae	1	2	
	Gobiidae	7	9	
	Anabantidae	1	1	
	Belontiidae	1	1	
	Osphronemidae	1	1	
	Channidae	1	5	
	Mastacembelidae	2	3	
	Pleuronectiformes	Soleidae	1	1
	Tetraodontiformes	Tetraodontidae	1	1
Total: 12	41	109	288	

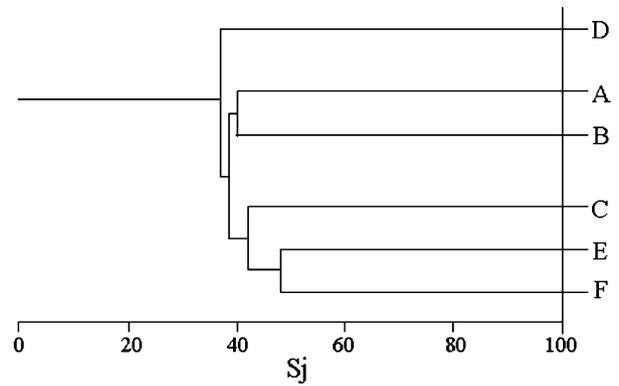


Figure 3 Dendrogram of the relationship among various zones drawn from similarity of fish species. The similarity seems to be decreasing, as the distance between the zone increases. Zones A and B seem to be isolated from the other zones. Zones C, E and F form one cluster while D is quite isolated from the other zones. This could be due to the difference in sampling efforts as discussed in the text.

contribution of the new records of fish species would be from zones C and D mainly, as, these zones are widespread, relative to zones A and B, and they are less studied. Furthermore, recent demonstrations of new species like *Osteocheilus (Osteochlichthys) longidorsalis*, *Travancoria elongata*, *Garra surendranathinii*, *Horabagrus nigricollaris* (Perthiyagoda & Kottelat, 1994; Shaji *et al.*, 1996) from zone B and *Parabatassio sharavatiensis* (Bhat, 2002) from zone D probably suggest that these zones may contribute both unrecorded species as well as new species.

Due to differences in sampling efforts the dendrogram (Fig. 2) shows complete isolation of zone D from the rest of the zones. The major reason is the fact that in zone D the rivers monitored are mainly the west-flowing rivers. A study by Easa & Shaji (1997) shows that there is a difference of c. 60% in the species composition in east-flowing and west-flowing rivers.

Another problem with assessment of fish diversity and distribution in the Western Ghats resides in taxonomic uncertainties in nomenclature, which has been very well documented by Daniels (1997). We tried to overcome this

Zone	Latitude (° N)	Families	Genera	Species	Endemic* species (%)†	Unique‡ species (%)†
A	8–10	25	53	103	43 (41.7)	12 (11.7)
B	10–12	29	65	136	64 (47.1)	19 (13.9)
C	12–14	22	53	126	45 (35.7)	4 (3.2)
D	14–16	29	65	111	35 (31.5)	3 (2.7)
E	16–18	19	51	90	22 (24.4)	2 (2.2)
F	18–20	27	59	137	41 (29.9)	11 (8.0)

*Endemic to the Western Ghats.

†Percentage out of total species found in the zone.

‡Endemic to zone.

Table 2 Latitudinal distribution of fishes.

problem by adapting the taxonomic status from Talwar & Jhingran (1991). Despite such limitations conclusions can be drawn on a broad spectrum.

The most well-recognized pattern in the global distribution of biological diversity shows that the tropics at lower latitudes harbour relatively more species per unit area (Gaston, 2000). In the Western Ghats amphibian and angiosperm distribution shows that the southern region is rich in species than the central and northern regions (Daniels, 1992). A similar zoogeographical distribution pattern can be observed in freshwater fishes of the Western Ghats. Unlike the southern region, the central and northern regions show low uniqueness (Table 2). This may be due to the fact that the rivers in these zones are ultimately connected to one of the three major river systems – Godavari, Krishna or Cauvery, making dispersal of the species more easier. However, the southern region rivers are not connected extensively to the rivers in the central and northern region causing dispersal of the species restricted only to the southern region. The southern region is isolated from the remaining zones by the Palghat gap (11° N latitude). Bhimachar (1945) and Silas (1951) have discussed the importance of Palghat gap as a barrier for the distribution of hill stream fishes in the Western Ghats as it hampers their migration.

The seasonal rain pattern in the Western Ghats shows a longer dry period as we go from 8 to 21° N latitude. The southern region is dry for 2–3 months, the central region for 4–5 months and the northern region for 5–8 months (Daniels, 1992). Thus streams in the southern region persist for longer duration. Variation in dry period can be one of the possible factors for a distinct distribution pattern among the hill stream fishes. Distribution of the major hill stream fishes, loaches (Family: Balitoridae), mainly in the southern region supports this prediction (Appendix).

Genera like *Puntius*, *Mystus*, etc. show widespread distribution whereas *Parapsilorhynchus*, *Homoleptera*, *Travancoria* and *Rita* are restricted. The 'Satpura Hypothesis' proposed by Hora (1949) predicts distribution of fish fauna of the Western Ghats and its endemism. During the Miocene epoch freshwater fishes from Malayan Peninsula spread through the Satpura hill ranges and reached the Western Ghats. During that period the Western Ghats was continuous with Sri Lanka (then Ceylon). Eventually, Sri Lanka separated from India but dispersal of fishes from Malaya to the Western Ghats continued. Development of the Palghat gap isolated the southern region from rest of the Western Ghats and nested the fish fauna of the southern region. In later years evolution of fishes in the southern region led to high endemism. Furthermore, the Palghat gap created a barrier for movement of fish species and the uniqueness of this region increased (Table 2). At the same time species in the northern and central regions also evolved. However, the continuity between these two regions allowed dispersal of species possible leading to low uniqueness. This also explains the pattern of species similarity between the six zones (Fig. 3).

The contribution of 'Satpura Hypothesis' to the distribution of hill stream fishes like loaches can be well illustrated in the following example. The genus *Homoleptera* is supposed to be one of the migrants from Malaya to the Western Ghats. On reaching the central region of the Western Ghats, it formed a better adapted genus *Bhavana*. *Homoleptera* and *Bhavana* migrated further south. *Travancoria* is suspected to be a further attempt of speciation from *Homoleptera* (Silas, 1951). The absence of these genera in the northern region could be due to the fact that most of the fauna of this region got destroyed due to volcanic eruptions (Bhimachar, 1945). This depicts the distribution of *Homoleptera*, *Bhavana* and *Travancoria* only in the central and southern regions (Appendix). In conjunction with the Satpura Hypothesis, this pattern of distribution of the loaches is likely to be an outcome of the palioendemism and neoendemism hypothesis proposed by Mora *et al.* (2003).

Besides geography, climatic conditions and history, the distribution of fishes are also dependent on life history, as diadromous fishes spend a fraction of their life cycle in the rivers and streams and another fraction in the sea. As the western slopes of the Western Ghats are aligned with the coastal region, some secondary freshwater fish species are part of the Western Ghats fish fauna and of these few are even diadromous (Appendix). However, as the number of diadromous fish species is relatively low there is no significant difference in the Jacquard's similarity index between zones (correlation coefficient, $r = 0.9946$, $P < 0.001$) either including or excluding diadromous species. A problem in discussing the distribution of the fish species in relation to life history resides in the fact that very few studies have been carried out on the life history of fishes and restricted to a few species.

The northern region of the Western Ghats contains *c.* 80 species of food fishes, 25 species of aquarium fishes and 32 species of larvivorous fishes (Yadav, 1997). Sarkar & Yadav (1996) have suggested the value of these 32 larvivorous species for biocontrol of malaria. Such natural wealth is under threat from various human impacts including pollution, heavy harvest, construction of dams and introduction of exotic fishes (Yadav, 1997; Kharat *et al.*, 2000, 2003; Dahanukar *et al.*, 2001).

The threat status of fishes in the Western Ghats suggests that nearly 41% of the fish fauna is threatened, being either VU, EN or CR. Conservation measures for protecting the fish fauna of the Western Ghats are thus essential. Yadav (1997, 2000b,c) and Kharat *et al.* (2000) suggest certain conservation measures including formation of fish sanctuaries, construction of fish ladders in dams, *in situ* conservation (conserving species within the habitat), *ex situ* conservation (conserving species outside the habitat), avoiding pollution of the water bodies, halting siltation, minimizing harvest and exploring check on the growth of exotic species, which can minimize the catastrophic loss of fish species from the Western Ghats.

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BIOSKETCHES

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Appendix Distribution and status of freshwater fishes in the Western Ghats of India.

Family/species*	Zones†						Status‡	Remark
Notopteridae								
<i>Notopterus chitala</i> (Hamilton–Buchanan)	–	–	–	–	–	F	EN	
<i>N. notopterus</i> (Pallas)	–	B	C	–	–	F	LR	
Megalopidae								
<i>Megalops cyprinoides</i> (Broussonet)	–	–	C	D	–	–	DD	s, d
Anguillidae								
<i>Anguilla bengalensis bengalensis</i> (Grey)	A	B	C	–	E	F	EN	s, d
<i>A. bicolor bicolor</i> (McClelland)	A	B	–	–	–	–	EN	s, d
Clupeidae								
<i>Hilsa (Tenuulosa) ilisha</i> (Hamilton–Buchanan)	–	–	C	–	–	–	VU	s, d
<i>H. (Hilsa) kelee</i> (Cuvier)	–	–	–	D	–	–	DD	s, d
<i>Dayella malabarica</i> (Day)	A	B	–	–	–	–	LR	e
Cyprinidae								
<i>Catla catla</i> (Hamilton–Buchanan)	A	B	C	–	E	F	VU	
<i>Cirrhinus cirrhosus</i> (Bloch)	–	B	C	–	–	F	VU	
<i>C. fulungee</i> (Sykes)	–	–	C	D	E	F	LR	e
<i>C. mrigala mrigala</i> (Hamilton–Buchanan)	A	–	–	–	E	F	LR	
<i>C. reba</i> (Hamilton–Buchanan)	–	B	C	–	E	F	VU	
<i>Ctenopharyngodon idella</i> (Valenciennes)	–	–	–	–	–	F		Intr.
<i>Cyprinus carpio comminus</i> Linnaeus	A	B	–	D	–	F		Intr.
<i>Gonoproktopterus curmuca</i> (Hamilton–Buchanan)	A	B	C	D	–	–	EN	e
<i>G. dubius</i> (Day)	A	B	–	D	–	–	EN	e
<i>G. kolus</i> (Sykes)	–	B	C	D	E	F	EN	e
<i>G. lithopidos</i> (Day)	A	–	–	D	–	–	EN	e
<i>G. micropogon</i> (Valenciennes)	A	B	C	–	–	–	EN	e

Appendix continued.

Family/species*	Zones†						Status‡	Remark
<i>G. thomassi</i> (Day)	–	–	C	–	–	F	EN	e
<i>Labeo ariza</i> (Hamilton-Buchanan)	–	B	C	–	–	F	CR	e
<i>L. bata</i> (Hamilton-Buchanan)	–	–	–	–	E	–	LR	
<i>L. boga</i> (Hamilton-Buchanan)	–	–	C	–	–	–	LR	
<i>L. boggut</i> (Sykes)	–	–	C	D	E	F	DD	
<i>L. calbasu</i> (Hamilton-Buchanan)	A	B	C	–	E	F	LR	
<i>L. dussumieri</i> (Valenciennes)	A	B	–	–	–	–	EN	e
<i>L. fimbriatus</i> (Bloch)	A	–	–	D	E	F	LR	
<i>L. kawrus</i> (Sykes)	–	–	–	D	–	F	DD	e
<i>L. kontius</i> (Jerdon)	–	B	C	–	–	–	EN	e
<i>L. nigrescens</i> Day	–	–	C	–	–	–	DD	e
<i>L. porcellus</i> (Heckel)	–	–	C	D	E	F	DD	
<i>L. potail</i> (Sykes)	–	B	C	–	–	F	DD	e
<i>L. rohita</i> (Hamilton-Buchanan)	–	B	–	–	E	F	LR	
<i>L. sindensis</i> (Day)	–	–	–	–	–	F	DD	
<i>Neolissochilus wynaadensis</i> (Day)	–	B	–	–	–	–	CR	e
<i>Oreochthys cosuatis</i> (Hamilton-Buchanan)	–	–	C	D	–	–	DD	
<i>Osteobrama bakeri</i> (Day)	A	B	–	D	–	–	EN	e
<i>O. bheemensis</i> Singh and Yazdani	–	–	–	–	–	F	DD	e
<i>O. cotio cotio</i> (Hamilton-Buchanan)	–	–	C	–	E	F	LR	
<i>O. cotio cunma</i> (Day)	–	–	–	–	–	F	VU	
<i>O. cotio peninsularis</i> Silas	–	–	–	–	–	F	EN	
<i>O. neilli</i> (Day)	–	–	C	–	–	F	DD	e
<i>O. vigorsii</i> (Sykes)	–	–	–	–	E	F	DD	
<i>Osteocheilus (Kantaka) brevidorsalis</i> (Day)	–	B	C	–	–	–	EN	e
<i>Osteocheilus (Osteochilichthys) godavariensis</i> (Rao)	–	–	–	–	–	F	DD	e
<i>O. (O.) longidorsalis</i> Pethiyagoda & Kottelat	–	B	–	–	–	–	CR	e
<i>O. (O.) nashii</i> (Day)	–	B	C	D	–	F	VU	e
<i>O. (O.) thomassi</i> (Day)	–	B	C	–	–	F	EN	e
<i>Puntius amphibius</i> (Valenciennes)	A	B	C	D	E	F	LR	
<i>P. arenatus</i> (Day)	–	–	–	–	–	F	DD	e
<i>P. arulius arulius</i> (Jerdon)	A	B	–	D	–	–	EN	e
<i>P. bimaculatus</i> (Bleeker)	–	B	–	D	–	–	DD	
<i>P. bovanicus</i> (Day)	–	B	–	D	–	–	CR	e
<i>P. burmanicus</i> (Day)	A	–	–	–	–	–	DD	
<i>P. carnaticus</i> (Jerdon)	A	B	C	D	–	–	VU	e
<i>P. cauveriensis</i> (Hora)	–	–	C	–	–	–	DD	e
<i>P. chalakudaiensis</i> Rema Devi, Menon & Thobias	–	B	–	–	–	–	DD	e
<i>P. chola</i> (Hamilton-Buchanan)	–	B	–	D	–	F	VU	
<i>P. conchoniensis</i> (Hamilton-Buchanan)	A	B	C	D	–	F	VU	
<i>P. deccanensis</i> Yazdani and Rao	–	–	–	–	–	F	CR	e
<i>P. denisonii</i> (Day)	A	B	–	–	–	–	EN	e
<i>P. dorsalis</i> (Jerdon)	A	B	C	D	E	F	EN	
<i>P. fasciatus</i> (Jerdon)	–	–	C	D	–	–	EN	
<i>P. filamentosus</i> (Valenciennes)	A	B	–	D	–	–	DD	
<i>P. fraseri</i> (Hora & Misra)	–	–	–	–	E	F	DD	e
<i>P. jerdoni</i> (Day)	–	B	C	D	E	F	EN	e
<i>P. melanampix melanampix</i> (Day)	A	B	C	–	–	F	LR	e
<i>P. melanostigma</i> (Day)	A	B	–	–	E	F	EN	e
<i>P. narayani</i> (Hora)	–	–	C	D	–	–	CR	e
<i>P. ophicephalus</i> (Raj)	A	–	–	–	–	–	EN	e
<i>P. parrah</i> Day	A	–	C	–	–	F	EN	e
<i>P. phutunio</i> (Hamilton-Buchanan)	–	–	–	D	–	–	LR	
<i>P. pleurotaenia</i> Bleeker	–	–	C	–	–	–	VU	
<i>P. sahyadriensis</i> Silas	–	–	–	D	E	–	DD	e
<i>P. sarana orphoides</i> (Valenciennes)	–	–	–	D	–	–	DD	

Appendix continued.

Family/species*	Zones†						Status‡	Remark
<i>P. sarana sarana</i> (Hamilton-Buchanan)	A	B	C	D	E	F	VU	
<i>P. sarana subnasutus</i> (Valenciennes)	A	B	C	D	E	F	LR	e
<i>P. sharmai</i> Menon-Rema Devi	–	B	–	–	–	–	DD	e
<i>P. sophore</i> (Hamilton-Buchanan)	A	B	C	D	E	F	LR	
<i>P. ticto ticto</i> (Hamilton-Buchanan)	A	B	C	D	E	F	LR	
<i>P. ticto punctatus</i> (Day)	–	B	–	–	–	–	CR	e
<i>P. vittatus</i> Day	A	–	C	D	–	–	VU	
<i>Rohitee ogilbii</i> Sykes	–	–	C	–	E	F	LR	e
<i>Schismatorhynchos (Nukta) nukta</i> (Sykes)	–	–	C	–	E	F	DD	e
<i>Tor khudree</i> (Sykes)	A	B	C	D	E	F	VU	
<i>T. mosal</i> (Hamilton-Buchanan)	–	–	C	–	–	–	EN	
<i>T. mussulah</i> (Sykes)	–	–	–	–	E	F	CR	e
<i>T. putitora</i> (Hamilton-Buchanan)	–	–	–	D	–	–	EN	
<i>T. tor</i> (Hamilton-Buchanan)	A	–	C	–	E	–	EN	
<i>Chela cachiis</i> (Hamilton-Buchanan)	–	–	–	–	E	F	DD	
<i>C. dadidurjori</i> (Menon)	–	–	–	D	–	–	DD	e
<i>C. fasciata</i> Silas	–	B	–	–	–	–	CR	e
<i>C. laubuca</i> (Hamilton-Buchanan)	A	B	–	–	–	F	LR	
<i>Salmostoma acinaces</i> (Valenciennes)	–	B	C	–	–	F	VU	
<i>S. bacaila</i> (Hamilton-Buchanan)	–	–	C	–	–	F	LR	
<i>S. boopis</i> (Day)	A	B	C	D	E	F	LR	e
<i>S. clupeoides</i> (Bloch)	–	B	C	D	E	F	EN	
<i>S. horai</i> (Silas)	–	–	C	–	–	–	DD	e
<i>S. novacula</i> (Valenciennes)	–	–	C	–	E	F	LR	e
<i>S. phulo</i> (Hamilton-Buchanan)	–	–	–	–	E	F	DD	
<i>Amblypharyngodon chakaiensis</i> Babu & Nair	A	–	–	–	–	–	CR	e
<i>A. melettinus</i> (Valenciennes)	A	B	C	–	–	F	LR	
<i>A. microlepis</i> (Bleekeri)	A	–	–	–	–	–	DD	
<i>A. mola</i> (Hamilton-Buchanan)	A	–	C	–	–	F	LR	
<i>Aspidoparia morar</i> (Hamilton-Buchanan)	–	–	–	–	E	F	LR	
<i>Barilius bakeri</i> Day	A	B	–	–	–	–	VU	e
<i>B. barila</i> (Hamilton-Buchanan)	–	–	C	–	–	–	VU	
<i>B. barna</i> (Hamilton-Buchanan)	–	B	C	–	–	F	LR	
<i>B. bendilisis</i> (Hamilton-Buchanan)	–	B	C	–	E	F	LR	
<i>B. canarensis</i> (Jerdon)	–	–	C	D	–	–	DD	e
<i>B. evezardii</i> Day	–	–	–	–	E	–	LR	e
<i>B. gatensis</i> (Valenciennes)	A	B	C	–	–	F	DD	e
<i>B. vagra</i> (Hamilton-Buchanan)	–	–	C	–	–	–	VU	
<i>Brachydanio rerio</i> (Hamilton-Buchanan)	–	B	C	D	E	–	LR	
<i>Danio aequipinatus</i> (McClelland)	A	B	C	D	E	F	LR	
<i>D. fraseri</i> Hora	–	–	–	–	–	F	DD	e
<i>D. malabaricus</i> (Jerdon)	A	B	C	D	–	F	LR	
<i>D. neilgherriensis</i> (Day)	–	B	–	–	–	–	DD	
<i>Esomus barbatus</i> (Jerdon)	–	B	C	–	–	–	DD	e
<i>E. danricas</i> (Hamilton-Buchanan)	–	B	C	D	–	–	VU	
<i>Parluciosoma daniconius</i> (Hamilton-Buchanan)	A	B	C	D	E	F	LR	
<i>P. labiosa</i> (Mukerji)	–	–	–	–	–	F	DD	e
<i>Rasbora caverii</i> (Jerdon)	–	–	C	–	–	–	DD	e
<i>R. rasbora</i> (Hamilton-Buchanan)	–	–	C	–	–	–	DD	
<i>Lepidopygopsis typus</i> Raj	A	–	–	–	–	–	CR	e
<i>Crossocheilus latius latius</i> (Hamilton-Buchanan)	–	B	–	–	–	F	DD	
<i>C. periyarensis</i> Jacob & Menon	A	–	–	–	–	–	VU	e
<i>Garra bicornuta</i> Rao	–	–	C	–	E	F	DD	e
<i>G. gotyla gotyla</i> (Gray)	–	–	–	–	E	F	VU	
<i>G. gotyla stenorhynchus</i> (Jerdon)	–	B	–	D	–	–	EN	e

Appendix continued.

Family/species*	Zones [†]						Status [‡]	Remark
<i>G. hughi</i> Silas	A	–	–	–	–	–	EN	e
<i>G. lamta</i> (Hamilton-Buchanan)	A	–	C	–	E	–	DD	
<i>G. maclellandi</i> (Jerdon)	A	B	–	–	–	–	EN	e
<i>G. menoni</i> Indra & Rema Devi	–	B	–	–	–	–	VU	e
<i>G. mullya</i> (Sykes)	A	B	C	D	E	F	LR	
<i>G. surendranathinii</i> Shaji, Easa & Arun	–	B	–	–	–	–	EN	e
Parapsilorhynchidae								
<i>Parapsilorhynchus discochorus</i> Hora	–	–	–	–	–	F	DD	e
<i>P. prateri</i> Hora and Misra	–	–	–	–	–	F	DD	e
<i>P. tentaculatus</i> (Annandale)	–	–	–	–	E	F	DD	
Balitoridae								
<i>Balitora brucei</i> Grey	–	–	C	–	–	–	LR	
<i>B. mysorensis</i> Hora	–	B	–	D	E	–	CR	e
<i>Bhavana australis</i> (Jerdon)	A	B	C	D	–	–	EN	e
<i>Homaloptera menoni</i> Shaji and Easa	–	B	–	–	–	–	DD	e
<i>H. montana</i> Herre	–	B	–	–	–	–	CR	e
<i>H. pillaii</i> Indra & Rema Devi	A	B	–	–	–	–	VU	e
<i>Travancoria jonesi</i> Hora	A	–	–	–	–	–	EN	e
<i>T. elongata</i> Pethiyagoda & Kottelat	–	B	–	–	–	–	CR	e
<i>Nemacheilus anguilla</i> Annandale	–	–	C	D	E	F	LR	e
<i>N. botia</i> (Hamilton-Buchanan)	A	–	C	D	E	F	LR	
<i>N. beavani</i> Gunther	–	B	C	–	–	–	DD	
<i>N. denisoni dayi</i> Hora	–	–	–	–	–	F	DD	
<i>N. denisoni denisoni</i> Day	A	B	C	D	E	F	VU	
<i>N. evezardi</i> Day	–	–	C	–	–	F	EN	
<i>N. guentheri</i> Day	A	B	–	–	–	–	LR	e
<i>N. keralensis</i> (Rita & Nalbant)	A	–	–	–	–	–	EN	e
<i>N. monilis</i> Hora	–	B	C	–	–	–	EN	e
<i>N. moreh</i> (Sykes)	–	B	C	–	–	F	DD	
<i>N. nilgiriensis</i> (Menon)	–	B	–	–	–	–	EN	e
<i>N. petrubanarescui</i> (Menon)	–	B	–	–	–	–	DD	e
<i>N. pulchellus</i> Day	A	–	C	D	–	–	DD	e
<i>N. rueppelli</i> (Sykes)	–	–	C	D	E	F	DD	e
<i>N. savona</i> (Hamilton-Buchanan)	–	–	–	–	E	F	DD	
<i>N. semiarmatus</i> Day	–	B	C	–	–	–	VU	e
<i>N. striatus</i> Day	–	B	C	D	–	F	DD	e
<i>N. triangularis</i> Day	A	B	–	–	–	–	LR	e
Cobitidae								
<i>Lepidocephalus guntea</i> (Hamilton-Buchanan)	–	B	–	D	E	F	DD	
<i>L. thermalis</i> (Valenciennes)	A	B	C	D	E	F	LR	
<i>Pangio bashai</i> (Easa & Shaji)	–	B	–	–	–	–	DD	e
<i>P. goaensis</i> (Tilak)	–	–	–	D	–	–	EN	e
<i>Botia striata</i> Rao	–	–	C	–	E	–	EN	e
Bagridae								
<i>Aorichthys aor</i> (Hamilton-Buchanan)	–	–	–	–	E	F	DD	
<i>A. seenghala</i> (Sykes)	–	B	C	D	E	F	DD	
<i>Batasio travancoria</i> Hora & Law	A	B	–	–	–	–	EN	e
<i>Horabagrus brachysoma</i> (Gunther)	A	B	–	D	–	–	EN	e, s
<i>H. nigricollaris</i> Pethiyagoda and Kottelat	–	B	–	–	–	–	CR	e
<i>Mystus armatus</i> (Day)	–	B	C	–	–	–	LR	
<i>M. bleekeri</i> (Day)	–	–	–	–	–	F	VU	
<i>M. cavasius</i> (Hamilton-Buchanan)	A	B	C	D	E	F	LR	
<i>M. gulio</i> (Hamilton-Buchanan)	A	–	–	–	–	F	LR	s
<i>M. keletius</i> (Valenciennes)	–	–	C	–	–	–	DD	
<i>M. malabaricus</i> (Jerdon)	A	B	C	D	E	F	EN	e
<i>M. menoda</i> (Hamilton-Buchanan)	–	–	C	–	–	F	DD	

Appendix continued.

Family/species*	Zones†						Status‡	Remark
<i>M. montanus</i> (Jerdon)	A	B	C	–	–	F	VU	
<i>M. oculatus</i> (Valenciennes)	A	B	C	–	–	–	LR	s
<i>M. punctatus</i> (Jerdon)	–	B	C	–	–	–	EN	e
<i>M. viittatus</i> (Bloch)	A	B	C	–	–	–	VU	
<i>Parabatassio sharavatiensis</i> Bhat & Jayaram	–	–	–	D	–	–	DD	e
<i>Rita kuturnee</i> (Sykes)	–	–	C	D	E	F	LR	
<i>R. pavimentatus</i> (Valenciennes)	–	–	–	–	E	F	EN	
<i>R. rita</i> (Hamilton-Buchanan)	–	–	–	–	–	F	LR	
Siluridae								
<i>Ompok bimaculatus</i> (Bloch)	A	B	C	D	E	F	EN	
<i>O. malabaricus</i> (Valenciennes)	A	–	–	D	–	–	CR	e
<i>O. pabo</i> (Hamilton-Buchanan)	–	–	–	–	E	F	DD	
<i>Silurus berdmorei</i> (Blyth)	–	–	C	–	–	–	DD	
<i>S. wynaadensis</i> Day	–	B	C	D	–	–	CR	e
<i>Wallago attu</i> (Schneider)	A	B	C	–	E	F	LR	
Schilbeidae								
<i>Eutropiichthys goongwaree</i> (Sykes)	–	–	–	–	–	F	DD	e
<i>E. vacha</i> (Hamilton-Buchanan)	–	–	–	–	E	–	EN	
<i>Neotropius khavalchor</i> Kulkarni	–	–	–	–	E	–	DD	
<i>Pseudeutropius atherinoides</i> (Bloch)	–	–	C	–	E	–	EN	
<i>Pseudeutropius mitchelli</i> Gunther	A	–	–	–	–	–	DD	e
<i>Proeutropiichthys taakree taakree</i> (Sykes)	–	–	–	–	E	F	CR	
<i>Silonia childreni</i> (Sykes)	–	B	C	–	E	F	EN	e
Pangasiidae								
<i>Pangasius pangasius</i> (Hamilton-Buchanan)	–	B	–	–	–	–	CR	
Sisoridae								
<i>Bagarius bagarius</i> (Hamilton-Buchanan)	–	–	–	–	E	F	VU	
<i>B. yarrellii</i> Sykes	–	–	C	–	–	F	DD	
<i>Gagata gagata</i> (Hamilton-Buchanan)	–	–	–	–	E	–	DD	
<i>Glyptothorax anamalaiensis</i> Silas	–	B	–	–	–	–	CR	e
<i>G. annandalei</i> Hora	–	B	–	D	E	F	EN	
<i>G. conirostre poonaensis</i> Hora	–	–	–	–	–	F	DD	e
<i>G. housei</i> Herre	–	B	–	–	–	–	DD	e
<i>G. lonah</i> (Sykes)	–	–	C	–	E	F	LR	e
<i>G. madraspatanum</i> (Day)	A	B	C	–	–	F	VU	e
<i>G. saisii</i> (Jenkins)	–	–	–	–	E	–	EN	
<i>G. trewavasae</i> Hora	–	–	–	–	E	–	DD	e
<i>Nangra itchkeea</i> (Sykes)	–	–	C	–	E	F	DD	
<i>N. viridescens</i> (Hamilton-Buchanan)	–	–	–	–	–	F	LR	
Clariidae								
<i>Clarias batrachus</i> (Linnaeus)	A	–	C	D	–	–	VU	
<i>C. dayi</i> Hora	–	B	–	–	–	–	EN	e
<i>C. dussumieri dussumieri</i> Valenciennes	–	B	–	D	–	–	VU	
<i>Horaglanis krishnai</i> Menon	A	–	–	–	–	–	CR	e
Heteropneustidae								
<i>Heteropneustes fossilis</i> (Bloch)	A	B	C	–	–	F	VU	
Hemiramphidae								
<i>Hyporhamphus limbatus</i> (Valenciennes)	–	B	–	D	–	F	DD	s
<i>H. xanthopterus</i> (Valenciennes)	A	–	–	–	–	–	CR	e
<i>Zenarchopterus striga</i> (Blyth)	–	–	–	D	–	–	DD	s
Belonidae								
<i>Xenentodon cancila</i> (Hamilton-Buchanan)	A	B	C	D	E	F	LR	
Oryziidae								
<i>Oryzias melastigma</i> (McClelland)	–	–	C	–	–	–	DD	s

Appendix continued.

Family/species*	Zones†						Status‡	Remark
Horaichthyidae								
<i>Horaichthys setnai</i> Kulkarni	–	–	–	–	–	F	DD	
Aplocheilidae								
<i>Aplocheilus blocki</i> (Arnold)	–	–	–	D	–	–	DD	
<i>A. lineatus</i> (Valenciennes)	A	B	C	D	E	F	LR	s
<i>A. panchax</i> (Hamilton-Buchanan)	–	–	–	–	–	F	DD	
Cyprinodontidae								
<i>Aphanius dispar</i> (Ruppell)	–	–	–	D	–	–	DD	
Poeciliidae								
<i>Gambusia affinis</i> (Baird & Girard)	–	–	–	–	–	F		Intr.
<i>Poecilia (Lebistes) reticulata</i> Peters	–	B	–	D	–	F		Intr.
<i>Xiphophorus helleri</i> (Heckel)	–	–	–	–	–	F		Intr.
Syngnathidae								
<i>Ichthyocampus carce</i> (Hamilton-Buchanan)	–	–	–	D	–	–	DD	s
<i>Microphis cunocalus</i> (Hamilton-Buchanan)	–	B	–	D	E	–	VU	s
Synbranchidae								
<i>Monopterus (Amphipnous) fossorius</i> (Nair)	A	–	–	–	–	–	EN	e
<i>M. (Amphipnous) indicus</i> (Silas and Dawson)	–	–	–	–	–	F	DD	e
<i>M. (Monopterus) eapeni</i> Talawar	A	–	–	–	–	–	CR	e
Ambassidae								
<i>Ambassis gymnocephalus</i> (Lacepede)	A	–	–	D	–	–	DD	s
<i>A. interruptus</i> Bleeker	–	–	–	D	–	–	DD	s
<i>A. nalua</i> (Hamilton-Buchanan)	A	–	–	–	–	–	DD	s
<i>Chanda nama</i> Hamilton-Buchanan	–	–	C	D	E	F	VU	
<i>Parambassis dayi</i> (Bleeker)	A	–	–	D	–	–	EN	e, s
<i>P. thomassi</i> (Day)	A	B	C	D	–	–	VU	e
<i>Pseudambassis baculis</i> (Hamilton-Buchanan)	–	–	–	–	–	F	DD	
<i>P. ranga</i> (Hamilton-Buchanan)	–	B	C	–	E	F	DD	
Lutjanidae								
<i>Lutjanus johni</i> (Bloch)	–	–	–	D	–	–	DD	s
Haenulidae								
<i>Pomadasys argenteus</i> (Forsskal)	–	–	–	D	–	–	DD	
Sciaenidae								
<i>Johnius belangerii</i> (Cuviear)	–	–	–	D	–	–	DD	s
Scatophagidae								
<i>Scatophagus argus</i> (Linnaeus)	A	–	–	D	–	–	DD	s
Nandidae								
<i>Nandus nandus</i> (Hamilton-Buchanan)	A	B	–	D	–	–	LR	s
<i>Pristolepis fasciata</i> (Bleeker)	A	–	–	–	–	–	DD	
<i>P. marginata</i> Jerdon	A	B	–	D	–	F	VU	e
<i>Badis badis</i> (Hamilton-Buchanan)	–	B	–	D	–	–	DD	
Cichlidae								
<i>Etoplus maculatus</i> (Bloch)	A	B	–	D	–	–	LR	s
<i>E. suratensis</i> (Bloch)	A	B	C	D	–	–	LR	s
<i>Oreochromis mossambica</i> (Peters)	A	B	C	D	E	F		Intr.
Mugilidae								
<i>Liza macrolepis</i> (Smith)	–	–	–	D	–	–	DD	s, d
<i>L. parsia</i> (Hamilton-Buchanan)	–	–	–	D	–	–	DD	s, d
<i>Mugil cephalus</i> Linnaeus	–	–	–	D	–	–	DD	s, d
<i>Rhinomugil corsula</i> (Hamilton-Buchanan)	–	B	C	D	E	F	VU	s, d
Blenniidae								
<i>Omobranchus punctatus</i> (Valenciennes)	–	–	–	D	–	F	DD	s
<i>O. zebra</i> (Bleeker)	–	–	–	D	–	–	DD	s

Appendix *continued.*

Family/species*	Zones†							Status‡	Remark
Gobiidae									
<i>Awaous grammepomus</i> (Bleeker)	–	–	–	D	–	–	DD	s, d	
<i>A. gutum</i> (Hamilton-Buchanan)	A	–	–	–	–	–	DD	s, d	
<i>Bathygobius fuscus</i> (Ruppell)	–	–	–	D	–	–	DD	s	
<i>Brachygobius nunus</i> (Hamilton-Buchanan)	–	–	–	–	E	–	DD	s	
<i>Glossogobius giuris</i> (Hamilton-Buchanan)	A	B	C	D	E	F	LR	s, d	
<i>Stigmatogobius javanicus</i> (Bleeker)	–	–	–	–	–	F	DD	s	
<i>Periophthalmus variabilis</i> (Eggert)	–	–	–	D	–	–	DD	s	
<i>Sicyopterus fasciatum</i> Day	–	B	–	–	–	–	DD	s, e, d	
<i>S. griseus</i> (Day)	–	B	–	–	–	–	VU	s, d	
Anabantidae									
<i>Anabas testudineus</i> (Bloch)	A	B	–	–	–	F	VU	s	
Belontiidae									
<i>Macropodus cupanus</i> (Valenciennes)	A	B	–	D	–	F	DD		
Osphronemidae									
<i>Osphronemus goramy</i> Lacepede	–	–	–	–	E	–	DD		
Channidae									
<i>Channa marulius</i> (Hamilton-Buchanan)	A	B	C	–	E	F	LR		
<i>C. micropeltes</i> (Cuvier)	A	–	–	–	–	–	CR		
<i>C. orientalis</i> Bloch & Schneider	A	B	C	D	E	F	VU		
<i>C. punctatus</i> (Bloch)	–	–	C	D	E	F	LR		
<i>C. striatus</i> (Bloch)	A	B	C	D	E	F	LR		
Mastacembelidae									
<i>Macrognathus guntheri</i> (Day)	A	B	–	–	–	–	VU		
<i>M. pancalus</i> Hamilton-Buchanan	–	–	C	–	–	–	LR	s	
<i>Mastacembelus armatus</i> (Lacepede)	A	B	C	D	E	F	LR	s	
Soleidae									
<i>Euryglossa orientalis</i> (Bloch & Schneider)	A	B	–	–	–	–	DD	s, d	
Tetraodontidae									
<i>Tetraodon travancoricus</i> Hora & Nair	–	B	–	D	–	–	EN	e	

DD, data deficient; VU, vulnerable; EN, endangered; CR, critically endangered; e, endemic to Western Ghats; s, secondary freshwater; d, diadromous; Intr., introduced to this region.

*Taxonomic status adapted from Talwar & Jhingran (1991).

†Zones as per Table 2.

‡Status adapted from Ajitkumar *et al.* (2000), BCPP Camp workshop on freshwater fishes of India (1997) and Shaji & Easa (1998).