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# Comparison of catch efficiency of wire mesh fish traps operated along the coast of Thoothukudi, South-east coast of India

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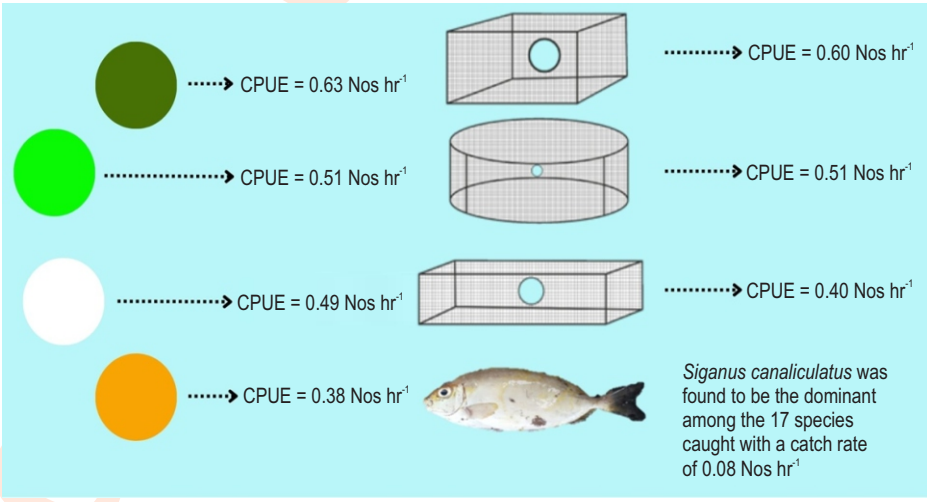
## Abstract

**Aim:** The study designs and fabricates traps with diverse wire mesh colors and shapes for field experiments. It also collects detailed catch data to assess their catch efficiency and determine the most effective design.

**Methodology:** Experimental fish traps were fabricated utilizing four distinct colors (Light green, Dark green, White and Orange) and three different shapes (rectangle, square and circle). Fishing trials were conducted in selected fishing villages of Thereshpuram, with the traps operated fortnightly from June 2022 to May 2023. The catch rate per trip (CPUE) was calculated using the Total catch (in numbers) divided by the Unit Effort (White, 1987). An economic analysis of trap fishery was also performed based on gross revenue and total cost (Geetha *et al.*, 2014).




**Results:** The traps' overall catch per unit effort (CPUE) was recorded at 0.48Nos $hr^{-1}$. *Siganus canaliculatus* emerged as the dominant species among the fishes trapped, constituting 16% of the total catch. Regarding trap color, the highest CPUE was observed with traps of dark green color (0.63 Nos $hr^{-1}$), followed by light green (0.51 Nos hr-1), white (0.49 Nos $hr^{-1}$) and orange (0.38 Nos $hr^{-1}$). Economically, the performance of the trap fishery was evaluated using indicators such as operating cost/year, fixed cost, gross revenue and profit cost ratio. The success of the trap fishery was further emphasized by a benefit-cost ratio (BCR) of 3.50.

**Interpretation:** Dark green-colored, square-shaped traps show promise in significantly enhancing fishermen's profits due to their higher catch per unit effort (CPUE) compared to other colors. Moreover, dark green traps may offer ecological advantages by blending into natural surroundings. This study highlights their potential and provides practical insights for fishermen to make informed gear choices, considering factors like color and shape.

**Key words:** BCR, Color, CPUE, Shape, Trap

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## Introduction

Trap fishing is one of the energy-efficient age-old fishing methods, and it is widely practiced worldwide in both tropical and temperate seas. Pots and traps are gears that make the entry of aquatic species and escapement difficult due to unique designs (Hawkins *et al.,* 2007). Net color influences fish catch efficiency, especially at different depths where colors are filtered differently. The visibility of the nets depends on the net color; the tone contrasted with the background, and the species of fish, which might be affected by the time of day and the seasonal changes in water clarity or color. Fish are myopic; therefore, they can see 10 m at a 20 m depth from the surface (Balık and Cubuk, 2001). The choice that fishermen often make in selecting colors and their intensities may be dependent on such factors as costs, availability of the material, netting color contrast for easier removal of the fish from the net after gear retrieval (Grimaldo *et al.,* 2019), and assumed catch efficiency of the gear (Hanamseth *et al.,* 2018). Furthermore, the color of lures may influence the catch rates in both longline (Hsieh *et al.,* 2001) and amateur fisheries (Moraga *et al.,* 2015; Wilde *et al.,* 2003).

Atessahin and Cilbiz (2019) assessed the effectiveness of different spinner colors in angling for rainbow trout in Karakaya Dam Lake (Malatya, Turkey), and it was found that red spinners yielded a catching percentage of 55.4%, followed by blue spinners at 26.2%, and yellow spinners at 18.5%. The mean CPUE values for red, blue and yellow spinners were 0.108, 0.051, and 0.036, respectively. Altinagac (2006) reported that green jigs were more effective than red ones in squid fishing in Turkey. In Beyżehir Lake (Turkey), green nets are commonly used by fishermen, with dark green nets particularly effective for catching carp and pike fish compared to light green ones (Balık and Cubuk, 2001). Ajik *et al.* (2023). investigated multiple troll lines utilizing two different lures, green and blue, and it was found that the numerous troll lines equipped with the green lure achieved the highest mean CPUE at 0.63±0.12 kg $hr^{-1}$, while the blue lure resulted in a mean CPUE of 0.35±0.7 kg $hr^{-1}$. Additionally, in a study conducted by Asia and Garcia (2009), it was observed that the CPUE of multiple handlines tended to increase with greater hook distances, and red lures yielded relatively higher CPUE compared to silver lures. Many comparative studies have been conducted worldwide on the color of netting materials in gill nets, long lines, and squid jigs. Still, no study has been conducted on the effect of netting color on the catch efficiency of fish traps. However, various global attempts have been made to study the impact of trap design, funnel design, and mesh size on catch efficiency. Besides, the traps operated by the fishermen of the Thoothukudi coast are made of natural materials like palmyra or bamboo sticks. Due to limitations such as durability and shelf life of traps made of natural material, nowadays, synthetic materials such as different colored plastic wire mesh available in the local market are used to fabricate traps around Thoothukudi coast. In view of the above, this study was conducted to assess the effectiveness of wire mesh fish traps varies with different colors and shapes.

## Materials and Methods

**Description of the study area:** The present study was carried out in the selected fishing grounds of Therespuram fishing village (Latitude: 8.834719 N, Longitude: 78.19163 E) (Fig. 1) stands as a significant fishing village within the Thoothukudi district, where fishermen are actively involved in various fishing activities including Chank fishing, longline fishing and gill net fishing. The village supports a considerable fishing fleet, with approximately 150 boats engaged in gill netting cum long line fishing, alongside another 100 boats involved in Chank fishing. Experimental fish traps were deployed from the shoreline to 10 nautical miles, covering depths ranging from 10 to 15 m. This strategic operation allows complete fishing trials within the specified area, enabling researchers to assess the effectiveness of different trap designs and colors in capturing target species.

**Fabrication of fish traps:** Four different colors, such as light green, dark green, white and orange, and three different shapes, viz. rectangle, square and circle, were used to fabricate experimental traps by using square-shaped wire mesh with a mesh size of 40mm. Rectangular-shaped traps were fabricated with dimensions 120 Lx70 Bx45 H cm, while square-shaped fish traps with dimensions 120 Lx120 Bx45 H cm (LxBxH) and circular-shaped traps with dimensions 120 cm dia x 45 cm (Table 1). A circular funnel was fabricated with a total length of 40 cm and 20

**Table 1:** Characteristics of three different traps used in this study.

| Trap shape | Dimensions LxWxH (cm) | Frame | Mesh size | Funnel dimension | Trap volume ($cm^3$) |
|---|---|---|---|---|---|
| Rectangle | 120x70x45 | Plastic wire mesh with 2 cm thickness | 40 mm square mesh | A circular shaped funnel with a total length of 40cm and a diameter of 20cm at the front end and 10cm | 378000 |
| Square | 120x120x45 | Plastic wire mesh with 2 cm thickness | 40 mm square mesh | A circular shaped funnel with a total length of 40cm and a diameter of 20cm at the front end and 10cm | 648000 |
| Circle | 120 x 45 | Plastic wire mesh with 2 cm thickness | 40 mm square mesh | A circular shaped funnel with a total length of 40cm and a diameter of 20cm at the front end and 10cm | 5400 |

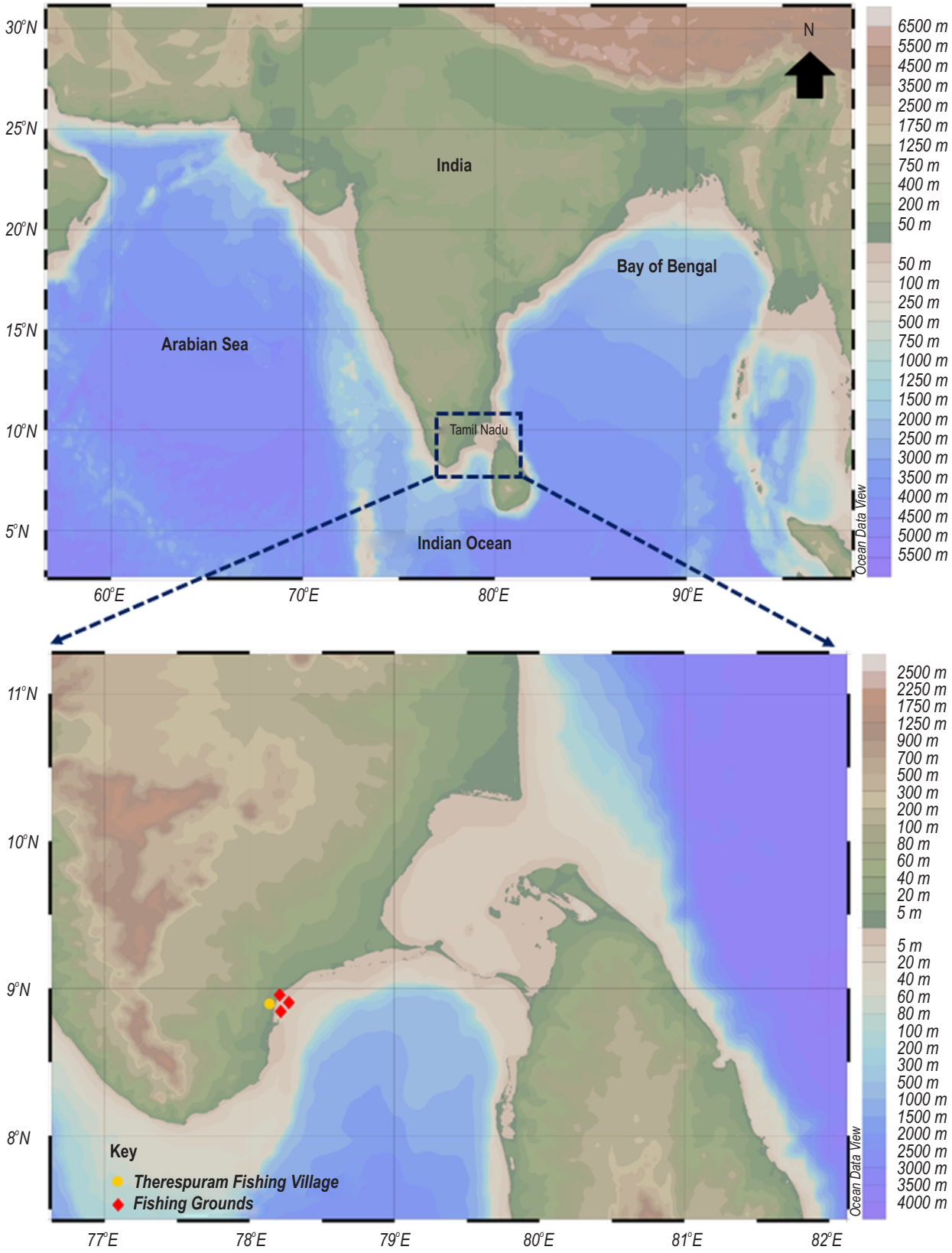


**Fig 1:** Map showing the study area.

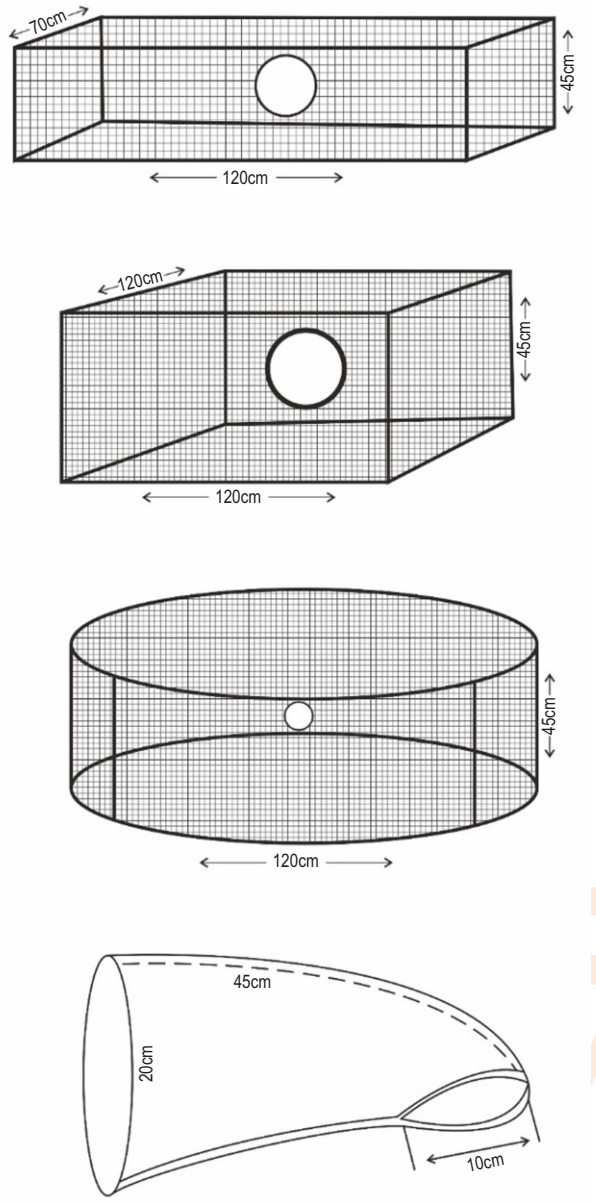


**Fig. 2:** Design details of experimental fish traps.

cm diameter at the front end and 10 cm at the back end (Fig. 2). The funnel was designed with a large entry in its front and gradually narrowed to its back. The bait bag was made of polyethylene webbing with a mesh size of 20 mm and was placed opposite to the funnel. Shrimp head waste was used @ 1kg per trap as bait to attract the fish into the trap. These traps were operated from the shore to 10 nautical miles (NM), having a depth range of 10- 15 m. The traps were kept for 24 hrs for all the fishing trials. While operating, the traps were placed at the sea bottom with the help of sinkers made of iron rods weighing 1kg was fixed to the bottom of the trap, and two bags filled with 5 kg sand each were placed on both sides of the iron rod to prevent the movement of the trap. About 5-7 crew per boat were engaged to operate the fish traps. They were hauled in the morning, and the bait was changed daily.

**Sampling methodology:** For each combination of four colors and three shapes, 12 traps were fabricated, and these traps were triplicated. Each set of triplicate traps was deployed in the same location. Thus, thirty-six (36) traps were used simultaneously for sampling during the study period. The samples were collected monthly twice for one year from June 2022 to May 2023. The collected fish samples were identified, and species were confirmed by referring to standard literature (Fischer and Bianchi, 1984; Nelson, 2016). They were updated with Fish Base (Froese and Pauly, 2000).

**Data analysis:** The Catch Per Unit Effort (CPUE) was calculated as per the equation of White (1987).

Unit Effort = Number of Traps operated x Soaking hours in the water; Total catch = Total catch in numbers from one collection from the trap in 24 hr.

**Economic analysis:** The economic performance of fishing methods was assessed by working out the following indicators: Operating cost /year = (Fuel charges + Food expenses + Ice charges + Miscellaneous). The fixed cost (FC) was calculated as the sum of depreciation of craft, gear, and engine (12%), interest on capital cost, insurance and repair and maintenance. The gross revenue is calculated from the species composition of the catch and price per species. The gross revenue was estimated by the formula given below:

$$GR \text{ per year} = \sum_{i=1}^{n} qi\ pi$$

**Statistical analysis:** Differences in the catch rates among the species and months were determined by ANOVA. Benefit cost ratio for both FC and operating cost was estimated for evaluating the economic performances of fish trap.

## Results and Discussion

Seventeen species of marine fin fishes belonging to thirteen families were caught in fish traps during the experimental period (Fig. 3). Based on the market price, the fishes caught in traps were categorized into commercially important fishes and low-valued fishes. The commercially important fishes included, *Scarus ghobban* (blue-barred parrotfish), *Cheilinus chlorourus* (Floral wrasse), *Psammoperca waigiensis* (Waigieu seaperch), *Scolopsis bimaculatus* (Thumbprint monocle bream), *Scolopsis vosmeri* (White cheek monocle bream), *Siganus canaliculatus* (white-spotted rabbit fish), *Acanthurus nigricauda* (Epaulette surgeon fish), *Cephalopholis formosa* (Blue lined hind), *Lutjanus fulviflamma* (Dory snapper), *Plectorhinchus ceylonensis* (Sri Lanka sweetlips), *Lethrinus nebulosus* (Spangled emperor) and *Plectorhinchus sordidus* (Sordid rubber lip), while the low market valued species trapped were *Abudefduf saxatilis* (Sergeant-

**Fig. 3:** Fishes caught in the experimental fish traps.

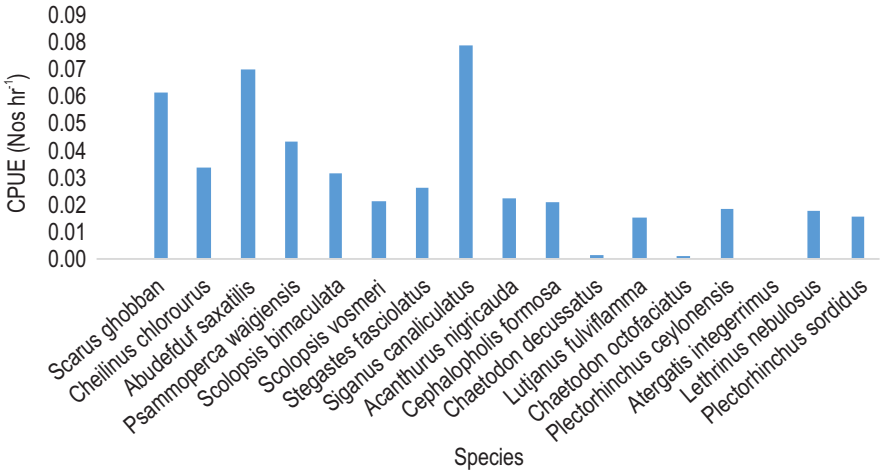


**Fig. 4:** Species-wise CPUE of fishes caught in the experimental traps

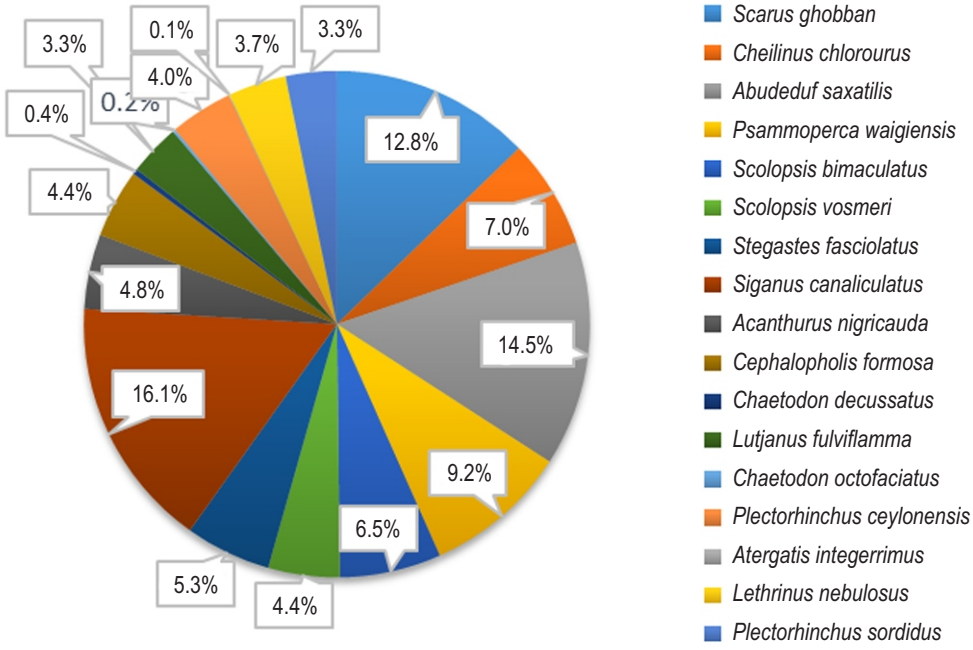


**Fig. 5:** Species composition of fishes caught in the experimental traps.

major), *Stegastes fasciolatus* (Pacific gregory), *Chaetodon decussates* (Indian vagabond butterfly fish), *Chaetodon octofasciatus* (Melon butterfly fish), and *Atergatis integerrimus* (Red egg crab). A total of 10,420 aquatic organisms were caught in the traps. In terms of numbers, the overall CPUE per trip of experimental fish traps was found to be 0.48 Nos $hr^{-1}$. Beenamol *et al.* (2017) observed that Siganidae dominated catches during October (51%) and November (83%), while from December to March, Scaridae dominated. However, in the present study, *Siganus canaliculatus* was found to be the dominant species with a catch rate of 0.08 Nos $hr^{-1}$ (Fig. 4.) throughout the study period. Regarding month-wise catch rate, the highest catch was recorded during February, with a catch rate of 0.71 Nos $hr^{-1}$ CPUE per trip (Fig. 6). Concerning length, weight and cost, *Scarus*

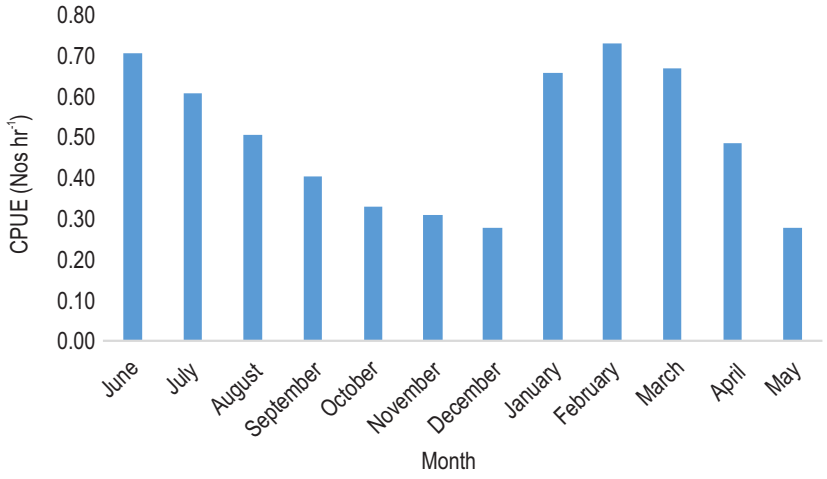


**Fig. 6:** Month-wise CPUE of fishes caught in the experimental fish traps.

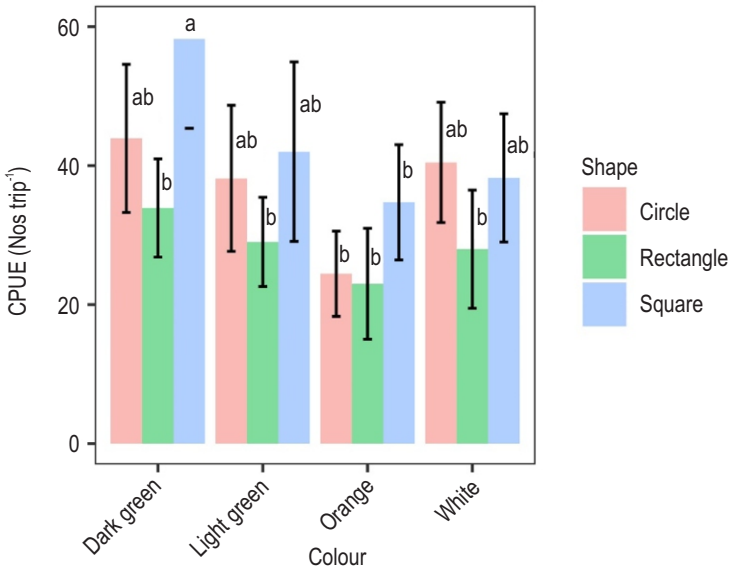


**Fig. 7:** Two-way ANOVA of fishes caught (CPUE) in the experimental fish traps (Colour wise).

*ghobban* (32 cm, 0.75 kg and Rs 500 per kg) was found to be the highest, and *Chaetodon octofasiatus* (3.5 cm,14 g and Rs 60 per kg) was lowest in number caught by experimental fish traps. Varghese *et al.* (2017) reported that *Siganus canaliculatus* dominated (28%), followed by *Scarus ghobban* (21%), among the 98 species of reef fishes that landed in the trap fishery of Gulf of Mannar. Similar findings were observed in our study, with *Siganus canaliculatus* as the most dominant species contributing about 16% of the total catch followed by *Abudefduf saxatilis* (15%), Scarus ghobban (13%), *Psammoperca waigiensis* (9%), *Scolopsis bimaculatus* (7%), *Scolopsis vosmeri* (4%), *Stegastes fasciolatus* (5%), *Acanthurus nigricauda* (5%), *Cephalopholis formosa* (4%), *Lutjanus fulviflamma* (3%), *Plectorhinchus ceylonensis* (4%), *Lethrinus nebulosus* (4%) *Plectorhinchus sordidus* (3%) *Cheilinus chlorourus* (7%), *Chaetodon decussatus* (<1%), *Chaetodon octofasciatus* (<1%) *Atergatis integerrimus* (<1%), respectively (Fig. 5). George *et al.* (1977) found that yellow-colored gill nets had the highest catch rate (6.45 kg per 100 $m^2$ of webbing) compared to orange, green, and blue gill nets at Govindsagar reservoir. Despite their findings, in the present study, it was found that the highest CPUE was recorded in dark green color (0.63 Nos $hr^{-1}$) followed by light green (0.51 Nos $hr^{-1}$),

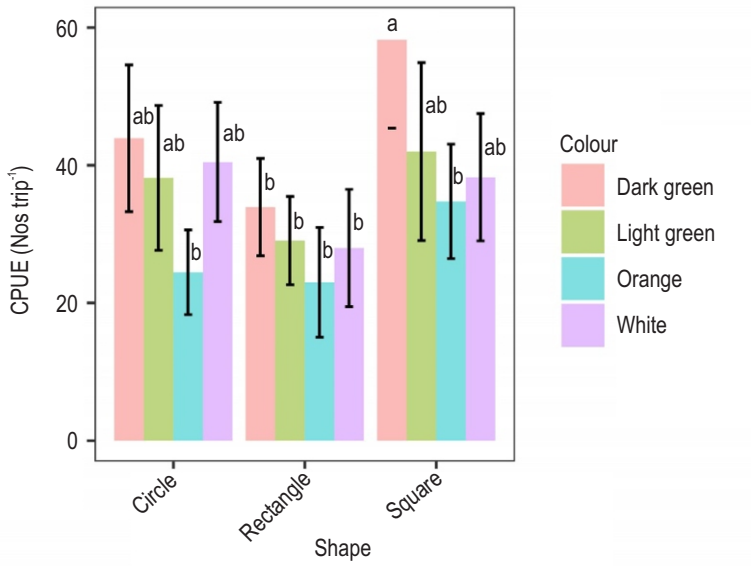


**Fig. 8:** Two-way ANOVA of fishes caught (CPUE) in the experimental fish traps (shape-wise).

**Table 2:** Economic analysis of experimental fish traps

| Particulars | Amount in Rupees |
|---|---|
| Capital cost | |
| FRP boat | 400000 |
| Engine and Propeller | 100000 |
| Trap (36 Nos.) | 24000 |
| Icebox (2 nos) | 1600 |
| Total Capital Cost | 525600 |
| Variable cost | |
| labor (5Nos) | 5000 |
| Fuel (@Rs.95 | 1425 |
| Bait/trip/36 traps | 1000 |
| Miscellaneous | 500 |
| Total Variable Cost | 7925 |
| Fixed Cost /Year | |
| Registration & Fishing License | 6000 |
| Depreciation @ straight line method | 43200 |
| Interest on Capital cost @12 % | 63648 |
| Repairs & maintenance | 5000 |
| Total Fixed Cost (TFC) | 117848 |
| TFC per fishing trip (25 trips/month) | 390.9 |
| Total Cost (TVC+TFC) | 8315.9 |
| Total Returns (Rs $Kg^{-1}$) | 29184 |
| Net returns/profit | 20868.1 |
| Benefit Cost Ratio @TC | 3.509422 |
| Benefit Cost Ratio @TVC | 1.7 |

white (0.49 Nos $hr^{-1}$) and orange (0.38 Nos $hr^{-1}$), respectively (Fig. 7). This outcome may be attributed to the green color combination with the sea background and the contrasting nature of the orange color against the sea background. Our findings correlate with those of Hlordzi *et al.* (2020), who similarly observed the increase in the catching efficiency of green-colored gill nets and concluded that this effect is due to the masking of the color of the net with that of the seawater as a result of the growth of green algae in the water thereby reducing visibility to aquatic fauna. By this hypothesis, Cerbule *et al.* (2023) investigated the impact of different gillnet colors, such as transparent, green and blue on catch efficiency in the pearl spot (*Etroplus suratensis*) fishery in Vembanad Lake, India. Green-colored gill nets exhibited significantly higher catch efficiency, recording an 81% increase compared to transparent and blue gillnets.

In addition, Balik and Cubuk (2001) demonstrated that dark green nets were particularly effective compared to light green ones, similar to our study where dark green traps exhibited higher CPUE than light green colored traps (Fig. 7). Aminisarteshnizi (2022) exhibited the performance of Opera house traps superior to cylindrical and Hokkaido-shaped traps. The present research revealed that the square-shaped trap attained the highest CPUE (0.60 Nos $hr^{-1}$), followed by the circle (0.51 Nos $hr^{-1}$) and rectangle (0.40 Nos $hr^{-1}$) traps, respectively (Fig. 8). This result can be attributed to the larger volume of square-shaped trap (6,48,000 $cm^3$), which allows more fish to enter and get captured, compared to the circle (5400 $cm^3$) and rectangle-shaped traps (3,78,000 $cm^3$). Additionally, the shape and volume of the trap may also affect how much fish can easily enter and get retained in the trap. For instance, circle-and rectangle-shaped traps were laterally compressed during operation, which led to the accumulation of fish at the rear end of the funnel inside the trap and to prevent the entry of new fish.

The larger volume of the square-shaped traps could potentially offer more free swimming space without blocking the entrance, thus providing more access for the fish to enter the trap and interact with the bait bag at the rear end of the funnel, leading to a higher catch rate compared to circle and rectangular traps. Consequently, the study concludes that the square-shaped trap is a suitable gear choice due to its efficient catches. Similarly, Khanipour and Melnikov (2007) investigated the comparative efficiency of different trap types, including rectangular and round-shaped traps, and their findings indicated that the mean annual CPUE in opera-shaped traps was 7.5 times higher than rectangle-shaped traps and four times higher than circle-shaped traps. This explains the superior catch performance of square-shaped traps in the present study compared to a rectangle and circle-shaped traps. The result of Two-way ANOVA revealed a significant difference in the catch when grouped by color and shape ($p<0.05$). However, there was no significant interaction ($P>0.05$) between the combined effect of color and shape on the catch rate. Therefore, the combined effect of color and shape on the catch rate is independent (Fig. 7, 8). The economic evaluation of trap fishery in Therespuram fishing village demonstrated that it is profitable for fishermen (Table 2). The benefit-cost ratio (BCR) calculated for the trap fishery stands at 3.50, indicating significant economic success and highlighting the effectiveness of trap fishing in Therespuram fishing village. According to the findings, this study would pave the way for fishermen to choose appropriate colors and shapes to fabricate traps to improve catch efficiency.

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**Authors' contribution: S. Mariappan:** Sample collection from fish landing centers and species identification; authored and prepared the first version of the manuscript; **T. Ravikumar:** Conceptualization of the theme and the idea of the research, Reviewed drafts of the manuscript, and approved the final version; **N. Neethiselvan:** Critical review of the research work and Reviewed drafts of the manuscript and approved the final version; **E. Dineshkumar:** Technical contributions to data analysis were carried out in collaboration with the research team; **N. Dhilipmaniraj:** Reviewed drafts of the manuscript; **S. Manickavasagam:** Helped in the identification of species.

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**Research content:** The research content of the manuscript is original and has not been published elsewhere.

**Ethical approval:** No animals were harmed during the entire research.

**Conflict of interest:** The authors declare that they do not have any conflict of interest.

**Data availability:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Consent to publish:** All the authors have gone through the manuscript and agree to publish the manuscript in *Journal of Environmental Biology.*

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