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ORIGINAL ARTICLE

# Investigates trammel net size selectivity as a critical metier for management of small scale fisheries at Aswan City, Nile River

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**Abstract**
Monofilament trammel net fishing tests were conducted in Aswan's River Nile to evaluate trammel net size selection and its impact on dominant species. Selectivity was determined for *Oreochromis niloticus* and *Coptodon zillii* captured using 56-, 64-, and 76-mm inner layer mesh sizes. The selectivity parameters were calculated using SELECT method. The bi-modal model accurately fit the selectivity curve for *O. niloticus* and *C. zillii.* In contrast, the linear equation described length-girth relationships: G= 0.7263TL+0.8342 for *O. niloticus* and G= 0.6957TL+1.5202 for *C. zillii*. The linear equation D= 0.361TL+0.3071 for *O. niloticus* and D= 0.3611TL+0.3886 for *C. zillii* described length-depth relationships. This study is the first to examine trammel net selectivity in Aswan, Egypt. The effects of mesh sizes on *O. niloticus* and *C. zillii* stock may be useful. To support *O. niloticus* and *C. zillii* stocks, Aswan fisherman should use 64-mm mesh nets.

**Keywords:** *Oreochromis niloticus*, *Coptodon zillii*, Select model, Mesh size

## INTRODUCTION

Nearly half of the seafood intended for human consumption is produced by small-scale fisheries (SSFs), which employ over 90% of all fishermen globally and provide jobs and food security for millions of people (FAO 2019; Nomura et al. 2022). Consequently, improved regulatory measures to regulate small-scale fishing operations that use non-selective fishing gear and techniques are needed to reduce their negative impact on fish populations and the incomes of small-scale fishing communities (Sabre & Aly 2023), Trammel nets are frequently employed inside Egyptian seas and play a crucial role in artisanal fishing endeavors (Saber et al. 2022). Trammel nets are widely used in both freshwater and marine water fisheries of Egypt, but the use of trammel nets is more common than gillnets especially in northern lakes as well as the Nile River and its tributaries in combination with third class canoes with an average 2 men (El-Bokhty 2004). It is a type of passive fishing gear, it is similar in their construction and methods of fishing with gill net. it is consist of three net panels, two outer large mesh size and a single inner small mesh size panel, are less species and size-selective than gillnets, netting panels suspended vertically in the water column (Gray et al. 2005; Grimaldo et al 2019). The catch mechanisms of trammel nets mainly catch fish and invertebrates by pocketing or trammeling (Erzini et al. 2006). In Aswan region the availability of research on the selectivity of trammel nets is limited (El-Bokhty & El-Far 2014). The fisheries in the River Nile are a one of the main source of fish production in Egypt. In 2020, 79533 tons of fish were produced in the River Nile, which accounted for approximately 18.99% of Egypt's total inland fish production (Gafrd 2020).

*O. niloticus* and *C. zillii* are the two most prevalent species in the Aswan sector, with *O. niloticus* making up more than 88% of the catch composition and *C. zillii* making up the remaining fraction (El-Bokhty & El-Far 2014). The relationship between total body length & body girth (LGR) in fish is important for comparing life histories and morphology between species or populations (Santos et al. 2006). The calculation of gear selectivity, as both length and girth have an important impact on the retention of fish by

different fishing gears, as well as the estimation of girth from length measurements, which are easier and more frequently available onboard (Stergiou & Karpouzi, 2003). Our current research aims to assess the size selection of trammel nets in the Nile River in Aswan, Egypt. Instead of evaluating the influence of various inner layer mesh sizes on the *O. niloticus* and *C. zillii* populations, Develop a management strategy for the most prevalent species in the Nile River in Aswan, Egypt.

## MATERIAL AND METHOD

**Study area:** The experimental fishing was conducted in River Nile at Aswan city (24° 2'4.68"N to 24°11'35.14"N). This region extended to about 18.6 Km in length (Fig. 1). To cover the whole area, four stations of fishing grounds were chosen (Ferial, Elmahata, Aboelrish and Bahreef), the ground of these areas is characterized by muddy and rocky bottom with depths ranging between 1.5 to 2.5m.

**Survey analysis:** Seven interviews were conducted with the fishermen to document the trammel net specifications. At this work the trammel net that used to do the experiment locally called "Eldak. Materials that used to construct the trammel nets are Naylon (Polyamide) with lightly yellow color. It is also distinguished by having an outer and inner monofilament layer installed on the upper float line and lower lead line. There are also some floats attached to the upper layer and some leads attached to the lead line. The specification of the commercial trammel nets is summarized as following, the total length of the nets ranged from 70 to 120m with the same depth 1.5m. The Inner layer ranging between 50 to 88.9mm with the thickness of the filament range from 0.08 mm to 0.14mm but the outer layer almost stationary as 152.4mm, with thickness of the filament ranger from 0.18 to 0.21mm. All fishermen shooting the net from 9 am to 6pm.

**The experimental fishing:** Total of 780 specimens of the cichlid species *O. niloticus* and *C. zillii* were collected from four stations during the period from December 2020 to November 2021, using experimental trammel net. Sampling was carried out

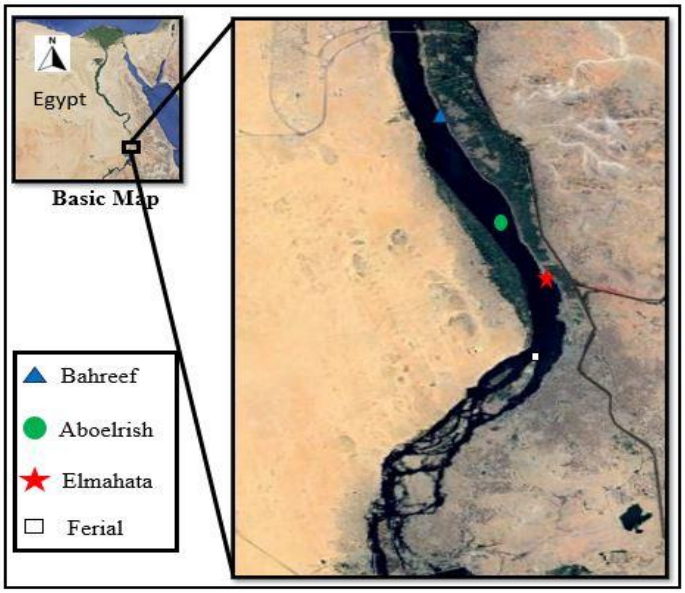


**Fig.1.** Satellite images showing the location of study in the River Nile at Aswan city, Egypt.

by small fishing vessels (symbok) without engines working by paddle. Two cichlid species (*O. niloticus* and *C. zillii*) were collected using improved nets, and the total length (TL) was measured with an accuracy of 0.1cm, while the total weight was measured with an accuracy of 0.1g.as well as the weight of the gonad, liver, and gutted weight were measured. Three of modified trammel nets with inner layers mesh size 56, 64 and 76mm, while the outer layer mesh size was 152.4mm for three nets. The three nets were constructed with the same twine diameter 0.13mm in inner layer and 0.21mm for outer layer (Table 1). The nets were used by one small fishing boat (symbok) in this experiment.

**Selectivity analysis:** The Millar (1992) SELECT method evaluates trammel selectivity curves. Millar & Holst (1997) and Millar & Fryer (1999) explain this gill net method. This method may catch (nlj) with a Poisson distribution based on length class (l) and gear size (j). pj (l) shows the relative catch and possibility that a fish of length l will engage with a piece of gear of size j if it contacts the combined gear.

Fish of length l contacting the combined gear are abundant. Common uses of the SELECT Modal:

$$n_{lj} = \text{Pois}\,(P_j\, \lambda_l\, r_j\, (l)) \qquad (1)$$

The number of fish of length (l) that were captured is represented as nlj using a mesh size of j and a

**Table 1.** Specification of modified trammel net used in fishing operations.

| Parameter | Net A | Net B | Net C |
|---|---|---|---|
| Gear Length(m) | 70 | 70 | 70 |
| Gear height(m) | 1.5 | 1.5 | 1.5 |
| Outer layer (mm) | 152.4 | 152.4 | 152.4 |
| Filament type | Mono | Mono | Mono |
| Filament thickness(mm) | 0.21 | 0.21 | 0.21 |
| Inner layer(mm) | 56 | 64 | 76 |
| Filament type | Mono | Mono | Mono |
| Filament thickness (mm) | 0.13 | 0.13 | 0.13 |
| Floating line thickness (mm) | 0.5 | 0.5 | 0.5 |
| Crock Size | Med | Med | Med |
| Distance in between (cm) | 100 | 100 | 100 |
| Lead line thickness (mm) | 0.5 | 0.5 | 0.5 |
| Lead weight (g) | 48.5 | 48.5 | 48.5 |
| Distance in between(cm) | 50 | 50 | 50 |
| Hanging ratio | 0.46 | 0.4 | 0.46 |
| Fishing duration | 9am-1pm | 9am-1pm | 9am-1pm |
| No. of spread | 36 | 36 | 36 |

Poisson distribution using the formula pj (l) l rj.

The proportion of fishing effort is given by pj (l) for all fishes with length( l) in the fishing methods ( j'); l is the total abundance of fish at length( l) ; and rj (l) indicates the chance that a fish of length (l) will be retained in the fishing nets ( j)'. The following equation represented log likelihood function (nlj).

$$\Sigma_l \Sigma_j \{n_l \log e [p_j \lambda_l r_j (l)] - p_j \lambda_l r_j (l)\} \quad (2)$$

Kolding and Skålevik (2011) used Pasgear 2 software version 2.5 to evaluate the selectivity of trammel nets for *O. niloticus* and *C. zillii*. Five probability distribution models were used. These mathematical models were applied using Gill net and trammel net's selectivity software (Millar 1992; Millar & Holst, 1997, 1999; Millar & Fryer 1999). After comparing all models' standard deviations, the one with the lowest was chosen. (Acarlı et al. 2013).

Normal location: (3)

Normal scale: (4)

Log-normal: (5)

Gamma: (6)

Bi-normal: (7)

Where: $\mu_i$: mean length of species collected by mesh size i (mi).

$\sigma_i$: standard deviation of total length of species collected by mesh size i (mi).

$L_j$: mean length of species with length class j.

$m_1$: the lowest mesh size.

k, α, and ω are constants.

The smallest value for the ratio D/df corresponds to the best fitting model, and the degree of freedom for deviance D/df was compared and the deviance residual plots were analysed (Fonseca et al., 2005).

**Morphometric analysis:** The body length-girth relationship (LGR) is calculated using the formula G= a+bL. Where is the G is fish's girth and a, b, and are the intercept and regression coefficient (slope), respectively, L is Total length of fish (Santos et al. 2006).

The total length and body depth relationship was determined for each fish species using equation.

D= a+bTL.

**The length at first sexual maturity:** The length at first maturity ($L_m$) means that the length at which 50% of the population matures was computed. The data of maturity stage were demanded to estimate the Lm, the first and second maturity stages were considered immature and the above stages were considered as mature fish, Length at first sexual maturity were obtained (at 50%) by plotting mature fish frequency percentage against their length (King 1995).

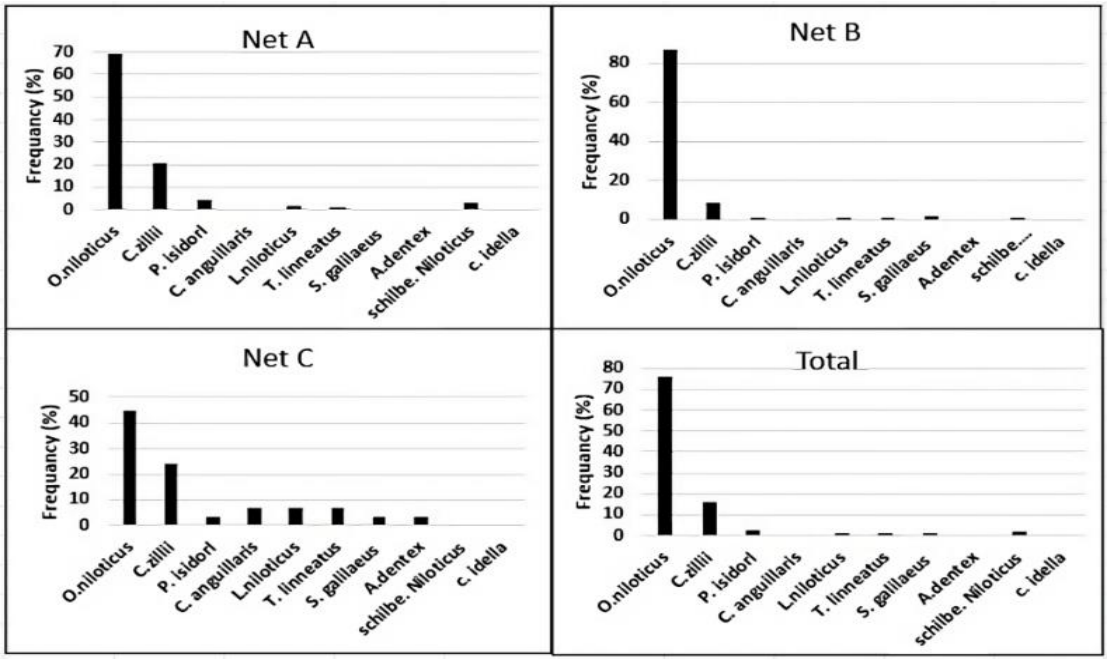


**Fig.2.** The percentage of species which caught by net A, B and C from the River Nile, Aswan city.

**Table 2.** The trammel net selectivity model parameters estimated by the SELECT model (MD: Model deviance, df: degree of freedom, P= probability).

| Species | Model | Equal fishing powers Parameters | M. D. | P | d.f. |
|---|---|---|---|---|---|
| *Oreochromis niloticus* | Normal location | (k, σ)= 0.28, 1.744 | 102.06 | 0.00 | 24 |
| | Normal scale | (k1, k2)= 0.287, 0.028) | 122.52 | 0.00 | 24 |
| | Gamma | (k,α)= 0.003,104.63 | 102.33 | 0.00 | 24 |
| | Log normal | (μ, σ)= 2.772,0.098 | 93.68 | 0.00 | 24 |
| | Bi-modal | (k1, k2, k3, k4, c)= 0.275, 0.019, 0.342,0.039 | 48.75 | 0.000542 | 21 |
| *Coptodon zillii* | Normal location | (k, σ)= 0.281,2.014 | 22.69 | 0.202 | 18 |
| | Normal scale | (k1, k2)= 0.285,0.030 | 18.62 | 0.415 | 18 |
| | Gamma | (α, k)= 76.211, 0.004 | 19.71 | 0.349 | 18 |
| | Log normal | (μ, σ)= 2.782, 0.121 | 20.5 | 0.305 | 18 |
| | Bi-modal | (k1, k2, k3, k4, c)= 0.281, 0.025, 0.365, 0.077 | 16.23 | 0.366 | 15 |

## RESULTS

**Experimental fishing:** For catching cichlid species, the trammel nets are widely used in River Nile in Aswan city, which are known as ELdak. Each net spread was 36 times during the studying period. A total of 780 specimens of 848 specimens belonging to cichlid species *O. niloticus* (No. 647) and *C. zillii* (No. 133) were caught by modified nets, so the *O. niloticus* consider the dominant species in study area with percentage 76.1% followed by *C. zillii* with percentage 15.68 %, and other species represented 8.13% (Fig. 2).

**Selectivity analysis:** The selectivity parameters for *O. niloticus* and *C. zillii* were determined independently using the PASGEAR II computer software, and the results are shown in Table 2. The Bi-modal for *O. niloticus* with degree of freedom 2 give the smallest deviance value as the same as in *C. zillii*. (Figs. 3 and 4). This study presents catch and selectivity curves for the dominant species in the catch, using three distinct mesh sizes. The size-frequency distributions of *O. niloticus* and *C. zillii*

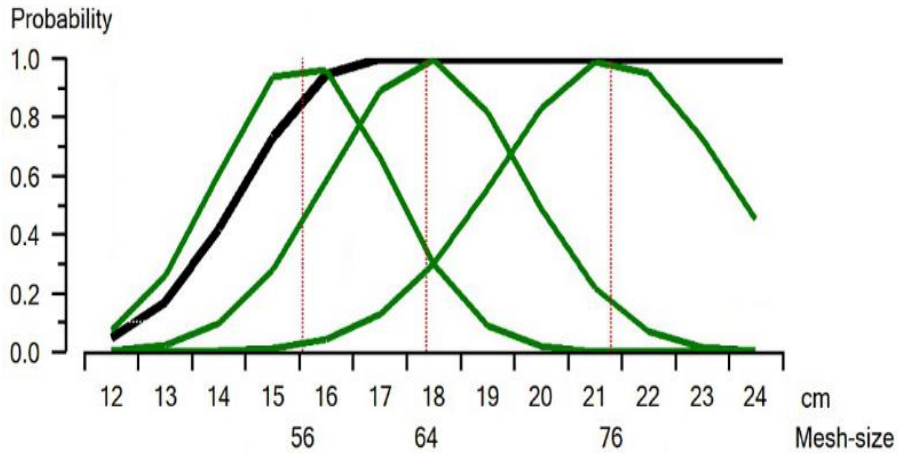


**Fig.3.** Selectivity curves of monofilament trammel nets for *O. niloticus* from the River Nile, Aswan city.

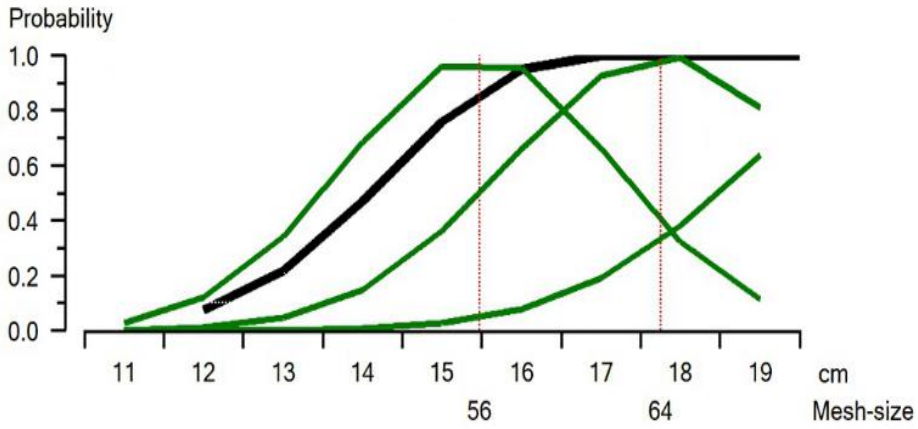


**Fig.4.** Selectivity curves of monofilament trammel nets for *C. zillii* from the River Nile, Aswan city.

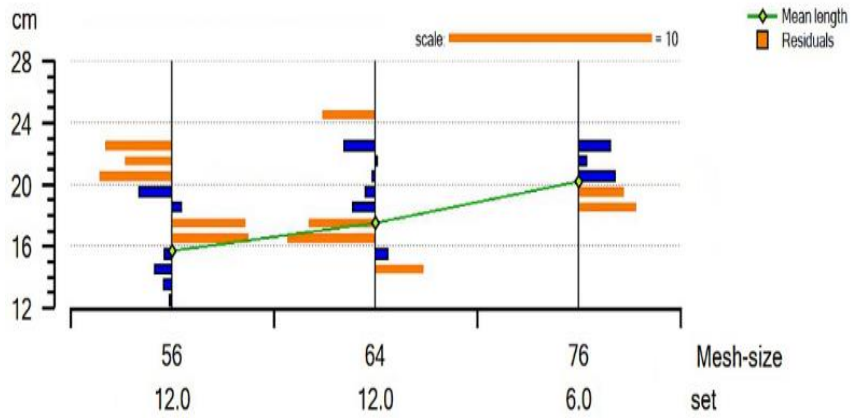


**Fig.5.** Deviance residuals of the selectivity curves estimated for *O. niloticus* from the River Nile, Aswan city.

recorded using mesh sizes of 56, 64, and 76mm exhibit a rightward shift as the mesh size increases. In comparison, the average total length of *O. niloticus* is 15.8±1.6, 18.1±1.4 and 21.4±1.3 for net A, B and C respectively. While the average total length of *C. zillii* is15.7±1.2, 18±1.8 and 20.2±1.7 for net A, B and C respectively. The deviation residual plots of the two species' estimated selectivity curves are shown in (Figs.5 and 6). The selection factors for *C. zillii* and *O. niloticus* vary across the three different net mesh sizes (nets A, B, and C), indicating distinct efficiencies in capturing each species at specific sizes.

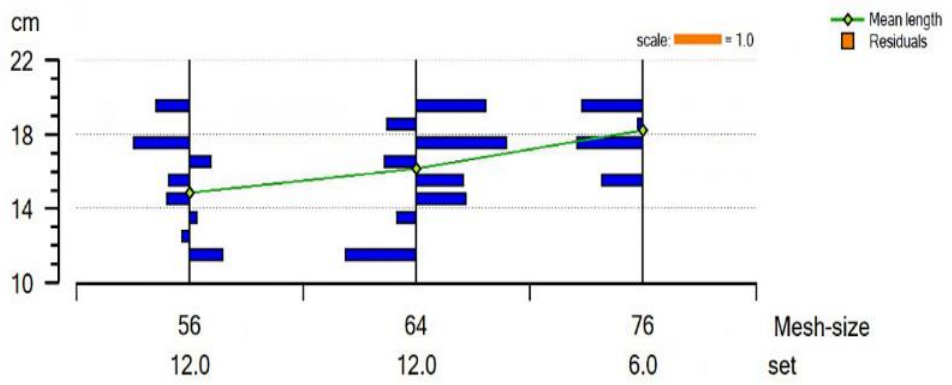


**Fig.6.** Deviance residuals of the selectivity curves estimated for *C. zillii* from the River Nile, Aswan city.

**Table 3.** Morphometric measurements of *O. niloticus* and *C. zillii* from the River Nile, Aswan city.

| species | Measurements (cm) | Number | Min | Max | Mean ± SD | TL (%) | Y= bx+a | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| *O. niloticus* | Total length (TL) | 647 | 12 | 24.3 | 16.64±1.73 | | | |
| | Standard length (SL) | | 9.5 | 19.5 | 13.1±1.48 | 78.7 | y= 0.7866x+0.0553 | 0.96 |
| | Body depth (BD) | | 4.9 | 9 | 6.3±0.73 | 37.8 | y= 0.361x+0.3071 | 0.82 |
| | Body Girth (BG) | | 10 | 18.3 | 12.89±1.47 | 77.5 | y= 0.7263x+0.8342 | 0.82 |
| *C. zillii* | Total length (TL) | 133 | 11 | 19.9 | 15.36±1.61 | | | |
| | Standard length (SL) | | 8.5 | 15.5 | 11.9±1.18 | 77.4 | y= 0.8125x-0.327 | 0.96 |
| | Body depth (BD) | | 4.3 | 8 | 5.9±0.66 | 38.4 | y= 0.3611x +0.3886 | 0.77 |
| | Body Girth (BG) | | 9 | 16.5 | 12.21±1.31 | 79.5 | y= 0.6957x+1.5202 | 0.74 |

For *C. zillii*, net A, with a selection factor of 0.275, demonstrates a higher selectivity compared to nets B (0.241) and C (0.203). Similarly, for *O. niloticus*, net an exhibits the highest selection factor at 0.296, followed by net B at 0.259 and net C at 0.218.

**Morphometric analysis:** The investigated samples of O. *niloticus* (No. 647) were ranged from 12 to 24.3cm with an average of 16.64±1.73cm and the standard length from 9.5 to 19.5 cm with an average of 13.1±1.48cm, the body girth ranged from 10 to 18.3cm with an average of 12.89±1.47cm, and the body depth ranged from 4.9 to 9cm with average of 6.3±0.73cm. Regarding another fish species *C. zillii*, the total length of 133 of samples was ranged from 11 to 19.9cm with an average of 15.36±1.61cm and the standard length from 8.5 to 15.5cm with an average of 11.9±1.18cm, the body girth ranged from 9 to 16.5cm with average of 12.21±1.31cm, and the body depth ranged from 4.3 to 8cm with average of 5.9±0.66cm. (Table. 3. & Fig. 7).

**Length at first maturity:** For *O. niloticus*, Males reached sexual maturity at a length of 15.1cm TL, and females at 12.9cm TL. As for *C. zilli*, it was calculated that males were Length at first maturity at 16.31cm TL and females were 12.16cm TL (Fig. 8).

## DISCUSSION

The selectivity of trammel nets plays a crucial role in managing small-scale fisheries, particularly in regions such as Aswan City along the Nile River. Effective management of these fisheries is essential for maintaining both ecological sustainability and local economic stability. Trammel nets, characterized by their design of layered netting, capture various fish sizes, thereby influencing species population dynamics and yield potential. Research suggests that adjustments in net size and mesh configuration can significantly impact fish species selectivity, thereby reducing bycatch and promoting sustainable practices (Gabriel et al. 2005).

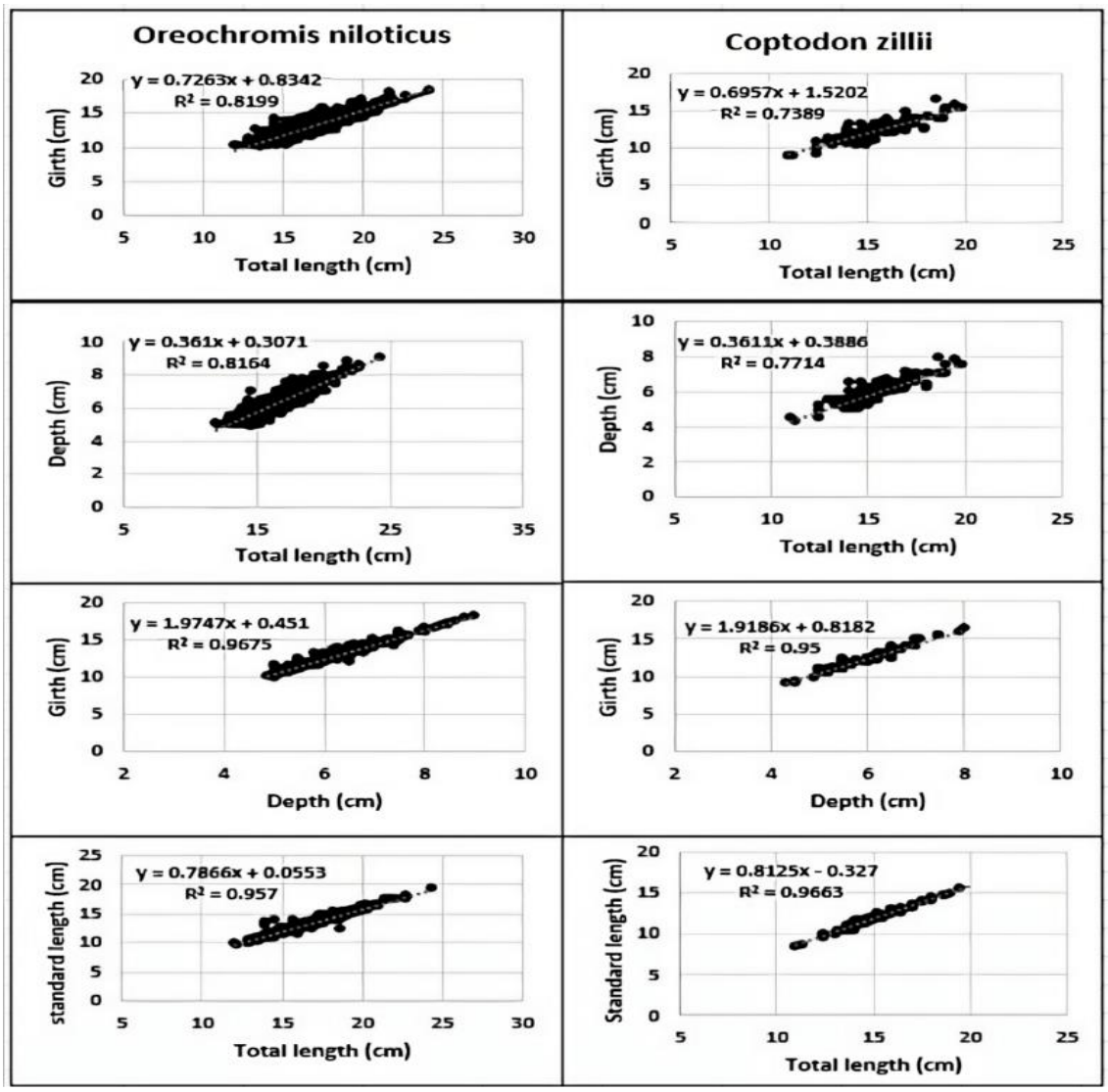


**Fig.7.** Morphometric analysis for *O. niloticus* and *C. zillii* from the River Nile, Aswan city.

Trammel nets mainly gathered Nile tilapia (*O. niloticus*) in this investigation, followed by redbelly tilapia (*C. zillii*). El-Bokhty & El-Far (2014) agree with this result in the Aswan region As Well As in contrast to Sabre & Aly (2023), they reported Mango tilapia (*Sarotherdon galilaeus*) as the primary species, followed by Nile tilapia (*O. niloticus*), both of which were collected using trammel nets in Lake Nasser.

Morphometric is a crucial ecological characteristic in fish. Different fish species differ in body girth and shape, even if they are equal in total length. The selectivity of fishing gears is depending on these variations (Hossain et al. 2009). For the target species, girth must be equal to or slightly higher than the mesh circumference (Hamley 1975; Reis & Pawson 1999). The common fish species in the present study *O. niloticus,* its total length was ranged from 12 to 24.3 cm. that very closed with result recorded by El-Bokhty (2017) from Lake Manzalah which gave total length ranged from 11.3 to 21.5cm while *C. zillii* ranged from 11 to 19.9cm. Relationships between length and body girth can be useful management tools for trammel net fisheries. In this study the exponent (b) of *O. niloticus* is 0.726 (Rsq= 82%) and 0.695 (Rsq= 74%) for *C. zillii*. The mean length ranges of *O. niloticus* and *C. zillii*, were measures for three modified nets used 56, 64, and 76 mm, shifted to the right as mesh size increased. These findings agree with those reported by El-Bokhty (2017), Fabi et al.

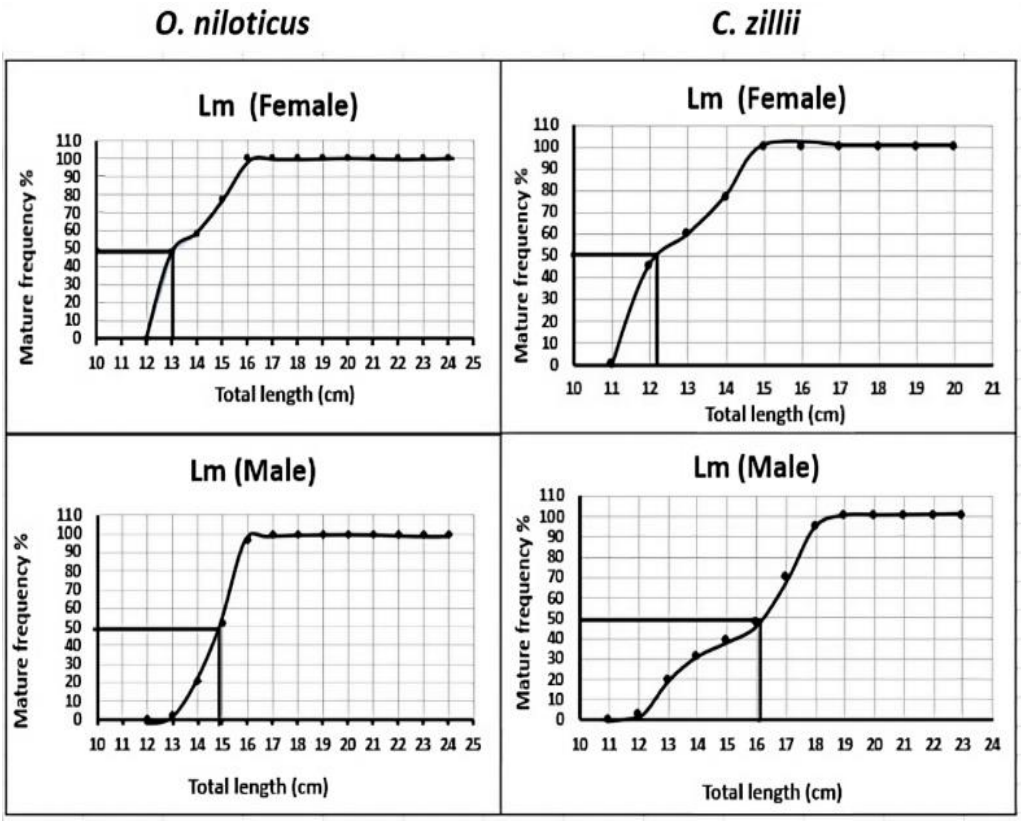


**Fig.8.** The Length at first maturity of male and female for *O. niloticus* and *C. Zilli* from the River Nile, Aswan city.

(2002), Saber et al. (2020) and Saber & Aly (2023). The 56mm mesh size was found to capture the greatest proportion of small individuals (< Lm) for both *O. niloticus* and *C. zillii* species.

The length at first sexual maturity in females was achieved before that in males. The Lm of *O. niloticis* was 12.9cm and 15.1cm for females and males, respectively. Shalloof et al. (2008) study recorded 14cm TL and 15cm TL for females and males, respectively, in Abu-zabal Lake, Egypt. This result considers nearly with current study. While The Lm of *C. zillii* was 12.16cm and 16.31cm for females and males, respectively. Mahomoud et al. (2011) study recorded 7.5cm TL and 8.4cm TL for females and males, respectively, in Lake Timsah, Egypt. This result is different from the current study. The observed discrepancy can be ascribed to variations in different areas of fishing study and divergent approaches to fishing techniques.

The SELECT method is a technique that applies Baranov's (1948) theory of geometric similarity to compare catches within the same length group, which are held by different fishing gears. This method assumes that there is an equal fishing influence for all mesh sizes utilized (Millar & Holst 1997; Millar & Fryer 1999; Carol & Garcia-Berthou 2007). The current study used the SELECT method for estimating the selectivity parameter of trammel nets at Nile River.

The bi-modal model was recorded as the best modal for *C. zillii,* this agrees with the results recorded in Lake Nasser by Saber & Aly (2023). We determined that the bi-modal model was the most appropriate fit for O*. niloticus*, exclusively captured using trammel nets. Saber & Aly (2023) concluded that the log-normal model provided the most precise fit for the *O. niloticus*, which is in stark contrast to the results of this study. The bi-normal selectivity curve is highly adaptable and capable of assuming a variety of configurations because of the merging of two normal scale curves (Hovgård 1996). The fishing technique and use of small mesh size to catch small size species may be the cause of the drop in Nile River at Aswan city fish productivity. The current research revealed

that Aswan has installed numerous trammel net specifications in the Nile. Some of these nets brought young fish (56mm) with relatively small mesh sizes, which might influence the Nile's resources. On the other hand, it is advisable to promote the utilization of a trammel net with a mesh size of 64mm. Therefore, it is strongly advocated that the 64 mm legal minimum mesh size of monofilament trammel nets should be applied as a preventative step for ethical fisheries management of the River Nile for *O. niloticus* and *C. zillii*.

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**مقاله کامل**

# بررسی انتخاب اندازه چشمه تور مانعی به‌عنوان یک معیار حیاتی برای مدیریت ماهیگیری در مقیاس کوچک در شهر اسوان، رودخانه نیل

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**چکیده:** بررسی‌های ماهیگیری تور مانعی تک رشته‌ای در رودخانه نیل اسوان برای ارزیابی انتخاب اندازه چشمه تور و تأثیر آن بر گونه‌های غالب انجام شد. گزینش‌پذیری برای گونه‌های *Oreochromis niloticus* و *Coptodon zillii* که با استفاده از اندازه‌های چشمه لایه داخلی ۵۶، ۶۴ و ۷۶ میلی‌متر صید شده‌اند، تعیین شد. پارامترهای گزینش‌پذیری با استفاده از روش SELECT محاسبه شدند. مدل دو وجهی با منحنی گزینش‌پذیری برای گونه‌های *O. niloticus* و *C. zillii* مطابقت دارد. در مقابل معادله خطی رابطه طول-دور را توصیف کرد: G=۰/۷۲۶۳TL±۰/۸۳۴۲ برای گونه *O. niloticus* و G=۰/۶۹۵۷TL±۱/۵۲۰۲ برای گونه *C. zillii*. رابطه خطی طول و و زن به ترتیب برای گونه‌های *O. niloticus* و *C. zillii* به‌صورت D=۰/۳۶۱TL±۰/۳۰۷۱ و D=۰/۳۶۱۱TL±۰/۳۸۶۶ بود. این مطالعه اولین مطالعه‌ای است که گزینش توری مانعی را در اسوان، مصر بررسی می‌کند. اثرات اندازه چشمه تور بر روی ذخایر *O. niloticus* و *C. zillii* ممکن است مفید واقع شود. برای حمایت از ذخایر *O. niloticus* و *C. zillii*، ماهیگیران اسوان باید از تورهای مشبک ۶۴ میلی‌متری استفاده کند.

**کلمات‌کلیدی:** *Oreochromis niloticus*، *Coptodon zillii*، مدل SELECT، اندازه چشمه توری