



Study of length-weight relationship and relative condition factor of *Epinephelus tauvina* (Forsskal, 1775) from Veraval Coast of Gujarat, India

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Abstract

The study of length-weight relationships (LWR) in fish species is crucial for understanding their growth patterns, health status, and for effective fisheries management. *Epinephelus tauvina* (Forsskal, 1775), commonly known as the greasy grouper, is an important commercial species along the southwest coast of India, particularly in Veraval, Gujarat. The LWR of *E. tauvina* was assessed based on fish specimens collected between December 2024 and November 2025. Fish specimens were collected monthly from marine fishermen directly before any mixing or sorting of the fishes. These samples were analysed using regression analysis to study the relationship between total length and total weight. The length range reported was 21.7 to 51.8 cm with the weight range varied between 104.6 and 854.2 g. Furthermore, the LWRs analysis revealed *b* value of 3.025 ($r^2 = 0.902$), 3.020 ($r^2 = 0.902$) and 3.002 ($r^2 = 0.948$) for male, female and pooled individuals, respectively, indicating isometric growth in males, females and the overall population of the species. These high r^2 values demonstrate a strong correlation between length and weight in *E. tauvina*. This study provides baseline information on several biological characteristics of the observed grouper species that will benefit and improve the fisheries management in the region. Such data are valuable for ensuring sustainable exploitation and supporting the conservation of this commercially significant grouper population in the region.

Keywords: condition factor; *Epinephelus tauvina*; greasy grouper; length-weight relationship

1 | INTRODUCTION

Groupers (Epinephelidae) are major targets of artisanal, recreational and commercial fisheries (Heemstra and Randall 1993; Craig *et al.* 2011). Groupers have white, tender and tasty meat that makes them a highly priced marine food fish. They are the favoured species in the live reef fish trade in Southeast Asia and demand the highest price. The high demand for these fishes in the interna-

tional markets has caused to indiscriminate fishing, resulting in the depletion of natural stocks at an alarming level. Many smaller species are also highly valued in the aquarium trade. Groupers are being subjected to increasing fishing pressure for food, ornamental display and medical purposes globally (Pauly *et al.* 2002; Vincent 2006).

Epinephelus tauvina (Greasy grouper) a protogynous hermaphrodite which does not exhibit any externally dis-

tinguishable sexual characters. In protogyny, males may develop directly from the larval/juvenile stage or may develop from adult females by sex reversal. The groups comprising at least 597 species across 72 genera, occurring in all oceans, but most species are from tropical and subtropical waters (Parenti and Randall 2020; Fricke et al. 2021). These species are of considerable economic value, especially in the coastal fisheries of tropical and subtropical areas. Fish length-weight relationships (LWRs) provide valuable basic biological information that is crucial for fisheries management and conservation (Froese 2006). Indeed, the link offers useful information for predicting, fish biomass estimates (Kimmerer 2004), and fish life cycle assessments (Petrakis and Stergiou 1995). LWRs are widely used by fishery managers and researchers to estimate weight from length in fish yield studies. By using the variables, a and b in the length-weight (L/W) relationship $W = aL^b$, it is possible to visualise a specific population regardless of individual variance, so giving an understanding of the condition and fitness of the fish population (Le Cren 1951). Growth, food availability and sexual maturity are among the baseline data for stock management provided by the LWR (Al-Zibdah and Odat 2007; Karna et al. 2012).

Although several studies have reported the biological characteristics and LWRs of grouper species from different geographical regions, information on the LWR and condition of *E. tauvina* from the Veraval Coast of Gujarat remains limited. The absence of recent information on the growth pattern and population characteristics of this commercially important species represents a knowledge gap. Therefore, the present study was undertaken to provide updated information on the LWR and condition factor of *E. tauvina* from the Veraval Coast of India.

2 | METHODOLOGY

In the present study, fish specimens were collected from the fishermen at Veraval Fish Landing Centre (20°54'22.2"N 70°23'00.9"E) in the northwest coast of Gujarat, India (Figure 1.) Fish specimens were collected monthly from December 2024 to November 2025 before any mixing or sorting of the catch; it was not possible to collect fish in June and July due to the 'closed season' fishing along the west coast of India. Fish samples were assessed from fishing vessels landing at the Veraval fish landing centres (Site A – Bhidiya Fish Landing Centre, Site B – Jetty Landing Centre, and Site C – Diwadandi Fish Landing Centre) for analysis. A stratified random sampling method was used to select the fish samples, with at least 30 specimens collected each month during the study period. The total length and body weight were measured for 300 fish specimens. In total, 300 *E. tauvina* (greasy grouper) specimens, comprising 154 females and 146 males, were studied.

2.1 LWRs and condition factor

The total length was examined in cm to the nearest of 0.01 cm and weight was assessed in g nearest to 0.01 g. Total Length were measured from the most forward point of the head to the farthest tip with the tail keeping in view that the mouth should be closed and tail should be compressed while the fish is lying on its side. Weight were recorded using measuring electronic weighing balance. The LWRs were examined using the allometric formula separately for both the sexes (Le Cren 1951), $W = aL^b$ or $\log W = \log a + b \times \log L$. Where, W is the total body weight (g), L is the total length (cm), and a and b are the coefficients of the functional regression between length and weight. The coefficient of determination (R^2) of a and b was also examined at 95% confidence limits. When using the LWR formula on fish samples, b may deviate from the "ideal value" of 3 that represents an isometric growth (Ricker 1958) because of certain environmental circumstances or the condition of the fish. When b is less than 3, fish become slimmer with increasing length, and growth will be negatively allometric. When b is greater than 3.0, fish become heavier, showing positive allometric growth and reflecting optimum conditions for growth. The condition factor is used to compare the condition, fatness or well-being of fish based on the assumption that heavier fish of a given length are in better condition (Wootton 1998).

In addition, relative condition factor is the quantitative parameters that represent the well-being of the fish, which reflects the condition of the fish in its habitat. It is strongly affected by both biotic and abiotic environmental factors. The relative condition factor, K_n for individual fish was calculated using the formula, $K_n = W_o/W_c$, Where, W_o = observed weight; W_c = calculated weight (Le Cren 1951).

3 | RESULT AND DISCUSSION

The present study examined the length-weight relationships (LWRs) and condition factor (K) of *E. tauvina* from Veraval Coast, Veraval, Gujarat. A total of 300 specimens including 154 females and 146 males were collected during the study period. The total length ranged from 21.7 to 51.8 cm with the mean total length of 31.65 cm. The weight ranged between 104.6 and 854.2 g with the mean total weight of 362.81 g. The total length of females ranged from a minimum of 21.7 cm to a maximum of 50.4 cm, while in males it varied between 25.2 cm and 51.8 cm. The recorded total weight in females ranged from 104.6 g to 754.8 g, whereas in males it ranged from 176.8 g to 854.2 g.

3.1 Length-weight relationships (LWRs)

The regression equations for the LWR were calculated as follows: $W = 0.007 L^{3.025}$ for male, $W = 0.011 L^{3.020}$ for female and $W = 0.011 L^{3.002}$ for pooled specimens. While,

the LWR was also represented in its logarithmic form as follows: $\text{Log } W = -2.1549 + 3.025 \text{ Log } L$ ($r^2 = 0.902$) for male; $\text{Log } W = -1.9586 + 3.020 \text{ Log } L$ ($r^2 = 0.902$) for female and $\text{Log } W = -2.0458 + 3.002 \text{ Log } L$ ($r^2 = 0.948$) for

pooled specimens. Analysis of covariance (ANCOVA) revealed that there is significant difference ($p < 0.05$) in the regression slope (b) of LWR between males and females (Table 1).

TABLE 1 Results of ANCOVA for length-weight relationships (LWRs) of males and females of *Epinephelus tauvina*.

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	p-value
Adjusted mean	1.442	1	1.442		
Adjusted error	19.025	299	0.064	22.509	<0.001
Adjusted total	20.467	300			
Test for homogeneity (equality) of slopes					
F-ratio	6.233				
p-value	0.013 ($p < 0.05$ significant, shows non-homogeneity of slopes)				



FIGURE 1 Sampling sites of the study (Source: Google Map).

The calculated regression coefficient “*b*” values based on total length were 3.025 for males, 3.020 for females, and 3.002 for the pooled specimens, indicating isometric growth in males, females and the overall population of the species. The coefficient of determination (r^2) value was 0.902 for males, 0.902 for females, and 0.948

for the pooled data. These high r^2 values demonstrate a strong correlation between length and weight in *E. tauvina*. The LWRs for males, females, and the pooled data attained from study area are shown in Figure 2, 3 and 4.

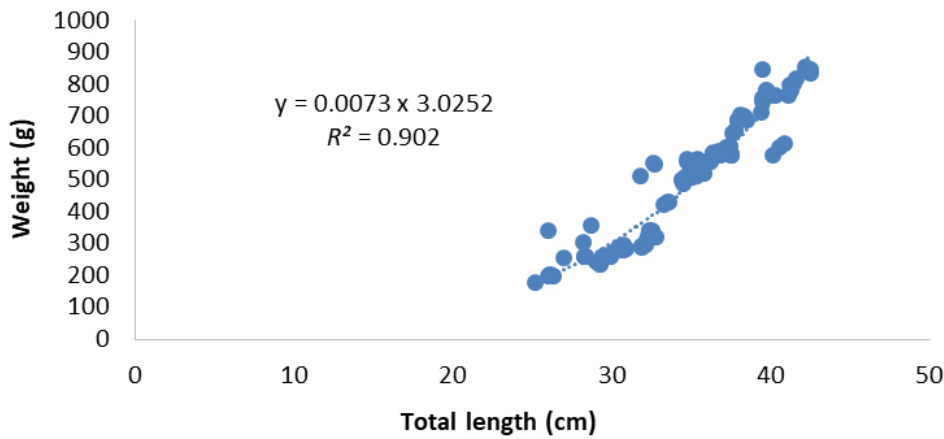


FIGURE 2 Length-weight relationship of male *Epinephelus tauvina* from Veraval Coast of Gujarat, India.

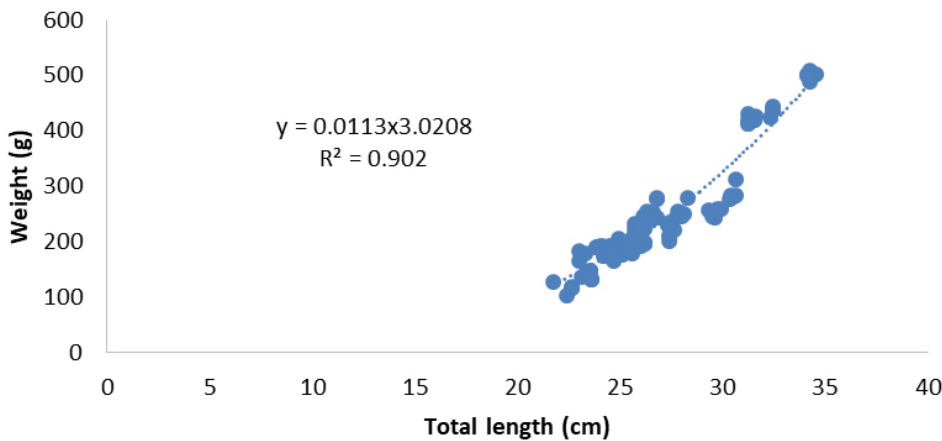


FIGURE 3 Length-weight relationship of female *Epinephelus tauvina* from Veraval Coast of Gujarat, India.

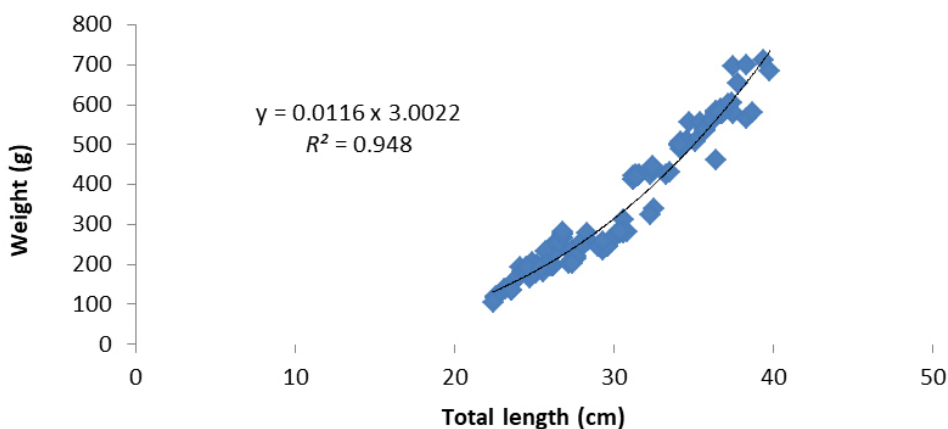


FIGURE 4 Length-weight relationship of pooled specimens of *Epinephelus tauvina* from Veraval Coast of Gujarat, India.

Previous studies on the LWRs of *E. tauvina* from the brackishwater of Vellar Estuary and from the Vellar-Coleroon estuarine complex, Porto Novo have revealed isometric growth patterns and the r^2 value was 0.9097 (Shanmugam et al. 2000). Agembe et al. (2010) studied LWRs of 15 species of groupers and found that most groupers exhibited isometric growth. Previously recorded b values of *E. diacanthus* from Indian waters ($b = 2.5\text{--}3.2$) by Ranjeet et al. (2015) was similar to our results ($b = 3.0$). The b values of *E. diacanthus*, reported by Premalatha (1989) and Manojkumar (2005), were 2.6117 and 2.82 respectively, which are notably less than the values determined in the present study. McIlwain et al. (2006) estimated the regression coefficient (b) as 2.938 for pooled sexes, indicating an isometric growth.

Haq et al. (2011) reported a strong LWR of *E. malabaricus* for males, females, and juveniles in 2009 and 2010, with correlation coefficients (r) above 0.9. The estimated b values were 2.05, 2.78, and 2.01 in 2009 and 2.66, 2.80, and 2.35 in 2010, respectively. The study found significant variation in the b values of male, female, and juvenile groupers from the Gulf of Mannar and Mandapam Palk Bay. Ramadhani et al. (2017) observed regressions of LWRs for each of the three grouper species showed that the b value for *E. areolatus*, *E. fasciatus*, and *E. merra* were 3.0548 ($r^2 = 0.97$), 3.0466 ($r^2 = 0.94$) and 3.1681 ($r^2 = 0.97$), respectively, indicating that three observed fish had a positive allometric growth shape and

had a strong correlation between body weight and total length, while *P. Maculatus* showed a positive allometric growth.

The variation in b values may caused by many factors, but it is widely accepted that fishing intensity and food availability are main factors, which makes fishes from different stock grow in different rates (Haberle et al. 2023). Similar to LWR parameters, fluctuations in relative condition factor values are typically caused by fishing intensity, environmental stress, food availability, and fish condition (Le Cren 1951; Jisr et al. 2018).

3.2 Relative condition factor (K_n)

A total 154 female and 146 male specimens of *E. tauvina* were evaluated for K_n analysis on monthly-basis. The mean monthly value was utilized to examine the differences in male and female conditions throughout the year. The mean K_n values for males and females in the current research were computed for various months and are shown in Table 2 and Figure 5. The K_n values was the highest in January (1.2202 ± 0.0649) and the lowest in September (0.7952 ± 0.0651) in males, whereas the highest and lowest values were found in December (1.1077 ± 0.0182) and September (0.8917 ± 0.0783) respectively in females. The monthly mean K_n values for males and females were 1.0505 ± 0.0578 and 1.0316 ± 0.0614 respectively.

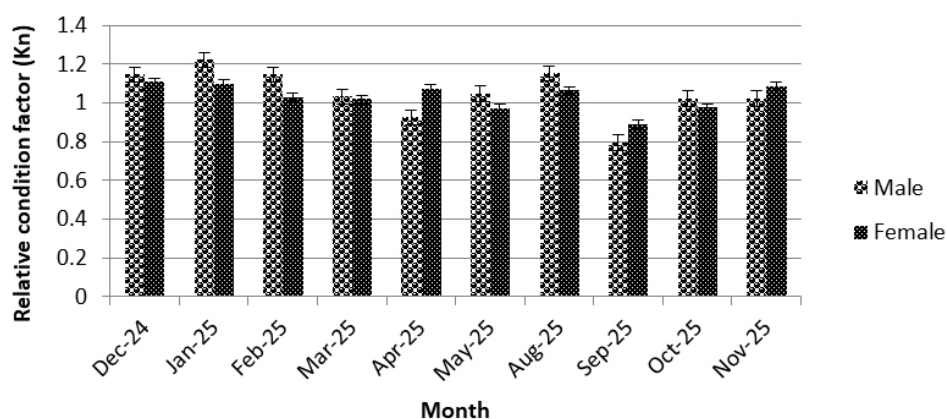


FIGURE 5 Monthly variation in relative condition factor (K_n) of female and male *Epinephelus tauvina*.

3.2.1 Relative condition factor in relation to size: Monthly variation in mean value of relative condition factor (K_n) for various size groups of *Epinephelus tauvina* is given in Figure 6. For males, the highest K_n value was recorded in the 35–40 cm size group, whereas the lowest K_n value was found in the 50–55 cm size group. Moderate K_n values were recorded in 40–45 cm and 45–50 cm size groups. In females, the highest value was observed in 21–25 cm size, while moderate values were found in 25–30 cm and 30–35 cm size groups. The lowest K_n value was

observed in the 45–50 cm size group (Figure 6).

In the present study, K_n value of *E. tauvina* for both male (1.0007 ± 0.0358) and female (1.0065 ± 0.0259) revealed a good health condition of fish. Monthly variation in K_n value did not change across month but fluctuated close to 1 in both sexes indicating a good condition in its habitat in terms of sexual maturity as well as the good fitness of the specimens. Many factors affect the growth condition of fish such as reproductive cycles, food availability, habitat and environmental factors (Morato et al.

2001). The deviation of K_n from reveals information concerning the variations in food availability and consequence of physicochemical characteristics on the life cycle of fish species (Le Cren 1951). High condition factor value simply suitable environmental conditions, whereas low values reflect less favourable environmental conditions (Blackwell *et al.* 2000). For grouper species, the K_n values

were equal to or greater than one for, indicating favorable environmental conditions for fish body growth (Paul *et al.* 2026). In the current study higher K_n values were reported, indicating that *E. tauvina* thriving in Veraval region, North west coast of India had a favourable habitat with plenty of food and favourable environmental conditions.

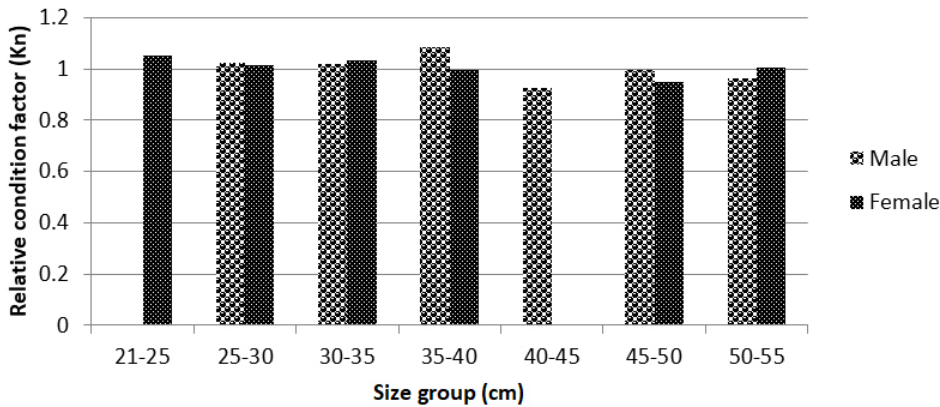


FIGURE 6 Size wise variation in relative condition factor (K_n) of female and male *Epinephelus tauvina*.

TABLE 2 Monthly variation in relative condition factor (K_n) (mean $\pm$ SE) of male and female *Epinephelus tauvina*.

Month	Male		Female	
	<i>n</i>	K_n	<i>n</i>	K_n
Dec 2024	5	1.1449 $\pm$ 0.0452	25	1.1077 $\pm$ 0.0182
Jan 2025	9	1.2202 $\pm$ 0.0649	21	1.0990 $\pm$ 0.0731
Feb 2025	10	1.1454 $\pm$ 0.0672	20	1.0304 $\pm$ 0.0169
Mar 2025	7	1.0322 $\pm$ 0.0726	23	1.0182 $\pm$ 0.0286
Apr 2025	17	0.9244 $\pm$ 0.1013	13	1.0706 $\pm$ 0.0984
May 2025	15	1.0461 $\pm$ 0.0662	15	0.9738 $\pm$ 0.0456
Aug 2025	21	1.1518 $\pm$ 0.0484	9	1.0628 $\pm$ 0.0431
Sep 2025	21	0.7952 $\pm$ 0.0651	9	0.8917 $\pm$ 0.0783
Oct 2025	21	1.0217 $\pm$ 0.0329	9	0.9742 $\pm$ 0.0456
Nov 2025	20	1.0236 $\pm$ 0.0142	10	1.0873 $\pm$ 0.1659
Mean	146	1.0505 $\pm$ 0.0578	154	1.0316 $\pm$ 0.0614

Similarly, in *E. aeneus*, higher K_n values were recorded: $K_n = 1.361$ from Mbour region, 1.311 in Joal and 1.212 in Soumbédioune region of Senegal (Ndiaye *et al.* 2015). The mean values of K_n were 1.311 $\pm$ 0.172; 1.361 $\pm$ 0.165 and 1.212 $\pm$ 0.147 in Joal, Mbour and Soumbédioune, respectively (Ndiaye *et al.* 2015). The higher K_n value (1.24) was reported for *E. aeneus* in the Qua Iboe River Estuary of southeastern Nigeria (Ekpo *et al.* 2013). K_n values of 1.123 and 1.114 were recorded in Alexandria region and Salloum Bay region of Egypt for the same species, respectively (Ezzat *et al.* 1982). Al-Marzouqi *et al.* (2015) observed the monthly mean K_n values ranged between 0.98 and 1.05. The data showed a major peak during April and minor peak during June. Based on the available data, it is possible to assume that for *E. diacanthus* the more active

feeding occurs in March–April before spawning season.

From a reproductive point of view, the gonadal maturation phase and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source (Bagenal and Tesch 1978). Furthermore, Vazzoler (1996) confirmed that lowest condition factor values during the more developed gonadal stages might mean resource transfer to the gonads during the reproductive period. The condition factor of *E. aeneus* showed no variation in different months, condition factor value was higher when fish entered into the maturation phase during the month of March, for rest of the months condition factor value was slightly lower (Ndiaye *et al.* 2015).

Le Cren (1951) reported that environmental factors,

food supply and parasitism have a significant impact on fish health. According to Ighwela *et al.* (2011), the condition factor provides information when comparing two populations living in specific feeding, density, climate, and other conditions when determining the period of gonad maturation and when monitoring a species level of feeding activity to ensure that it is making good use of its source. It is influenced by both environmental conditions and can be affected by factors like sex, season, age and maturity stages of fish.

Condition factor also provides information when comparing two populations living in different feeding, density, climate, and other conditions; when figuring out the gonadal maturation period; and when monitoring a species' level of feeding activity to verify whether it is making good use of its feeding source (Bagenal and Tesch 1978). The condition factor of fish reflects physical and biological circumstances and fluctuations by interaction among feeding conditions, parasitic infections and physiological factors (Le Cren 1951). This also indicates the changes in food reserves and therefore an indicator of the general fish condition.

4 | CONCLUSIONS

This study highlights several preliminary aspects of *E. tauvina* from the Veraval Coast of Gujarat, which can be applied to develop practical and effective fisheries management strategies for the species in this region. It provides baseline data on total length, length–weight relationship, and condition factors of *E. tauvina*. As an apex predator, this species plays an important role in maintaining ecological health and exhibits diverse food preferences.

The data generated in this research can serve as a baseline for future studies. The observed fish displayed an isometric growth pattern. The condition factor further indicates that the specimens were generally in good physiological condition, reflecting favorable habitat quality and adequate food availability along the Veraval Coast.

Moreover, the length–weight relationship parameters obtained in this study can serve as reliable reference values for biomass estimation, population modeling, and ecological investigations along the northwestern coast of India. The condition factor data may also be useful for monitoring temporal changes in fish health in response to environmental fluctuations, fishing pressure, and climate-related impacts.

Overall, this study establishes a scientific baseline for the assessment and sustainable management of *E. tauvina*. The information generated will not only support regional fisheries management but also contribute to future research on grouper biology, stock assessment, and ecosystem-based fisheries management in the Arabian Sea.

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ETHICAL APPROVAL

All applicable international, national and/or institutional guidelines for the care and use of animals were followed in this study.

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTION

Conceptualization: HSR, DTV; Methodology & Investigation: HSR, DTV, KRK; Formal analysis: HSR, NVR; Writing – original draft: HSR, AIB; Writing – review & editing: DTV, HSR.

AI-USE STATEMENT

AI tools (OpenAI) were used solely for language improvement and grammar correction. The authors take full responsibility for the accuracy and scientific content of the research.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

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