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Fisheries Management of *Terapon puta* (Small-Scaled Terapon) from Lake Temsah, Egypt

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ABSTRACT

A study on the mortality rates of *Terapon puta* from Lake Temsah revealed high levels of exploitation. Growth parameters were estimated using the von Bertalanffy growth model. The total mortality rate (Z) was calculated at 2.116 $year^{-1}$, with natural mortality (M) at 0.481 $year^{-1}$ and fishing mortality (F) at 1.64 $year^{-1}$. This corresponds to an exploitation ratio (E) of 0.77, indicating that a substantial proportion of the stock is harvested annually. The length at first capture (Lc) was estimated at 11.2cm. Further analysis using the relative yield per recruit model demonstrated that the current fishing pressure on *T. puta* in Lake Temsah is unsustainable. Urgent management interventions are therefore required, including the implementation of minimum size limits, the establishment of fishing quotas, and the designation of protected areas, in order to ensure the long-term sustainability and conservation of this important fishery resource.

INTRODUCTION

Terapon puta, a medium-sized fish belonging to the family Teraponidae, inhabits marine waters along the Egyptian coast. It is valued as a seafood species with a reasonable market price. Although it does not constitute a major commercial fishery, it contributes to a consistent year-round catch.

Previous studies on *T. puta* have been conducted in different regions. In India, research was carried out by **Karna and Panda (2012)** and **Nandikeswari *et al.* (2013)**, while **Ahmed and Benzer (2015)** studied the species along the Karachi coast of Pakistan. In Egypt, several studies have addressed its biology and fisheries: **Rizkalla *et al.* (2016)**, **Sabrah *et al.* (2016)**, **Abu El-Nasr and El-Drawany (2017)** in Lake Timsah; **El-Drawany (2017)** in the Bitter Lakes; **Kassem (2017)**, **Hasanen *et al.* (2017)** and **Aiatt and Shalloof (2019)** in Bardawil Lagoon; and **Philips (2019)** in the eastern Egyptian Mediterranean waters.

The present study investigated population dynamics of *T. puta* in Lake Timsah, with a particular focus on mortality rates, exploitation levels, and relative yield per recruit. These assessments aimed to provide a systematic basis for the sustainable management and conservation of this fishery resource.

MATERIALS AND METHODS

1. Study area

Lake Temsah (Fig. 1) is a saline, shallow lake and the largest water body in Ismailia City, with an approximate surface area of 14km². It is situated between Suez City to the south and Port Said City to the north, at coordinates 32°19′30.54″ E and 30°35′46.55″ N.

Fig. 1. Map of study area (Temsah Lake)

2. Critical lengths

Lr (Length at Recruitment):

This is the smallest size of fish captured by the fishing gear. It is a crucial parameter, as it directly influences the number of juvenile fish removed from the population.

Lc (Length at First Capture):

Defined as the length at which 50% of the fish in a population are retained by the fishing gear. It is often considered equivalent to Lr. Estimation of Lc is commonly carried out using catch curve analysis **(Pauly, 1984)**.

Z (Total Mortality):

Represents the overall rate of death within a fish population, encompassing both natural and fishing mortality. Z was estimated using the following methods:

- **Jones and Van Zalinge Method (1981)**: assumes a linear relationship between the natural logarithm of cumulative frequency and the natural logarithm of the difference between asymptotic length and observed length.
- **Hoenig and Lawing Method (1982)**: requires only the maximum age attained by the fish.
- **Pauly Method (1983)**: based on length-frequency data. Lengths are converted to relative ages using the von Bertalanffy growth function. Z is then estimated from the linear regression of the natural logarithm of the ratio between fish numbers in a length class and the time required to grow into that class, against relative age.

M (Natural Mortality):

Represents the rate of fish loss due to natural causes such as predation, disease, or senescence. It was estimated using:

- **Pauly's Empirical Equation (1980):** incorporates multiple biological and environmental factors.
- **Ursin's Method (1967):** based solely on mean body weight.
- **Rikhter and Efanov's Empirical Model (1976):** based on age at massive maturity.

F (Fishing Mortality):

Represents the rate of mortality caused by fishing activities. It is estimated as: $F = Z - M$

Exploitation Ratio (E):

Represents the proportion of total mortality attributable to fishing. It is calculated as: $E = F / Z$

Relative Yield per Recruit (Y/R'):

The Beverton–Holt model was applied to evaluate the effects of fishing on the population. The equation is expressed as:

$$Y'/R = (E \times U \times M / K)\,[1 - (3U / (1 + m)) + (3U^2 / (1 + 2m)) - (U^3 / (1 + 3m))]$$

Where:

- E = exploitation rate
- M = natural mortality rate
- K = von Bertalanffy growth coefficient
- $m = (1 - E) / (M / K) = K / Z$
- $U = 1 - (L_c / L_\infty)$

RESULTS

1. Critical lengths

T. puta length recruitment (Lr) in Temsah Lake was 7.8 cm. The length at first capture (Lc) was 11.2 cm (Fig. 2).

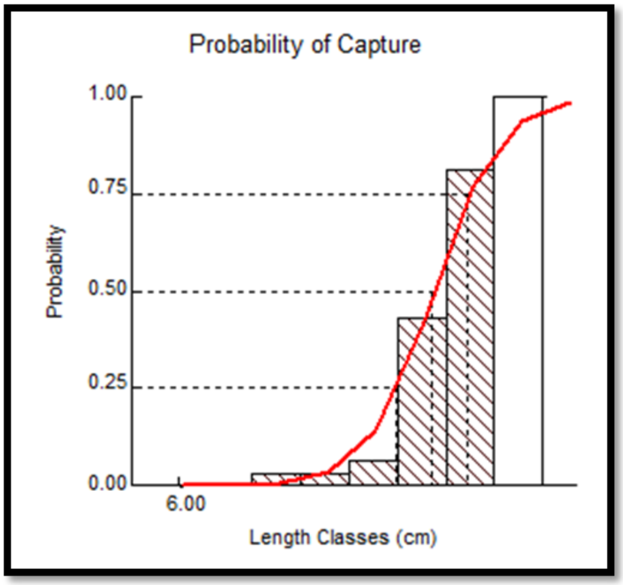

Fig. 2. Length at first capture of *Terapon puta* from Lake Temsah

2. Mortality and exploitation rates findings

Table (1) summarizes the estimates of the total mortality coefficient (Z) obtained using three different methods, which are also illustrated in Figs. (3, 4). Table (2) presents the geometrical interpretation of the natural mortality (M) values derived from each method. Based on a fishing mortality coefficient (F) of 1.64 $year^{-1}$, the exploitation ratio (E) was calculated at 0.77 $year^{-1}$. This value exceeds the commonly accepted optimal exploitation level (E = 0.5). Accordingly, both the fishing mortality and exploitation rate indicate a high level of exploitation pressure on the stock.

Table 1. Z calculation of the different methods for *Terapon puta* from Lake Temsah

Method	Z
Hoenig and Lawing (1982)	1.1
Jones and Van Zalinge (1981)	2.9
Pauly (1983)	2.4
Geometric Mean	2.1

Table 2. M estimation from the different methods for *Terapon puta* from Lake Temsah

Method	M
Rikhter and Efanov (1976)	0.4
pauly(1980)	1.1
Ursin (1967)	0.4
Geometric Mean	0.5

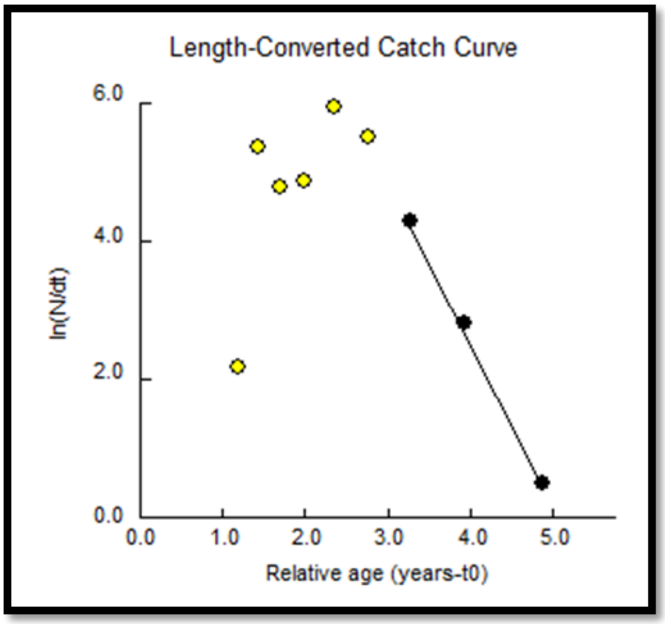

Fig. 3. Length converted catch curve of of *Terapon puta* from Lake Temsah

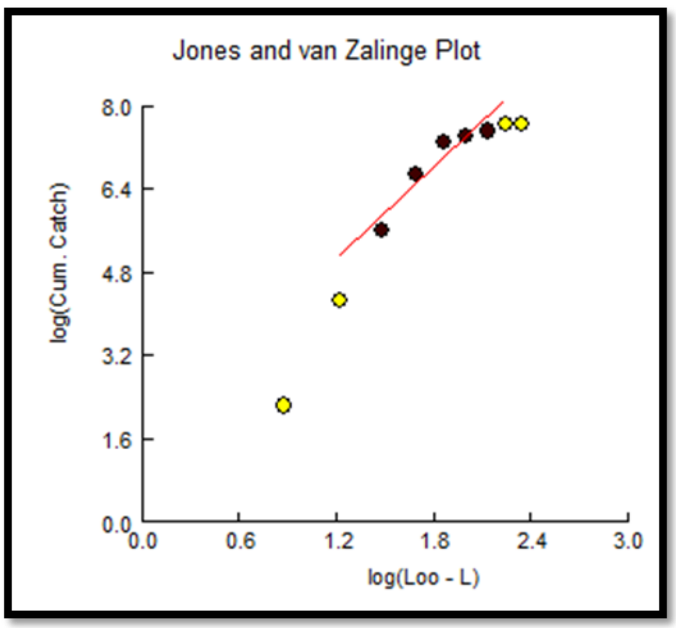

Fig. 4. Cumulated catch curve of *Terapon puta* from Temsah Lake

3. Relative yield per recruit (Y/R)'

Fig. (5) presents the estimated relative yield-per-recruit (Y/R) for *Terapon puta* in Lake Temsah. The analysis shows that the current exploitation rate (E = 0.77), with a length at first capture (Lc) of 11.2 cm and natural mortality (M) of 0.48 year^{-1}, falls short of maximizing Y/R. The maximum Y/R is predicted at an exploitation rate of

0.85, indicating that the current fishing mortality (F = 1.64 $year^{-1}$) exceeds the sustainable level.

The study further determined reference points: $E_{0.1}$ (the exploitation level at which the marginal yield increment is 1/10 of the initial level) at 0.76, and $E_{0.5}$ (the exploitation level that reduces unexploited biomass by 50%) at 0.40. Since the present exploitation rate (E = 0.77) exceeds $E_{0.5}$, a substantial reduction in fishing effort—estimated at approximately 48.1%—is recommended to ensure the sustainable harvest of *T. puta* in Lake Temsah.

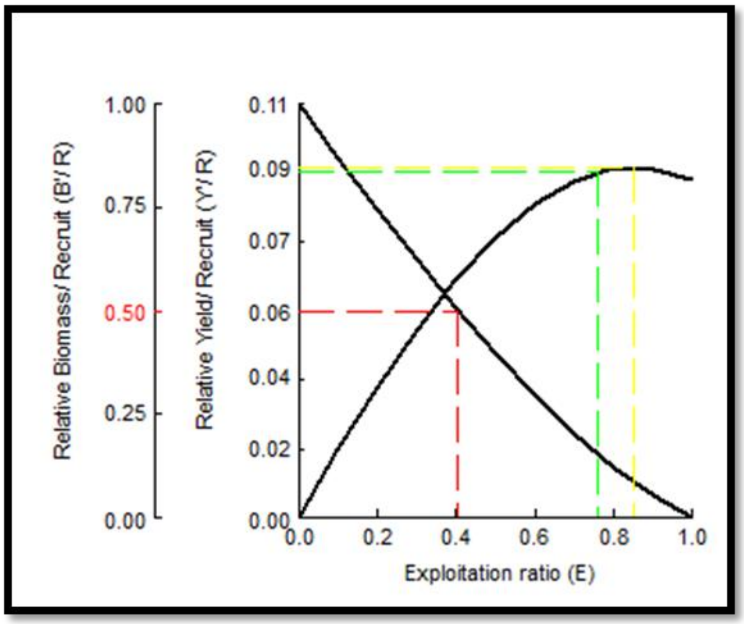

Fig. 5. Per-recruit analysis of *Terapon puta* from Lake Temsah

DISCUSSION

The observed variations in the performance of *Terapon puta* across different regions can be attributed to a combination of high fishing pressure and significant natural mortality (Table 3). Accurate comparisons of mortality rates remain challenging due to limited data availability and because the total mortality coefficient is largely influenced by local environmental conditions rather than species-specific traits. High predation levels, particularly on juveniles, along with environmental factors such as temperature and hydrodynamic conditions, can substantially affect mortality rates. These findings are consistent with those of **Christensen and Pauly (1997)**, who emphasized the combined influence of physiological and environmental factors on mortality parameters.

Notably, **Abu El-Nasr and El-Drawany (2017)**, who examined the same species in a similar location, also reported elevated fishing pressure, total mortality, and exploitation rates, corroborating the results of the present study. However, the current findings indicate even higher values for these parameters compared to the study of **Abu El-Nasr and El-Drawany (2017)**, suggesting that fishing pressure on the *T. puta* population in Lake Temsah has intensified over time.

The analysis highlights that the main obstacles to sustainable fisheries development in Lake Temsah are overexploitation resulting from excessive fishing pressure, the use of destructive and illegal fishing methods, and the lack of comprehensive knowledge regarding the biological, ecological, social, and economic aspects of the fishery. To address these challenges, it is recommended to implement regulations that control mesh size and prohibit destructive fishing gear, to adjust closed seasons in order to protect spawning fish, and to establish a Total Allowable Catch (TAC) once sufficient information on fish stocks and fishery dynamics becomes available. Furthermore, continued scientific research is needed to evaluate and manage the fish populations of the lake, and the creation of an accurate and comprehensive fisheries database is essential to provide reliable records that can support the effective assessment and management of this valuable resource.

Table 3. Recorded length at first capture (Lc), mortalities (Z, F, M) and exploitation rate (E) in previous present studies

Authors	Region	(Lc)	(Z)	(F)	(M)	(E)
Hasanen *et al.* (2017)	Bardawil lagoon	12.7	0.71	0.38	0.33	0.53
(Abu El-Nasr and El-Drawany, 2017)	Temsah Lake	12.2	1.6325	1.202	0.4304	0.73
El-Drawany (2017)	Bitter lakes	10.8	0.8840	0.6626	0.2214	0.75
Philips (2019)	East Egyptian Mediterranean Waters	10.26	1.0374	0.3933	0.9797	0.3797
PRESENT STUDY	Temsah Lake	11.2	2.11	1.64	0.48	0.77

CONCLUSION

Assessments based on established fisheries management methods indicate that the *Terapon puta* population in Lake Temsah is currently overexploited. To achieve sustainable levels, the exploitation rate must be reduced to 0.41, representing a decrease of approximately 48.2%. Such a reduction is essential for maintaining adequate spawning biomass, enabling population replenishment, and preserving the ecological balance of the lake. Effective fisheries management strategies—including the establishment of minimum size limits, the implementation of seasonal closures, and restrictions on destructive fishing gear—are therefore critical to achieving this target and safeguarding the future of the *T. puta* population in Lake Temsah.

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