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Studies on temporal variations of exploited fishery resources and their trophic levels in a tropical estuary

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ABSTRACT

Estuaries are dynamic ecosystems that warrant detailed examination of trophic interactions due to diversified prey items contributed simultaneously from marine and freshwater environments. Most coastal and estuarine fisheries resources are either fully exploited or overexploited due to the involvement of increased number of fishermen, employment of more efficient fishing gears and adoption of mechanization. The present study elucidates trophic level status of fish resources exploited from Vembanad lake, S. India as an indicator of fishery-induced impacts in food web structure and thereby delineating its usefulness in describing the state of fisheries in this ecologically fragile ecosystem. Results showed that fishery resources of Vembanad lake has dwindled considerably from 115 species contributing 3068.29 tonnes during 1987–1988 to 80 species constituting 1192 tonnes during 2012–2013. The species richness has reduced to 3.78 in latter period from 6.40 in former period. A perceptible variation in composition of trophic groups was also observed in exploited fishery resources of the two periods. The number of species representing herbivores–omnivores–detritivores (Trophic Level-2.0-2.99) reduced from 31 to 28, mid-level carnivores (Trophic Level-3.0-3.99) from to 66 to 43 and the same of high-level carnivores from 18 to 9 species. Chi-square test revealed significant ($p<0.05$) difference in reduction of both mid-level carnivores and total species exploited from the lake. Large marine migrant predators, which showed predominance during 1987–1988, declined along with a significant influx of freshwater and lower trophic fishes in fish catch of 2012-13. The significant reduction in the diversity of fishes represented in exploited fishery bring about theories like 'fishing down the food web' and 'top down effect' and change in ecology of the lake. These ecological changes are brought about by a combination of natural as well as anthropogenic causes which demand continuous monitoring of fish catch in order to ascertain the ecosystem health of Vembanad lake.

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1. Introduction

The concept of trophic level is essential in improvement of our knowledge on the structure and the function of an ecosystem (Pasquaud et al., 2010). However, these trophic levels are not always simple integers, because organisms often feed at more than one trophic level (Odum and Heald, 1975; Pimm and Lawton, 1978). In marine ecosystems, trophic levels of most fish and other consumers take values between 2.0 and 5.0. The upper value, 5.0, is unusual for even large fish, Cortés (1999) and occurs in apex predators of marine mammals, such as polar bears and killer whales (Pauly et al., 1998).

Estuarine food webs and their trophic dynamics have received considerable attention throughout the world (Kharlamenko et al., 2001; Persic et al., 2004; Kieckbusch et al., 2004; Alfaro, 2006). The complexity of physical and biological processes found in these transition zones between land and sea, however, pose challenges for those investigating estuarine trophodynamics (Alfaro et al., 2006). Estuarine ecosystems are increasingly overexploited and threatened by climate change and anthropogenic development (Mahoney and Bishop, 2017). Temporal changes in production and ecology have recently been reported in many estuaries (Banerjee et al., 2017; Rakshit et al., 2017; García-Seoane et al., 2016; Baptista et al., 2015). The Vembanad lake, situated between latitude 9° 28′ and 10° 10′ North and longitude 76° 13′ and 76° 3′ East, is the largest brackish water body and one of most productive areas along south west coast of India (Qasim and Gopinathan, 1969). Consequent to the commissioning of a salinity barrier in 1976, its ecosystem

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Table 1
Details of fish landing and trophic level status of various species supporting fishery during Period I and II.

Sl.no	Species	Period I	Period II	Trophic level	Column habitat
1	*Acentrogobius caninus*	✓		3.5	Demersal
2	*Alectis indica*	✓		4.09	Reef-associated
3	*Alepes kleinii*	✓		3.54	Reef-associated
4	*Ambassis ambassis*	✓	✓	2.8	Demersal
5	*Ambassis gymnocephalus*	✓		3.91	Demersal
6	*Amblypharyngodon microlepis*		✓	3.2	Benthopelagic
7	*Amblypharyngodon mola*	✓	✓	2.9	Benthopelagic
8	*Anabas testudineus*	✓	✓	2.7	Demersal
9	*Anguilla bengalensis*		✓	3.8	Benthopelagic
10	*Anguilla bicolor* [a]	✓		3.55	Demersal
11	*Anodontostoma chacunda* [a]	✓	✓	2.84	Pelagic-neritic
12	*Aplocheilus panchax*		✓	3.2	Benthopelagic
13	*Arius maculatus* [a]	✓	✓	3.36	Demersal
14	*Arius subrostratus* [a]	✓	✓	2.83	Demersal
15	*Brachirus orientalis* [a]	✓	✓	3.5	Demersal
16	*Bunaka gyrinoides*	✓		3.6	Demersal
17	*Carangoides praeustus*	✓		3.9	Demersal
18	*Caranx carangus*	✓		3.83	Reef-associated
19	*Caranx ignobilis*	✓		4.48	Reef-associated
20	*Caranx sexfasciatus* [a]	✓		3.58	Reef-associated
21	*Cata catla*		✓	2.8	Benthopelagic
22	*Chaca chaca*		✓	4.2	Demersal
23	*Channa marulius*	✓	✓	4.5	Benthopelagic
24	*Channa orientalis*		✓	3.8	Benthopelagic
25	*Channa striata*	✓	✓	3.36	Benthopelagic
26	*Chanos chanos*	✓	✓	2.4	Benthopelagic
27	*Chelon macrolepis* [a]	✓	✓	2.57	Demersal
28	*Chelon parsia* [a]	✓	✓	2	Demersal
29	*Chelon planiceps*		✓	2	Demersal
30	*Clarias batrachus*	✓	✓	3.42	Demersal
31	*Colletteichthys dussumieri*	✓		3.7	Demersal
32	*Cynoglossus bilineatus*	✓	✓	3.5	Demersal
33	*Cynoglossus cynoglossus*		✓	3.5	Demersal
34	*Cynoglossus microlepis*		✓	3.5	Demersal
35	*Cynoglossus puncticeps*	✓		3.27	Demersal
36	*Dayella malabarica*	✓		3.1	Pelagic-neritic
37	*Daysciaena albida* [a]	✓		3.8	Benthopelagic
38	*Ehirava fluviatilis*	✓		3.06	Pelagic-neritic
39	*Eleotris fusca*	✓	✓	3.62	Demersal
40	*Eleuotheronema tetradactylum*	✓	✓	4.11	Pelagic-neritic
41	*Elops machnata*	✓	✓	4.04	Pelagic-neritic
42	*Epinephelus tauvina* [a]	✓		4.13	Reef-associated
43	*Escualosa thoracata*	✓		2.89	Pelagic-neritic
44	*Etroplus maculatus*	✓	✓	2.8	Benthopelagic
45	*Etroplus suratensis* [a]	✓	✓	2.91	Benthopelagic
46	*Gazza minuta*	✓		4	Demersal
47	*Gerres erythrourus*	✓		3.34	Reef-associated
48	*Gerres filamentosus* [a]	✓	✓	3.2	Demersal
49	*Gerres setifer*		✓	3.3	Benthopelagic
50	*Glossogobius giuris*	✓	✓	3.57	Benthopelagic
51	*Gobiopsis macrostoma*	✓		3.78	Demersal
52	*Heteropneustes fossilis*	✓	✓	3.89	Demersal
53	*Himantura uarnak*	✓	✓	3.6	Reef-associated
54	*Horabagrus brachysoma*	✓	✓	3.3	Demersal
55	*Hyporhamphus limbatus* [a]	✓		3.2	Pelagic-neritic
56	*Hyporhamphus xanthopterus* [a]	✓	✓	3	Pelagic-neritic
57	*Ilisha melastoma*	✓		3.45	Pelagic-neritic
58	*Johnius coitor*		✓	3.3	Demersal
59	*Karalla dussumieri*		✓	3.2	Demersal
60	*Labeo dussumieri* [a]	✓	✓	2	Benthopelagic
61	*Labeo rohita*		✓	2.2	Benthopelagic
62	*Lates calcarifer* [a]	✓	✓	3.83	Demersal
63	*Leiognathus brevirostris*	✓	✓	2.96	Demersal
64	*Leiognathus equulus*	✓	✓	3.01	Demersal
65	*Lethrinus microdon*	✓		3.79	Reef-associated
67	*Lutjanus argentimaculatus* [a]	✓		3.85	Reef-associated
68	*Lutjanus johnii* [a]	✓		4.19	Reef-associated
69	*Lutjanus rivulatus*	✓		4.13	Reef-associated
70	*Lutjanus russellii*	✓		3.8	Reef-associated
71	*Macrognathus guentheri*	✓	✓	3.3	Benthopelagic
72	*Mastacembelus armatus*	✓		2.78	Demersal

(*continued on next page*)

became separated into an estuarine portion in its northern downstream regions and a freshwater habitat in the southern upstream portions (Kurup et al., 1993).

The fishery resources of backwaters and estuaries in this region are depleting at an alarming rate. Kurup (1989) reported that

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