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The Effect of Net Colour on the Catch Efficiency of Gillnets Operated in Vembanad Lake, Kerala, India

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Abstract

Gillnets are commonly used in inland lakes due to their simplicity in construction and operation, efficiency, and low energy usage. The Vembanad lake is one of the most prominent lakes in Kerala, contributing significantly to the small-scale and artisanal fisheries, in which gillnets are the predominant gear. There have been studies on the effect of gillnet panel colour on the selective capture of fish species, primarily in the open ocean and rivers. Although a considerable number of studies exist on the species profile and fish catching methods in the lake, the efficiency of coloured webbing for gillnets is not available. The efficiency of coloured webbing for gillnets is not documented, which, if available, would be a crucial input for implementing gear-based technical measures for conservation in gillnets in the lake. In this regard, a study was conducted along Vembanad lake and the lower reaches of the Muvattupuzha river to compare the catch efficiency and species profile of transparent gillnets typically employed in the region with gillnets fabricated using blue and green coloured webbing. The results demonstrated a considerable increase in CPUE for green-coloured gillnets (708.9±12.8 grams per operation) compared to blue and transparent gillnets, which had CPUE values of 397.9±80.2 and 293.7±70.6 grams per operation, respectively. Significantly higher catches of *Horabagrus brachysoma* and *Etroplus suratensis* were obtained with the green-coloured gillnets than with the control (Transparent). Length-wise data showed that green-coloured nets captured larger individuals of *E. suratensis*, but significant difference was not observed in other species. The number of *E. suratensis* captured in each gillnet contributed to the most dissimilarity in all comparisons, followed by *Gerres sp.* and *H. brachysoma*, according to similarities percentage analysis conducted to comprehend the species assemblage structure. This is the first report on the effect of gillnet colour on the catch efficiency of gillnets in Vembanad lake, and the results, which indicate species-specific differences in capture, will be one of the many inputs necessary for implementing gear-based technical measures in the gillnet fishery in the lake.

Keywords: Vembanad lake, gill nets, colour, nMDS, *Etroplus suratensis*

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Introduction

Gillnets are one of the most commonly used gears in marine and inland waters due to their effectiveness, ease of construction, low cost, and simplicity of operation (Reis & Pawson, 1992; FAO, 2016). Compared to other gears, gillnets are considered to be more size and species selective for a given mesh size (Gulland, 1983).

There are studies from different parts of the world that report the effect of the colour of the gillnet webbing on species catch (Hurst, 1953; Nomura, 1959; Grimaldo et al., 2019). Many of these studies have contradictory results, and there is no conclusive evidence that a specific colour of webbing increases catches. Nevertheless, it is known that fish have complex vision and can see light of different wavelengths (Losey et al., 1999), but the role of colour vision in the selective capture of fishes under actual field conditions is poorly understood. The visibility of the water, the colour of the webbing, the colour of the background, the temperature, the condition of the intended catch, etc., are some of the variables that affect capture in gillnets (Hurst, 1953; Losey et al., 1999).

Many studies exist on the fisheries of the Vembanad lake, which is one of the most important lakes along the southwest of India and a designated Ramsar site (Gopi, 2000; Bijukumar & Sushama, 1999; Ajithkumar et al., 2003; Raghavan et al., 2008). Studies on the fisheries profile of the Vembanad and nearby regions were reported by Renjith et al. (2016); Ajay et al. (2022), including the changing profile of the lake's physical and chemical properties (Asha et al., 2014). The gears used in the lake are also widely reported (Renjith et al., 2016; Ajay et al., 2022), and it is obvious that among the various fishing methods used, gillnets contribute significantly to the lake's total fish yield (Pauly, 1991; Ajay et al., 2021). Pearlspot and black clam (*Villorita cyprinoides*) account for more than 70% of the region's commercial catches, with gillnets contributing more than 30% of the overall (Pauly, 1991; Ajay et al., 2022).

Due to its accessibility, the majority of the region's fishermen use transparent or blue webbing. Studies conducted elsewhere in the Indian waters were primarily in the marine waters and reservoirs (George et al., 1975; Kunjipalu et al., 1984), where some positive benefits were reported by altering the colour of the used webbing, whereas other studies reported no significant difference in the mean catches (Narayanappa et al., 1977). In Indian waters, studies on the influence of the colour of the webbing of gillnets, the most important fishing gear employed in estuary environments, is minimal. In this context, a study was conducted along the Vembanad lake and the region adjacent to the Muvattupuzha river to examine the effects of gillnets made of blue, green, and transparent webbing on the total CPUE and the species profile captured in these nets.

Material and Methods

The study was carried out along the eastern side of the Vembanad lake and in the areas close to the mouth of the Muvattupuzha river. The location of fishing trials is shown in Fig. 1.

Gillnets made of polyamide (PA) monofilament twine of diameter (0.2 mm) and mesh size of 65 mm were used for the study. Three gillnets of length 150 m and depth of 2.5 m each, made of different coloured webbings, (i.e., blue, green and transparent) were used for the field trials. A total of 150 floats (50/20 mm), were attached at an interval of 2 m to the headline made of 4 mm dia. polypropylene rope. The sinkers used were sheathed aluminium wires, which is the common practice among the gillnet fishers in the region.

The gillnets were deployed in early morning, starting from 06:00 AM and they were soaked for about 5 hours, after which they were hauled, based on the order by which it was deployed (the first net to be hauled was the first to be deployed). The

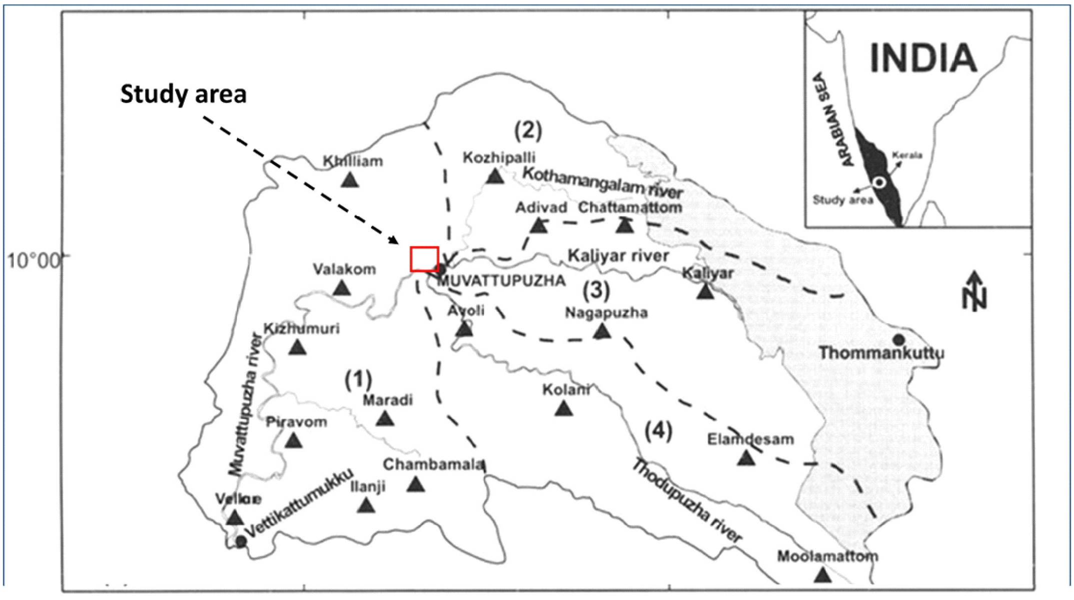

Fig. 1. Locations of study at Vembanad lake (Source: Modified from Girish and Seralathan., 2004).

deployment of the gillnets was parallel to one another and were allowed to drift. To ensure randomness and avoid bias, the three gillnets were deployed randomly during the fishing operations.

During hauling itself, the fishes from each coloured net were kept separately in bins and used for length and weight measurements at the shore. Length was measured to the nearest centimeter using a scale and weight to the nearest gram using an electronic balance. The fish were identified to the lowest possible taxonomic unit using standard identification keys.

The mesh size of the nets was measured every week using a scale to ascertain any change in the size of the mesh during the operations, which may affect the selectivity of the net during the course of the experiment. The experimental fishing operations were carried out during the pre-monsoon season (February 2021 to May 2021) and the fishing operations were carried out onboard a private canoe with an LOA of 6 m and fitted with a 4.5 HP outboard engine.

In addition to the number and weight of each species caught, the duration of soaking, and the depth at each site was recorded for each simultaneous operation.

The catch per unit effort (CPUE) of each gillnet was determined based on the total weight expressed in grams per operation and the total number of each species of fish caught in the respective gillnet. The weight and numbers of each species from the same-coloured nets were clubbed and used for analysis. A chi-squared test was used to determine if the number of each species caught was significantly different between the coloured gillnets. ANOVA test was carried out to find if the length of each species varied significantly, after checking for homogeneity of variance. Wherever assumption of homogeneity was not met, ANOVA on ranks was carried out, followed by multiple comparisons using suitable post-hoc test. Multivariate analysis was carried out to understand the species assemblages structures in the three different coloured gillnets. Analysis of Similarity (ANOSIM) was used to test the overall differences in the catches from the three gillnets followed by Similarities Percentage Analysis (SIMPER) to identify the species that contributed to between and within differences between the three gillnets used for the study (Clark & Warwick, 1994). A non-metric multidimensional scaling (nMDS) was used to generate a two-dimensional ordination of the assemblages in Bray-Curtis space (Bray & Curtis, 1957).

Results and Discussion

During the study period from February 2021 to May 2021, thirty simultaneous deployments of the experimental gillnets could be conducted. The depth of the operations ranged from three meters to seven meters in the study area. The mesh measurements made during the study showed that the average mesh size between the different coloured webbing (65.0±0.01) did not vary significantly. The total catch recorded from all the operations during the study was 42.1 kg comprising of twenty different species. The percentage contribution of major species in the respective coloured gillnet is shown in Table 1. The major species that was captured in all the three different coloured nets was *Etroplus suratensis*, followed by *H. Brachysoma* and *L. dussumieri*. The

Table 1. The weight of percentage contribution of major species to the total catch captured in the gillnets made using different coloured webbing

Species	Green	Blue	Transparent
Etroplus suratensis	36.63	28.44	34.29
Horabagrus brachysoma	22.54	7.42	12.55
Labeo dussumieri	13.85	25.52	19.23
Carangoides sp.	10.95	17.34	9.27
Gerres sp.	3.24	9.20	6.95
Gibelion catla	3.03	5.10	9.00
Crabs	1.78	0.00	0.00
Tenualosa sp.	1.49	2.04	1.37
Lagocephalus inermis	1.20	0.00	0.00
Lutjanus sp.	1.08	0.00	0.00
Jellyfish	0.95	0.00	0.00
Chanda nama	0.82	1.54	0.76
Megalaspis cordyla	0.68	2.28	0.83
Etroplus maculatus	0.66	0.00	0.00
Mugil cephalus	0.59	0.00	0.00
Stolephorus sp.	0.22	0.27	0.00
Ambassis ambassis	0.15	0.26	0.00
Tetraodon sp.	0.15	0.32	0.00
Thryssa dussumieri	0.00	0.28	4.94
Puntius sarana	0.00	0.00	0.81

other important species were *Carangoides* sp., *Gerres* sp. and *Gibelion Catla.* Recent research on fish diversity indicates that Perciformes and Cypriniformes are the major orders along the lower riverine reaches of the Muvattupuzha (Zeena and Beevi, 2011). Another investigation of fish diversity in the region showed an abundance of *H. brachysoma* and non-native *G. catla* (Renjith et al., 2016).

The mean CPUE recorded in the green-coloured gillnet was 708.9±12.8 grams per operation, which was significantly higher (K-W; H=9.96, 2, p<0.01, pair wise multiple comparison on ranks using student-Newman-Keuls method) than the mean CPUE of 397.9±80.2 grams per operation in blue-coloured nets and 293.7±70.6 grams per operation in transparent nets. The mean CPUE was not significantly different between the blue and transparent nets (Fig. 2). The total number of species caught in green coloured net (7±1) was significantly different (K-W; H=7.96, 2, p<0.05, pair wise multiple comparison on ranks using Student-Newman-Keuls method), compared to mean number caught in blue and transparent nets, whereas mean number of species caught in blue and transparent nets were the same (4±1) shown in (Table 2; Fig. 2). The average weight of fishes caught in the different coloured gillnets are shown in Table2. The numbers of two abundantly caught species *H. brachysoma* (÷2 *= 7.35; df=2; p<0.05)* and *E. suratensis (*÷2 *=15.6; df=2; p<0.01*) captured in the three gillnets were significantly different, when checked using a chi-square test based on even distribution of the catch among the gillnets. Species with a total count of less than 10, were excluded from the analysis. The number of individuals of other species caught in the different coloured gillnets were not significantly different.

The difference in length of specieswere tested using one-way ANOVA (before testing for Cochran's test for homogeneity of variances and transformation if required). The average length measurements of fish

Table 2. Number, mean length and standard error of major species caught in three different coloured gillnets (same colour combined). Individual species (n>10) were tested for differences in numbers caught among different gillnets, using a chi-square test based on even distribution of catch among gillnets. Not significant (n.s.); *p<0.05

Species	Green			Blue			Tran.			Total	Chi-squ
	n	*mean (cm)*	*SE*	*n*	*mean*	*SE*	*n*	*mean*	*SE*		
Carangoides sp.	10	17.5	2.6	8	15.5	1.4	8	17.7	*4.7*	*28*	*n.s.*
Horabagrus brachysoma	23	12.9	1.9	15	10.9	3.8	8	11.3	*2.4*	*46*	*
Labeo dussumieri	12	20.1	4.8	10	15.6	2.7	6	23.1	*7.5*	*28*	*n.s.*
Etroplus suratensis	87	17.3	2.7	50	14.7	2.9	48	16.3	*1.1*	*185*	*
Gerres sp.	21	10.6	3.6	23	12.6	1.7	21	11.3	3.2	64	n.s.

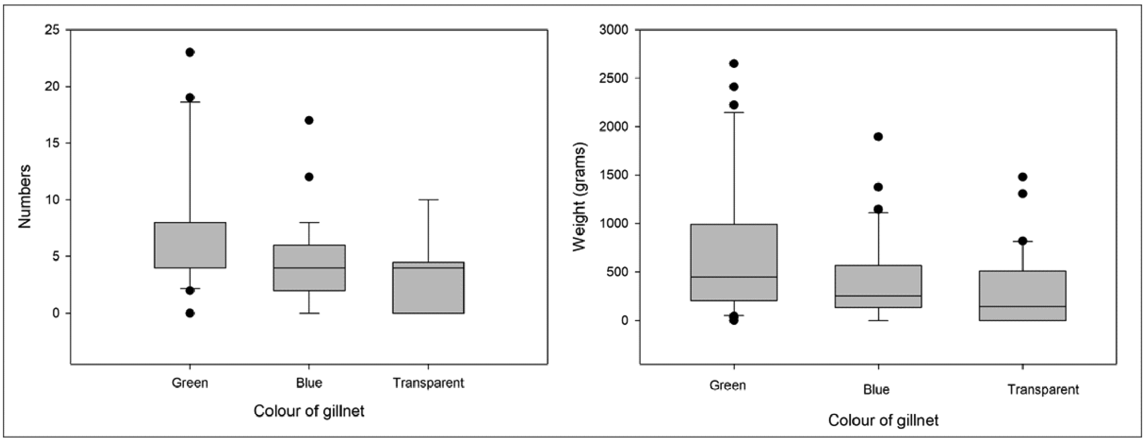

Fig. 2. The mean CPUE in terms of number and weight (grams) in different coloured gillnets operated along Vembanad lake

Table 3. Average abundance and dissimilarity of the different species derived using SIMPER analysis

Group: Green & Blue; Avg. dissimilarity – 81.66	Green: Avg. abundance	Blue: Avg. abundance	Avg. dissimilarity	Contribution %
Etroplus suratensis	1.45	0.96	25.27	33.06
Gerres sp.	0.34	0.44	12.12	15.85
Horabagrus brachysoma	0.38	0.28	8.13	10.63
Labeo dussumieri	0.21	0.02	4.21	5.51
Chanda nama	0.10	0.08	3.99	5.22
Group: Green & Transparent; Avg. dissimilarity – 76.44	Green: Avg. abundance	Transparent: Avg. abundance	Avg. dissimilarity	Contribution %
Etroplus suratensis	1.45	1.15	25.27	33.06
Gerres sp.	0.34	0.50	12.12	15.85
Horabagrus brachysoma	0.38	0.02	8.13	10.63
Labeo dussumieri	0.21	0.15	4.21	5.51
Carangoides sp.	0.10	0.20	3.99	5.22
Group: Blue & Transparent; Avg. dissimilarity – 78.19	Blue: Avg. abundance	Transparent: Avg. abundance	Avg. dissimilarity	Contribution %
Etroplus suratensis	0.96	1.15	25.71	32.88
Gerres sp.	0.44	0.50	15.58	19.92
Horabagrus brachysoma	0.28	0.02	8.86	11.33
Gibelion catla	0.02	0.15	5.99	7.65
Thryssa sp.	0.08	0.20	4.68	5.98

caught in different gillnets showed significant variations in length for *E. suratensis* (H=11.82, df=2, p<0.01). The average length of this species (Table 3; Fig. 3), in green-coloured nets (17.3 cm) were significantly higher (multiple comparison using Dunn's Method) than the mean lengths in blue (14.7 cm) and transparent gillnets (16.3 cm). No significant differences in the lengths were noticed between the three coloured gillnets in the case of *Gerres* sp., *H. brachysoma*, *L. dussumieri* and *Carangoides* sp. (Kruskal-Wallis one way ANOVA).

The data on the number of each species caught in the respective gillnets were used for the multivariate tests. Dissimilarity file without any transformation was used for the analysis of similarities (ANOSIM) test, non-metric multidimensional analysis (nMDS) and for cluster analysis (Fig. 4). The global R value for the ANOSIM test was -0.023 with the significance level of 0.08. The similarities percentage analysis showed that major dissimilarity among the groups were for the green and blue gillnets (81.66), followed by species dissimilarity between blue and transparent gillnets (78.19) and green and transparent (76.44). The major species contributing to the dissimilarity between the different coloured gillnets is shown in Table 3. The number of *E.suratensis* in each gillnet was the factor that contributed to the most dissimilarity in all comparisons, followed by *Gerres* sp. and *H. brachysoma*. This trend is noticed in other tests like the chi-squared test which showed a significantly higher number of individuals of *E. suratensis* and *Gerres* sp. recorded in green coloured webbing than the other nets. The stress value for the nMDS was 0.01, which shows good separation of species caught in the three gillnets in multidimensional space (Gamito & Raffaelli, 1992; Lane & Brown, 2007). The low value of stress is reported in some cases of small sample size in studies, but this will not be applicable here, since the data from 30 hauls were used for the analysis.

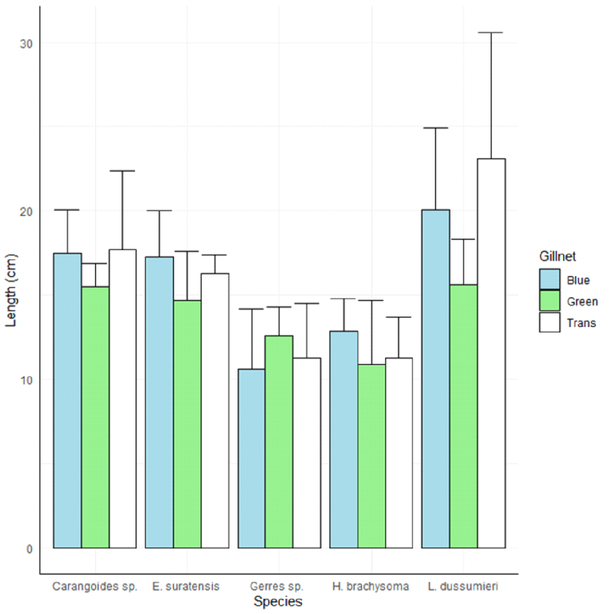

Fig. 3. Mean length (cm) +/- SE of the most abundant species encountered in the different coloured gillnets

The results of the study indicate that the colour of the gillnet has an effect on the total catch, especially for certain species. The majority of the increase in overall captures is attributable to an increase in catches of specific species, such as *E. suratensis* and *H. brachysoma.* Green-colored gillnets had the highest catch rate for three out of the five species for which comparisons with other gillnet colours were possible. The length and number of *L. dussumieri* caught in transparent gillnets was significantly more than in other types of gillnets, revealing a striking contrast. The underwater visibility of gillnets is determined by the colour contrast between the webbing and the background. It is sensitive to time zones, water clarity, and seasonal colour changes (Backiel & Welcomme, 1980). Andreev (1966) advised the use of dark-colored nets in clear or well-lit water and light-colored nets in murky water. The estuarine conditions change often with the tide and are relatively murky, which would have made the green-colored webbing less apparent than the clear webbing, which would have led to greater catches.

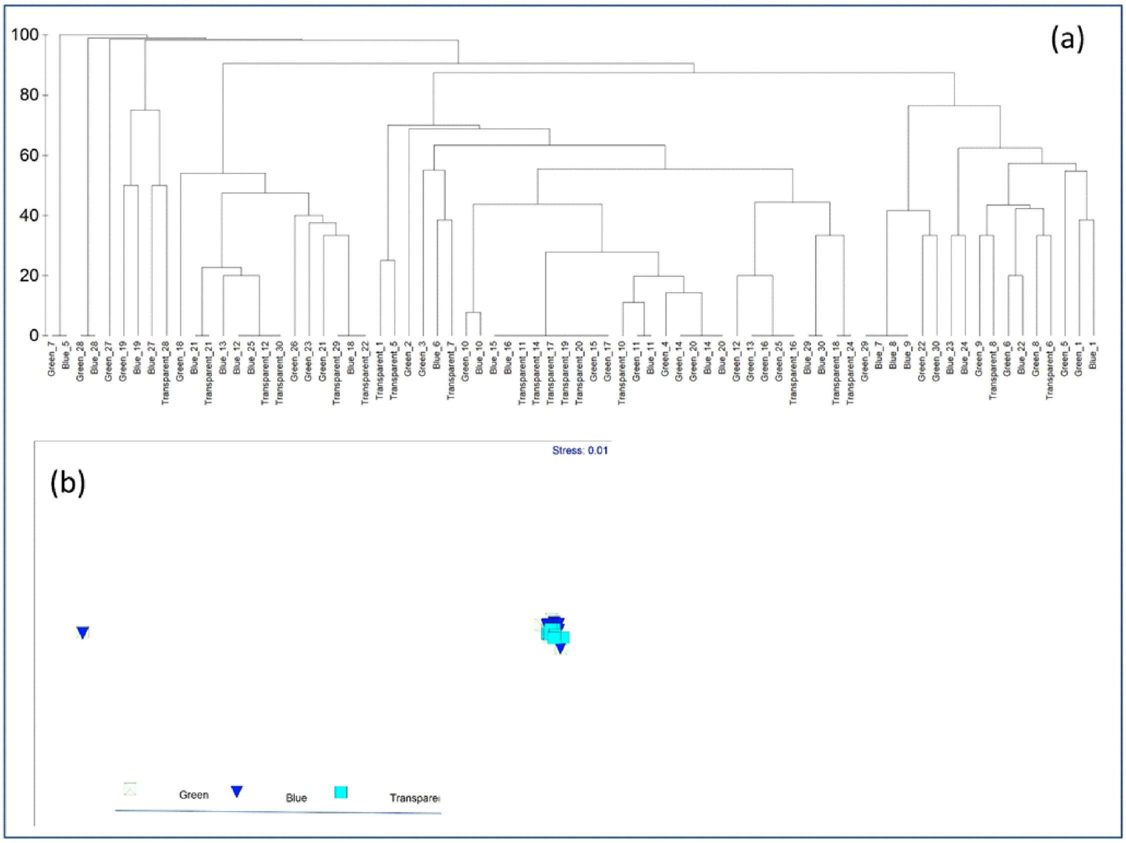

Fig. 4. Results of the multivariate tests (a) representation of the species as clusters (b) nMDS ordination plot of the species assemblages differentiated from three different coloured gillnets in 2-dimensional space

Vembanad lake has experienced a severe decline in its fisheries due to a myriad of challenges, one of which being the use of illicit fishing gears and techniques (Asha et al., 2014). This study helped to generate a baseline data on the effect of the colour of the twine used in gillnets on catch per unit effort and species assemblages, which would be one of the many inputs necessary for implementing gear-based technical management of fisheries in the lake. However, the results of the study were based on a single season, and focused studies spanning the entire season at different locations of the lake would provide a better understanding of the effects of webbing colour on the species profile and the effectiveness of using coloured gillnets for selective capture.

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