Asian J Biol Life Sci., 2025; 14(3):709-718.
https://ajbls.com

Research Article

Effect of Ectoparasitism on Length-Weight Relationship and Condition Factor of Five Fish Species in River Penna, Kadapa, Andhra Pradesh

Anu Prasanna Vankara*

Department of Zoology, Yogi Vemana University, YSR District, Andhra Pradesh, INDIA.

ABSTRACT

Objectives: This study investigates the impact of ectoparasitic infections on Length-Weight Relationships (LWR) and condition factor of five freshwater fishes of River Penna, Kadapa, Andhra Pradesh from three sampling sites between March, 2017 to March, 2018. **Materials and Methods:** Sampled fish were examined for ectoparasites and their associated pathologies according to standard protocols. Their lengths and weights were measured to determine the length-weight relationships and condition factors. A total of 465 fishes (122 *Labeo calbasu*, 45 *Mastacembelus armatus,* 70 *Mystus vittatus,* 133 *Oreochromis niloticus* and 95 *Wallago attu*) were sampled. **Results:** Overall, 80% of the sampled fishes were infected with ectoparasites; *Labeo calbasu* (75.7%), *M. armatus* (91%), *M. vittatus* (77.1%), *O. niloticus* (68.4%) and *W. attu* (98.9%). The prevalence rates were significantly influenced by size (p=0.960, χ^2= 0.6256, non-significant) and weight (p<0.00001, χ^2= 72.66, significant) and negative allometric growth patterns (b < 2) were observed irrespective of the parasitic status of the fishes. There was strong positive correlation between the length and weight of the fish species (r> 0.92), except for *M. armatus* (r> 0.066). The mean condition factor (K) varied between 1.00 to 3.56 throughout in the study according to sex, species, season and ectoparasitic status of the fish. The results indicated that K factor of *M. armatus, W. attu* and *M. vittatus* was higher (K> 2) than *L. calbasu* and *O. niloticus* (K< 2). Male fishes showed slightly higher K factor than the female fishes during the summer and rainy seasons than winter season. The Condition Factor (K) of infected and uninfected fishes showed that the K factor of uninfected fishes was somewhat greater than that of infected fishes, with the exception of the K factor of infected *L. calbasu*, which was slightly higher than the uninfected *L. calbasu*. **Conclusion:** The present investigation concluded that ectoparasite infection has a substantial impact on LWR and condition factors of fish from the River Penna. The control of ectoparasitic infection of cultured fishes is vital for improved conditions, health and production yields in fishery sectors in India.

Keywords: Allometric growth, Condition factor, Ectoparasitism, Fish Health, Length-weight relationship, River Penna.

Correspondence:
Dr. Anu Prasanna Vankara
Department of Zoology, Yogi Vemana University, YSR District-516005, Andhra Pradesh, INDIA.
Email: annuprasanna@gmail.com; dr.anu@yogivemanauniversity.ac.in
ORCID: 0000-0003-0286-2387
LiveDna ID: http://livedna.org/91.16872

Received: 03-07-2025;
Revised: 24-09-2025;
Accepted: 14-11-2025.

INTRODUCTION

Protein insufficiency is a significant global issue, particularly in underdeveloped nations.[1] Fish is a rich source of animal protein for humans and cattle, providing approximately 40% of the protein in the diets of two-thirds of the world's population and helping to reduce poverty in many areas in developing nations.[2-6] However, a higher fish output entails escalating production, which has been linked to increased parasite risks and deteriorated water quality.[7,8] The prevalence of parasitic infections in fish species makes them one of the biggest dangers to the industry's output, which results in significant production losses and lowers the industry's profit.[9] Thus, fish health is a vital factor of sustainable fisheries and aquaculture which is strongly influenced by parasitic infections. On fish species, parasites produce mechanical damage (gill lamellar fusion, tissue replacement), physiological harm (cell proliferation, immunomodulation, altered development, adverse behavioural responses), and reproductive damage.[10-13] Ectoparasites are even more perilous than endoparasites and have been linked to increased mortality in cultured fish species.[14,15] Their occurrence often interrupts normal metabolic activities, thus manipulating essential biological indices including Length-Weight Relationship (LWR) and Condition Factor (K), which are extensively used to determine fish health and well-being. Condition factor and growth are imperative strategies for fish species to manage length-weight and length-length relationships.[16,17] The length-weight relationship provides

DOI: 10.5530/ajbls.20250066

Publishing Partner : ScienScript Digital. [www.scienscript.com.sg]

insights into the growth patterns and health status of fish populations. It helps to establish whether the growth is isometric or allometric and serves as an imperative tool in fisheries biology for understanding ecological dynamics. The length-weight association aids in identifying a population's or an individual's condition factor. Meanwhile, the condition factor offers a simple and effective means of assessing the general fitness and nutritional status of fish. Individual condition plays a significant role on a fish's performance, survival, and reproductive success.[18] Both these indices are sensitive to environmental aspects and parasitic pressure. The quantity of energy that may be used by an individual for different metabolic activities, such as reproduction, foraging, and overwinter survival, is known as the condition factor in energetic terms.[19] The River Penna, an important freshwater system in southern Andhra Pradesh, sustains a diversity of indigenous and commercially important fish species. However, the ecological balance of this river is increasingly threatened by anthropogenic activities, pollution, and parasitic infestations. Despite this, limited studies have investigated the impact of parasitism on the biometric parameters of fish in this region. This study aims to evaluate the effect of ectoparasitic infection on the length-weight relationship and condition factor of five commonly occurring fish species - *Labeo calbasu, Mastacembelus armatus, Mystus vittatus, Oreochromis niloticus* and *Wallago attu* in the River Penna, Kadapa district. By comparing infected and non-infected individuals, this study seeks to contribute to the understanding of fish health under parasitic stress and to provide baseline data for future ecological and fisheries management in the region.

MATERIALS AND METHODS

Description of Study Areas

Study area

The River Penna is a perennial river that supports a diverse range of freshwater fish species and plays a vital role in local aquaculture and inland fisheries. Sampling sites were chosen based on accessibility, fishing activity, and ecological diversity. Three sampling sites of catchment areas of River Penna flowing through YSR Kadapa district were selected for the host samples collection during the present study

Site-1: Mylavaram Reservoir located in Mylavaram village (Lat.14° 0′ 15″N 78° 20 40″E longitude), YSR Kadapa District, Andhra Pradesh.

Site 2: Aadinimmayapalle Dam in Chennur Village, YSR Kadapa district, located at 14″34′0.12″N, 78″48′ 0″E longitude.

Site-3: Backwaters of Somasila reservoir across the Penna River at Somasila village (14°29′22″ N 79°18′19″E), Nellore District, Andhra Pradesh, near Vontimitta Village, Kadapa.

The Kadapa region has a hot semi-arid climate with year-round high temperatures (mid-March-mid-July) ranging from 26-46ºC, a scarce rainy season (mid-July-mid-November) with temperatures ranging from 19-25ºC, an average annual rainfall of 615 mm, and relative humidity ranging from 56-65%. The winter season is milder with temperatures ranging from 25-35ºC (https://en.wikipedia.org/wiki/Kadapa).[20]

Selection of Fish Farms and Samples for the Study

Fish sampling belonging to the five species was carried out during the period of March, 2017 to March, 2018 from the three sampling sites of River Penna. A total of 465 fishes (122 *Labeo calbasu*, 45 *Mastacembelus armatus,* 70 *Mystus vittatus,* 133 *Oreochromis niloticus*, 95 *Wallago attu*) were examined for the study. The fish samples were quickly brought to the Parasitology Laboratory at Yogi Vemana University for dissection and additional analysis. All fish specimens were handled and inspected within 12 hr of their capture. The fish species were identified using the formerly described keys.[21,22]

Morphometric Measurements

The fishes' sizes (standard and total lengths in cm) were measured using a measuring tape and thread, and their weights were determined with an electronic balance (0.1 g error margin). The sizes (x) were classified as small sized groups (S-I) of (80 mm ≥ x < 100 mm) for *L. calbasu*, (69 mm ≥ x < 93m) for *M. armatus*, (30 mm ≥ x ≤ 50 mm) for *M. vittatus*, (50 mm ≥ x ≤ 80 mm) for *O. niloticus* and (70 mm ≥ x ≤ 100 mm) for *W. attu*; medium sized groups (S-II) of (100 mm ≥ x < 120 mm) for *L. calbasu*, (94 mm ≥ x < 120 mm) for *M. armatus*, (60 mm ≥ x ≤ 80 mm) for *M. vittatus*, (80 mm ≥ x ≤ 110 mm) for *O. niloticus* and (100 mm ≥ x ≤ 130 mm) for *W. attu* and Large Sized Group (S-III) being (120 mm ≥ x < 140 mm) for *L. calbasu*, (121 mm ≥ x < 145 mm) for *M. armatus*, (90 mm ≥ x ≤ 110 mm) for *M. vittatus*, (110 mm ≥ x ≤ 140 mm) for *O. niloticus* and (130 mm ≥ x ≤ 160 mm) for *W. attu*. The weights (x) were as low weight groups (W-I) of (120 g ≥ x < 420 g) for *L. calbasu*, (250 g ≥ x < 300 g) for *M. armatus*, (30 g ≥ x ≤ 70 g) for *M. vittatus*, (100 g ≥ x ≤ 250 g) for *O. niloticus* and (150 g ≥ x ≤ 270 g) for *W. attu*; medium weight groups (W-II) of (420 g ≥ x < 720 g) for *L. calbasu*, (300 g ≥ x < 350 g) for *M. armatus*, (70 g ≥ x ≤ 110 g) for *M. vittatus*, (250 g ≥ x ≤ 400 g) for *O. niloticus* and (270 g ≥ x ≤ 390 g) for *W. attu* and heavy weight groups (W-III) being (720 g ≥ x < 1020 g) for *L. calbasu*, (350 g ≥ x < 400 g) for *M. armatus*, (110 g ≥ x ≤ 150 g) for *M. vittatus*, (400 g ≥ x ≤ 550 g) for *O. niloticus* and (390 g ≥ x ≤ 510 g) for *W. attu*.

Determination of the Sex

Both sexes of the fish were established by the palpation method followed by dissection and gonad examination.[23] Specifically, squeezing the abdomen of some adult fish specimens resulted in the production of white milk for males and eggs for females. Dissection of some adult female samples revealed enlarged eggs in the paired ovaries, while adult male samples showed flattened, elongated, white and non-granular testes. In addition, the shape of the gonad was used to determine sex in young fish specimens. Otherwise, the gonads were removed and examined under a microscope for the existence of immature eggs (female) or creamy semen (male) in juvenile fish.

Detection of Ectoparasites on Fish

The fish samples were inspected for ectoparasites with a hand lens. Briefly, systematic head-to-tail skin scrapings and scrapings from fins and gills of the sampled fish were performed using a swab stick mixed with 3 mL of 0.9% saline and smeared on clean grease-free glass slides to examine the external parasites under a light microscope in the Department of Zoology Parasitology laboratory at Yogi Vemana University. Each sample was tested individually, as stated by Ekanem *et al*., (2011).[24] Parasites were identified based on unique and morphological traits using reference keys for fish parasite taxa.[25,26]

The Length-Weight Relationship (LWR)

The coefficients of the length-weight relationships were computed by the subsequent algorithm:[27]

$$W = aL^b$$

In this equation, 'b' is an exponent between 2 and 4, 'W' is the fish's weight in grams, 'L' is its length in centimetres, and 'a' is the constant (intercept).

'b' represents the length exponent (slope). The regression parameters 'a' and 'b' of the LWR were determined using a linear regression equation. After logarithmic translation of weight and length data, log W equals log a + b log L.

The Fulton's Condition factor (K)

The Fulton's Condition Factor (K), which proposes that the weight of the fish is proportional to the cube of the length, was used to measure the overall health of the fish on an individual and population basis. All individuals' total length, standard length, and body mass were measured. The allometric equation, with the b exponent set to a constant, was used to compare the health indexes of various fish categories. Fulton's Condition Factor (K) was computed using the formula:

$$K = W*100/ L^b,$$

Where 'W' is the fish's weight (g), 'L' is its standard length (cm), and 'b' is the coefficient of allometry (equal to 3).[28]

The Fulton's condition factor was multiplied with 100 to get it close to 1, and the number 1 indicated a normal condition of the fish, greater 1 indicated fat fish and less than 1 indicated skinny fish. This morphometric index assumes that the heavier fish for a given length, the better condition.

Statistical Analysis

Microsoft office Excel 2007 was used for entering obtained data for descriptive statistics. The data was transferred to the Statistical Package for the Social Sciences (version 21, SPSS Inc., USA) for additional statistical analysis.[29] The prevalence of ectoparasites in fish species was estimated as the number of fish infected divided by the total number of fish investigated and expressed as a percentage.[30-32] A fish sample was classified as infected if it was positive for any ectoparasites group. A positive test was coded as 1 and the negative test as 0. The chi-square statistic was employed to determine the degrees of associations and relationship between the risk factors and ectoparasite infection.[33] A linear regression table was utilized to determine the significance of the association found in the length weight analysis of infected and uninfected fish species. Analysis of Variance (ANOVA) was used to analyze the association between host sex, weight, total length, location, and parasite infection in pooled data, with a significance level of $p<0.05$.

RESULTS AND DISCUSSION

The current investigation indicated mixed fish species farming of *L. calbasu, O. niloticus, M. vittatus, M. armatus* and *W. attu* with significant incidence of numerous ectoparasites (single and co-infections) in the River Penna. The identified ectoparasites include Monogeneans, Crustaceans and Isopods.

Prevalence of Ectoparasites of Fish Species According to Morphometric Measurements

Overall, 372 (80%) of 465 examined fish species in the River Penna were infected with ectoparasites as follows: *Labeo calbasu* (75.7%), *M. armatus* (91%), *M. vittatus* (77.1%), *O. niloticus* (68.4%) and *W. attu* (98.9%) (Table 1). The fishes sampled were parasitized with Monogeneans (70.7%), Crustacean copepods (29.1%) and Isopods (0.094%) at individual level. The prevalence of ectoparasites varied among fish species, with the highest observed in *Wallago attu* (98.9%) and the lowest in *O. niloticus* (68.4%). The most commonly observed ectoparasites in these fish species included 10 species of monogeneans (e.g., *Dactylogyrus fotedari- L. calbasu; Mastacembelocleidus bam- M. armatus; Scutogyrus longicornis, Cichlidogyrus tilapiae, C. sclerosus- O. niloticus; Cornudiscoides vittati, Bifurcohaptor indicus- M. vittatus* and *Thaparocleidus indicus, T. wallagonius, Mizellus indicus- W. attu*), 2 species of copepods (e.g., *Ergasilus malnadensis- M. vittatus, W. attu; Lamproglena hospetensis- M. vittatus*), and one species of isopod (e.g., *Alitropus typus- W. attu*) (Table 2). The incidence and related risk factors of ectoparasite infections in numerous fish species River Penna have already been described.[34,35] The prevalence rates were significantly influenced by size (p=0.960, $\chi 2$= 0.6256, non-significant) and weight ($p<0.00001$, $\chi 2$= 72.66, significant).

Table 1: Data of fish species examined for spatial distribution of ectoparasites from YSR (Kadapa) District, Andhra Pradesh.

Name of the host	Total length (cm) Mean±SD (min-max)	Weight (g) Mean±SD (min-max)	Number of fish examined	Number of fish infected	Number of parasites obtained	Prevalence (%)	Mean Intensity	Family
1. *Labeo calbasu* Hamilton, 1822	7.95±1.78 (5-11)	429.9±191.42 (120-1000)	122	92	2123	75.4	23.1	Cyprinidae
2. *Mastacembelus armatus* Lacepede, 1800	10.8±1.70 (6.9-14.5)	328.88±56.89 (250-400)	45	41	965	91.1	23.5	Mastacembelidae
3. *Mystus vittatus* Bloch, 1794	7.02±2.14 (3-11)	87±26.6 (30-140)	70	54	238	77.1	4.41	Bagridae
4. *Oreochromis niloticus* Linnaeus, 1758	8.82±1.42 (5-12)	229.6±80.7 (100-500)	133	91	4028	68.4	44.3	Cichlidae
5. *Wallago attu* Bloch and Schneider, 1801	11.52±1.95 (7-15)	293.15±100.9 (150-500)	95	94	3202	98.9	34.1	Siluridae

Effect of Ectoparasite Infection on Length - Weight Relationships (LWR) and Fulton's Condition (K) Factor of Fish Species

Overall, there was a weak to strong positive correlation (R^2 range from -0.0806 to 0.96) existed in the LWR and negative allometric growth type of the fishes was observed in this study (Tables 3 and 4). The high R^2 indicated that the variability of the fish species were associated length. The Fulton's Condition Factor (K) of investigated fishes showed significant variations with sex and season ($p<0.001$), but not by species ($p>0.05$). Ectoparasitic infection had a significant ($p<0.05$) effect on the Fulton's Condition Index (K) of the fish examined in the present investigation and uninfected fish had a higher K value than infected fish (Table 3). Species significantly ($p<0.05$) influenced the K value among the infected fishes and not ($p>0.05$) among the uninfected fishes. Uninfected female and male fishes showed significantly ($p<0.05$) higher K values than in the infected female and male fishes. The difference in K value between infected and uninfected fishes was not affected by sex and season. The 'a' and 'b' values, equations of LWR and K values for all uninfected and infected sampled fishes as well as according to sex and season are shown in Tables 3 and 4. Overall, size (length) and weight were major factors of ectoparasites infection of the fishes. The higher infection rates were observed in large heavier fish (>110 g) among *M. armatus, M. vittatus* and *O. niloticus* which can be associated to their large body surface area, longer exposure to ectoparasites and diverse food sources in the river compared to the smaller, lighter (<30 g) and younger fishes. The present study was in concurrence with Vankara *et al*., (2011)[36] who reported higher infections rates in larger (65%) and >120 g weight (100%) fishes than smaller (17%) and <120 g weight (41.6 - 76.92%) fishes. Similarly, higher prevalence rates have also been reported among small and younger *L. calbasu* and medium large *W. attu* as they seem to be more vulnerable to parasitic infection with incidence rates reducing with age of the fishes.[37] Fish length is a key indicator for fishery resource management while the weight varies with respect to the length of the fish.[38] Thus, the Length-Weight Relationship (LWR) acts as an indispensable parameter providing insights into fish development trends and its productivity in fish biology and fisheries management.[39,40] The prevalence rates were significantly influenced by size ($p=0.960$, $\chi 2= 0.6256$, non-significant) and weight ($p<0.00001$, $\chi 2= 72.66$, significant) and negative allometric growth patterns (b < 2) were observed irrespective of the parasitic status of the fishes. A considerable positive correlation existed between the length and weight of the fish species (r> 0.92), except for *M. armatus* (r> 0.066). The mean condition factor (K) varied from 1.00 to 3.56 throughout the investigation, based on the sex, species, season and ectoparasitic status of the fish. The results indicated that the K factor of *M. armatus, W. attu* and *M. vittatus* was higher (K> 2) than that of *L. calbasu, O. niloticus* and *M. vittatus* (K< 2). Male fishes showed slightly higher K factor than the female fishes during the summer and rainy seasons than winter season. The Condition Factor (K) of infected and uninfected fishes revealed that the K factor of uninfected fishes was slightly greater than that of the infected fishes, except the K factor of infected *L. calbasu* which is slightly higher than the uninfected *L. calbasu*. The present study revealed that ectoparasite infection significantly influence length-weight relationships and condition factor of fishes River Penna. The exponential values of the LWR (b values) of cultured fishes were less than 3 (b<3) suggesting negative allometric growth trends since fishes with *b* values less than 3 showed more axial growth (length) than weight.[41] However, the values obtained in this study were less than the lower value of the recommended range (2 - 4) for fresh water fishes.[16,42,43] Sample size variation, life phases, growth disparities, changes in physiological conditions during spawning times, gonad development, sex, physicochemical conditions of the environment, and other environmental variables like space and nutrition have all been linked to variations in b values.[44] The Condition Factor (K) indicates

Table 2: Data of parasitic species obtained from the sampled fish of YSR (Kadapa) District, Andhra Pradesh.

Name of the Parasitic group	Name of the fish	Name of parasitic species	Number of fish examined	Number of fish infected	No. of parasites obtained	Prevalence (%)	Mean Intensity
Monogeneans	*Labeo calbasu* Hamilton, 1822	*Dactylogyrus fotedari* (Jain, 1960) Gusev, 1978	122	92	2123	75.4	23.1
	Mastacembelus armatus Lacepede, 1800	*Mastacembelocleidus bam* (Tripathi,1959) Kritsky *et al*., 2004	45	10	14	22.2	1.4
	Mystus vittatus Bloch, 1794	*Cornudiscoides vittati* Dubey,Gupta and Agarwal,1992	70	36	90	51.4	2.5
		Bifurcohaptor indicus Jain, 1958		41	119	58.6	2.9
	Oreochromis niloticus Linnaeus, 1758	*Cichlidogyrus sclerosus* Paperna andThurston, 1969	133	99	2245	74.4	22.6
		Cichlidogyrus tilapiae Paperna, 1960		76	725	57.1	9.5
		Scutogyrus longicornis (Paperna and Thurston, 1969) Pariselle and Euzet, 1995		82	1058	61.7	12.9
	Wallago attu Bloch and Schneider, 1801	*Thaparocleidus indicus* (Kulkarni, 1969) Lim, 1996	95	53	688	55.8	12.9
		Thaparocleidus wallagonius Jain, 1952		54	405	56.8	7.5
		Mizelleus indicus Jain, 1957		2	03	2.1	1.5
Copepods	*Mastacembelus armatus* Lacepede, 1800	*Ergasilus malnadensis* Venkateshappa, Seenappa and Manohar, 1998	45	41	951	91.1	23.2
	Wallago attu Bloch and Schneider, 1801		95	92	2096	96.8	22.8
	Mystus vittatus Bloch, 1794	*Lamproglena hospetensis* Manohar, Seenappa and Venkateshappa, 1992	70	12	29	17.14	2.4
Isopods	*Wallago attu* Bloch and Schneider, 1801	*Alitropus typus* Milne-Edwards, 1840	95	9	10	9.5	1.1

Table 3: Data of fish species examined for spatial distribution of ectoparasites from YSR (Kadapa) District, Andhra Pradesh.

Factors	Variable	a mean value	B mean value	R2	Standard Length	Weight (g)	W-L equation	Growth Type	K factor (g/cm³)
		(95% CI)	(95% CI)		(cm) mean±S.D (min- max)	Mean±S.D (Min - Max)			Mean±S.D (Min - Max)
Total	n=465	1.2551	1.19385	0.389	9.0722±2.37 (3-15)	283.28±162.47 (30-100)	$W= 1.2551L^{1.19385}$	Negative allometry	1.458823±0.820889 (0.46655-5.173)
Species	*L. calbasu* (*n*=122)	1.535	1.188	0.581	7.95±1.78 (5-11)	429.92±191.42 (120-1000)	$W= 1.53L^{1.18809}$	Negative allometry	1.0594±0.359 (0.416-2.156)
	O. niloticus (*n*=133)	0.704	1.736	0.833	8.827±1.42 (5-12)	229.58±80.787 (100-500)	$W=0.704L^{1.736}$	Negative allometry	1.598±0.316 (1.07413-2.88)
	M. armatus (*n*= 45)	2.42	0.0806	0.066	10.81±1.71 (6.9-14.5)	328.888±56.89 (250-400)	$W=2.42L^{0.0806}$	Negative allometry	3.56±0.872 (2.19-6.62)
	W.attu (*n*=95)	0.969	1.397	0.719	11.52±1.95 (7-15)	293.16±100.87 (150-500)	$W=0.969L^{1.397}$	Negative allometry	3.12±0.752 (2.03-5.18)
	M.vittatus (*n*=70)	0.277	1.756	0.927	7.02±2.15 (3-11)	87±26.61 (30-140)	$W=0.277L^{1.756}$	Negative allometry	2.41±0.34 (1.92-3.85)
Sex	Male (*n*=342)	1.192	1.263	0.407	8.99±2.41 (3-15)	281.30±160.79 (30-1000)	$W=1.192L^{1.263}$	Negative allometry	1.58±0.883 (0.507-5.64)
	Female (*n*=123)	1.5	0.929	0.338	9.29±2.26 (5-14)	288.78±167.61 (70-1000)	$W=1.50L^{0.929}$	Negative allometry	1.16±0.671 (0.362-4.09)
Season									
	Summer (*n*=81)	0.899	1.705	0.415	8.44±1.49 (5-11)	374.19±254.52 (100-1000)	$W=0.899L^{1.705}$	Negative allometry	1.22±0.800 (0.456-4.04)
	Rainy (*n*=158)	1.157	1.232	0.427	9.03±2.33 (3-15)	240.79±131.38 (40-1000)	$W=1.157L^{1.232}$	Negative allometry	1.121±0.60 (0.43-4.08)
	Winter (*n*=226)	1.3	1.148	0.568	9.32±2.61 (3-14)	280.39±122.92 (30-550)	$W=1.3L^{1.148}$	Negative allometry	1.098±0.477 (0.383-2.76)

a fish's physiological status in connection to its welfare[18] and is widely used to evaluate the impact of both biotic and abiotic variables on the health condition or overall well-being of the fish population.[45,46] The K value is especially useful for comparing two populations that thrive in similar climate, density, feeding and other conditions.[47,48] A Condition Factor (K) of 1.00 signifies that the fish is poor, long, and thin; 1.20 implies that the fish is in moderate and acceptable condition; and 1.40 shows that the fish is good and well-proportioned.[49] The mean condition factor of investigated fishes in the present research was larger than one (>1), indicating good fish health, adequate food, and appropriate environmental circumstances.[50,51] Overall, uninfected fish had a much higher mean condition factor value than infected fish. This means that the parasitism did not promote the fish's development or survival. The impact of environmental factors on growth and survival has previously been documented.[52] The results of this study also demonstrated that female fish and fish collected during the winter season had greater condition factors than male fish and fish taken during the rainy season. Differences in condition factors may be associated to factors such as fluctuations in environmental factors over time (e.g., water quality), accessibility of nutritious food supply, physiological circumstances (e.g., fat deposition and gonad maturation),[53] and stage of maturity.[16] Higher fish condition factors are linked to better environmental circumstances (physicochemical and biological parameters), and vice versa.[54,55] In addition, biological interactions involving intra- and interspecies competition for food and space, such as sex, maturity stages, stomach contents, food availability, and health status, have been reported to cause variation in K values.[56,57] Though species differences had no effect on the condition of uninfected fish, they did have a significant impact on the condition of infected fish. The highest condition among the infected fishes was recorded in *L. calbasu* followed by *Wallago attu* while the remaining three fishes showed almost same values. Reduced K values due to stress in fishes infected with parasites, bacteria, virus as well as fishes in poor water quality factors stop eating have been recorded.[58-63] Individual growth and condition are important components of performance for fish survival and

Table 4: Data of fish species examined for spatial distribution of ectoparasites from YSR (Kadapa) District, Andhra Pradesh.

Factors	Variable	A mean value	B mean value	R2	Standard Length	Weight (g)	W-L equation	Growth Type	K factor (g/cm3)
		(95% CI)	(95% CI)		(cm) Mean±S.D (min- max)	mean±S.D (Min - Max)			Mean±S.D (Min - Max)
Total	N=465								
	Parasitized (N=382)	1.613	0.8005	0.297	9.55±2.3 (4-15)	282.01±151.7 (40-1000)	$W= 1.613L^{0.8005}$	Negative allometry	1.14±0.603 (0.28-4.19)
	Non-parasitized (N=83)	0.831	1.668	0.315	8.22±1.77 (4-11.8)	289.1±206.1 (30-750)	$W= 0.831L^{1.668}$	Negative allometry	1.23±0.93 (0.297-5.03)
Species	*L.calbasu* (N= 122)								
	Parasitized (N= 92)	-0.048	2.95	0.596	7.84±1.85 (5-11)	401.1±194.43 (120-1000)	$W= -0.048L^{2.95}$	Negative allometry	1.12±0.57 (0.23-3.30)
	Non-parasitized (N=30)	1.98	0.778	0.47	8.3±1.53 (5-11)	518.3±153.4 (250-750)	$W= 3.07L^{0.778}$	Negative allometry	1.03±0.27 (0.43-1.53)
	O.niloticus (N= 133)								
	Parasitized (N= 101)	-0.703	1.754	0.861	8.94±1.48 (5-12)	243.96±84.74 (100-500)	$W=0.703L^{1.754}$	Negative allometry	1.01±0.165 (0.65-1.47)
	Non-parasitized (N= 32)	1.03	1.313	0.729	8.46±1.13 (6-10)	184.22±42.71 (100-250)	$W=1.03L^{1.313}$	Negative allometry	1.01±0.164 (0.70-1.48)
	M.armatus (N= 45)								
	Parasitized (*n*=41)	2.14	0.0917	0.0723	10.85±1.73 (6.9-14.5)	330.48±55.76 (250-400)	$W=1.03L^{1.313}$	Negative allometry	1.015±0.172 (0.75-1.27)
	Non-parasitized (*n*=4)	2.69	-0.2049	- 0.08067	10.35±1.37 (8.4-11.8)	312.5±75.0 (250-400)	$W=1.03L^{1.313}$	Negative allometry	1.02±0.247 (0.80-1.33)
	W.attu (*n*=95)								
	Parasitized (*n*=94)	0.969	1.396	0.716	11.52±1.95 (7-15)	294.15±100.95 (150-500)	$W=0.969L^{1.369}$	Negative allometry	1.02±0.23 (0.66-1.66)
	Non-parasitized (*n*=01)	0	0	0	0	0	0	0	0
	M.vittatus (*n*=70)								
	Parasitized (*n*=54)	1.02	0.986	0.934	9.11±2.10 (4-12)	92.4±24.4 (40-140)	$W=1.02L^{0.986}$	Negative allometry	1.00±0.098 (0.77-1.26)
	Non-parasitized (*n*=16)	3.116	1.002	0.96	7±2.52	68.75±29.3 (30-120)	$w=3.116L^{1.002}$	Negative allometry	3.14±0.42 (2.39-3.99)
Sex	Male (*n*=342)								
	Parasitized (*n*=277)	1.54	0.8865	0.313	9.45±2.30 (4-15)	281.30±160.79 (30-1000)	$W=1.54L^{0.8865}$	Negative allometry	1.13±0.585 (0.288-4.11)
	Non-parasitized (*n*=65)	0.65	1.836	0.342	8.19±1.85 (4-11.8)	271.3±206.0 (30-750)	$W=0.65L^{1.836}$	Negative allometry	1.27±1.02 (0.301-5.82)
	Female (*n*=123)								
	Parasitized (*n*=105)	1.808	0.5788	0.262	9.79±2.23 (5-14)	277.71±160.2 (70-1000)	$W=1.808L^{0.5788}$	Negative allometry	1.16±0.65 (0.32-4.35)
	Non-parasitized (65)	2.17	0.312	0.178	8.33±1.49 (5-11)	353.33±198.6 (70-750)	$W=2.17L^{0.312}$	Negative allometry	1.29±0.64 (0.30-2.42)
Season									
	Summer (*n*=81)								
	Parasitized (*n*=38)	1.92	2.357	0.543	8.42±1.63 (5-11)	373.4±285.5 (100-1000)	$W=1.92L^{2.357}$	Negative allometry	1.19±0.73 (0.45-2.91)

	Non-parasitized (*n*=43)	1.68	0.86603	0.246	8.41±1.36 (5-11)	374.8±227.10 (100-750)	$W=1.68L^{0.86603}$	Negative allometry	1.213±0.726 (0.38-2.54)
	Rainy (*n*=158)								
	Parasitized (*n*=139)	1.165	1.2217	0.415	9.24±2.3 (3-15)	245.8±132.8 (40-1000)	$W=1.165L^{1.2217}$	Negative allometry	1.12±0.59 (0.43-4.09)
	Non-parasitized (*n*=19)	1.05	1.366	0.461	7.52±1.98 (3-10)	203.9±116.8 (50-500)	$W=1.05L^{1.366}$	Negative allometry	1.13±0.64 (0.49-2.65)
	Winter (*n*=226)								
	Parasitized (*n*=205)	1.55	0.897	0.519	9.54±2.5 (4-14)	289.61±117.19 (60-550)	$W=1.55L^{0.897}$	Negative allometry	1.085±0.42 (0.39-2.31)
	Non-parasitized (*n*=21)	2.41	-0.3463	0.698	7.16±2.70 (3-11.8)	190.47±143.4 (30-500)	$W=2.41L^{-0.3463}$	Negative allometry	1.51±1.21 (0.167-4.09)

reproductive success.[64,65] In the current study, the condition index was noticeably different between parasitized and non-parasitized fishes, and the results were concordant with previous studies that reported the link of parasite pathogenicity with various factors such as host size, age and health, size and developmental stages of parasite and environment stress, isolation, pollution.[66]

CONCLUSION

The study revealed that ectoparasite infection has a substantial impact on the length-weight relationship and condition factor of fish inhabiting River Penna. Regardless of parasitic status, the fish exhibited a negative allometric development pattern, and there was a link between body weight and length of fish. However, male fishes, fishes sampled during the summer season and uninfected fishes had better condition and were relatively healthier compared to female fishes, fishes harvested during the rainy season and infected fishes.

ACKNOWLEDGEMENT

The corresponding author commemorates this work to late Dr. Asha Kiran Modi, who worked under the financial assistance of UGC Faculty improvement programme (FIP)- Award No.APSC021/001(TF)ZOOLOGY/PH.DXII PLAN/2016-17 dt. July 2016.

ABBREVIATIONS

LWR: Length-Weight Relationship; **K:** Condition factor; **S-I:** Small sized groups; **S-II:** Medium sized groups; **S-III:** Large sized group; **W-I:** Low weight groups; **W-II:** Medium weight groups; **W-III:** Heavy weight groups; **SPSS:** Statistical Package for the Social Sciences; **ANOVA:** Analysis of Variance.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

FUNDING

The work was funded to Late, Mrs. Asha Kiran Modi under UGC Faculty Improvement Programme (FIP)- Award No. APSC021/001(TF)ZOOLOGY/PH.DXII PLAN/2016-17 dt. July 2016.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

All procedures contributing to this work comply with the ethical standards of the relevant national guides on the care and use of laboratory animals and was approved and authorized by IAEC (Institution of Animal Ethics Committee-Regd. No.1460/PO/a/11/CPCSEA, dt. 20.05.2011), Department of Zoology, Faculty of Life Sciences, Yogi Vemana University, Andhra Pradesh.

CONSENT FOR PUBLICATION

The authors give consent for publication in the journal.

AVAILABILITY OF DATA AND MATERIAL

The raw data used to support the findings of this study are available from the corresponding author upon reasonable request.

AUTHORS' CONTRIBUTIONS

APV designed and collected (along with late Dr. Asha Kiran Modi) the samples and carried out the experiments, framed the manuscript.

REFERENCES

1. Semba RD. The rise and fall of protein malnutrition in global health. Ann Nutr Metab. 2016;69(2):79-88.
2. Tidwell JH, Allan GL. Fish as food: aquaculture's contribution. Ecological and economic impacts and contributions of fish farming and capture fisheries. EMBO Rep. 2001;2(11):958-63.
3. Beveridge MC, Thilsted SH, Phillips MJ, Metian M, Troell M, Hall SJ. Meeting the food and nutrition needs of the poor: the role of fish and the opportunities and challenges emerging from the rise of aquaculture. J. Fish. Biol. 2013;83(4):1067-84.
4. Béné C, Barange M, Subasinghe R. Feeding 9 billion by 2050 - Putting fish back on the menu. Food Sec. 2015;7:261-74. https://doi.org/10.1007/s12571-015-0427-z.
5. Henchion M, Hayes M, Mullen AM, Fenelon M, Tiwari B. Future Protein Supply and Demand: Strategies and Factors Influencing a Sustainable Equilibrium. *Foods*. 2017;6:53. https://doi.org/10.3390/foods6070053

6. Boyd CE, McNevin AA, Davis RP. The contribution of fisheries and aquaculture to the global protein supply. Food Sec. 2022;14:805-27. https://doi.org/10.1007/s12571-021-01246-9.
7. Ojwala RA, Otachi EO, Kitaka NK. Effect of water quality on the parasite assemblages infecting Nile tilapia in selected fish farms in Nakuru County, Kenya. Parasitol Res. 2018;117(11):3459-71.
8. Öktener A, Bănăduc D. Ecological Interdependence of Pollution, Fish Parasites, and Fish in Freshwater Ecosystems of Turkey. *Water*, 2023; *15*: 1385. https://doi.org/10.3390/w15071385.
9. Buchmann K. Control of parasitic diseases in aquaculture. Parasitol. 2022;149(14):1985-97.
10. Vankara AP, Chikkam V. Histopathology of heart of freshwater spiny eel, *Mastacembelus armatus* naturally infected with *Tetracotyle* metacercaria (Trematoda: Strigeidae). Res. J. Parasitol. 2013;8(2):45-54.
11. Kotob MH, Menanteau-Ledouble S, Kumar G. The impact of co-infections on fish: a review. Vet Res. 2017;47:98. https://doi.org/10.1186/s13567-016-0383-4.
12. Vankara AP. Mode of attachment and Pathogenecity of *Circumonchobothrium shindei* (Eucestoda: Ptychobothriidae) in *Mastacembelus armatus* of River Godavari, Andhra Pradesh, India. Int. J. Zool. Res. 2018;14(1):1-7.
13. Gudivada M, Vankara AP, Chikkam, V. Pathological Changes in the intestine of the Marine fish *Polydactylus sexfilis* (Val. 1831), due to heavy infestation of the acanthocephalan parasite, *Raorhynchus polynemi* from Eastern Coast of Bay of Bengal. J. Env. Bio-Sci. 2021;35(1):47-53.
14. Vankara AP, Thummala C, Khateef R, Peddinti RA. Histopathological evaluation of *Wallago attu* (Bloch and Schneider, 1801) infested by ectoparasites. J. Bas. Appl. Zool. 2022;83:32.
15. Abdisa T, Bula B, Etana M, Getu M. Epidemiology of Helminthes, Protozoans and Ectoparasites of Fishes: A Review. Vet. Med. Animal Sci. 2023;6(1):1126.
16. Jisr N, Younes G, Sukhn C, El-Dakdouki MH. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. The Egypt. J. Aquat. Res. 2018;44(4):299-305.
17. Oyebola OO, Omitoyin SB, Hounhoedo AOO, Agadjihouèdé H. Length-weight relationship and condition factor revealed possibility of mix strains in *Clarias gariepinus* population of Oueme Valley, Benin Republic (West Africa). Tot. Env. Res. Them. 2022; 3-4.
18. Datta SN, Kaur VI, Dhawan A, Jassal, G. Estimation of length-weight relationship and condition factor of spotted snakehead *Channa punctata* (Bloch) under different feeding regimes. Spring. Plus. 2013;2:436.
19. Schloesser RW, Fabrizio MC. Condition indices as surrogates of energy density and lipid content in juveniles of three fish species. Trans. Amer. Fish. Soc. 2017;146:1058-69. https://doi.org/10.1080/00028487.2017.1324523.
20. https://en.wikipedia.org/wiki/Kadapa.
21. Jayaram KC. The fresh water fishes of India, Pakistan, Bangladesh, Burma and Sri Lanka - A handbook. *Zoological Survey of India. Calcutta,* 1981.
22. Day F. The fishes of India, being a Natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon. Fourth Indian report, 1994; 1-2.
23. Kano Y. Sexing fish by palpation: a simple method for gonadal assessment of fluvial salmonids. J. Fish Biol. 2005;66:1735-9. https://doi.org/10.1111/j.0022-1112.2005.00706.x
24. Ekanem AP, Eyo VO, Sampson AF. Parasite of landed fish from Great Kwa River, Calabar, Cross River, Nigeria. Int. J. Fisher. Aquacul. 2011;3(12):225-30.
25. Hiware CJ, Jadhav BV, Mohekar AD. Applied Parasitology. A practical manual. *Mangaldeep Publications*, Jaipur. 2003; ISBN: 81-7594-115-4;1-243.
26. Buchmann, K. 2007. Practical methods in Fish Parasitology- Classical and Molecular Techniques. Biofolia Press, ISBN: 978-87-913-1939-6;1-130.
27. Froese R. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. J. Appl. Ichthyol. 2006;22:241-53.
28. Sarkar UK, Khan GE, Dabas A, Pathak AK, Mir JI, Rebello SC, *et al.* Length weight relationship and condition factor of selected freshwater fish species found in River Ganga, Gomti and Rapti, India. J. Environ. Biol. 2013; 34: 951-956.
29. Vankara AP. Prevalence and spatial distribution of ectoparasites in *Wallago attu* of River Penna, YSR District, Andhra Pradesh, India. Appl. Biol. Res. 2022;24(3):367-75. doi: 10.5958/0974-4517.2022.00047.7.
30. Margolis L, Esch GW, Holmes JC, Kuris AM, Schad GA. The use of ecological terms in parasitology (report of an Adhoc Committee of the American Society of Parasitologists). J. Parasitol. 1982;68:131-7.
31. Bush O, Lafferty AD, Lotz JM, Shostak AW. Parasitology meets ecology on its own terms: Margolis et al. Revisited. J. Parasitol. 1997;83:575-83.
32. Modi AK, Vankara AP. Prevalence and spatial distribution of the ectoparasites on the gills of *Mystus vittatus* from River Penna flowing through YSR Kadapa District, Andhra Pradesh, India. J. Par. Dis. 2021;45(1):43-49.
33. Houda B, Abir S, Ahlem L, Fatiha S, Nouha K, Chahinaiz B. Effect of parasitic copepods on the length-weight relationship and the condition factor of crucian carp (*Carassius carassius*) in the Beni-Haroun Dam, Mila City, Northeast Algeria. Anim res Int,19(3):4625-33.
34. Modi AK, Vankara AP. The monogenean community on the gills of *Labeo catla* Hamilton, 1822 from YSR Kadapa District, Andhra Pradesh, India. Mal. J. Biosci. 2019;6(1):42-52.
35. Vankara AP, Modi AK. Gill ccommunity istructure iand ispatial iallocation iof iCichlidogyrid imonogenean iparasites ion ithe igills iof i*Oreochromis iniloticus* (Linné, i1758) iof iYSR iKadapa idistrict, Andhra ipradesh, iIndia. UP J. Zool. 2021;41(23):72-85.
36. Vankara AP, Mani G, Vijayalakshmi C. Metazoan parasite infracommunities of the freshwater eel, *Mastacembelus armatus* Lacèpéde, 1800 from River Godavari, India. Int. J. Zool. Res. 2011;7(1):19-33.
37. Dewi RR, Desrita, Fadhilla A. The prevalence of parasites in ornamental fish from fish market in Medan. *IOP Conf. Ser.: Earth Environ. Sci*. 2018; 122 012110.
38. Tseng CH, Hsieh CL, Kuo YF. Automatic measurement of the body length of harvested fish using convolutional neural networks. Biosys. Eng. 2020;189:36-47.
39. Getso BU, Abdullahi JM, Yola IA. Length-weight relationship and condition factor of *Clarias gariepinus* and *Oreochromis niloticus* of Wudil River, Kano, Nigeria. Agro-sci. J. Trop. Agricul. Food. Environ. Exten. 2017;16(1):1-4.
40. Rodríguez-García, C., Castro-Gutiérrez, J., Domínguez-Bustos, Á.R., García-González, A. and Cabrera-Castro, R. Every fish counts: challenging length-weight relationship bias in discards. *Fish*. 2023;8:222.
41. Kuraikose S. Estimation of length weight relationship in fishes. Chapter,17: 215-220. Summer School on Advanced Methods for Fish Stock Assessment and Fisheries Management. CMFRI, Frad.. Training Manual on Fish Stock Assessment and Management, 2014; 150.
42. Sánchez-González JR, Arbonés A, Casals F. Variation over time of length-weight relationships and condition factors for four exotic fish species from a restored shallow lake in NE Iberian Peninsula. *Fish*. 2020;5:7.
43. Rana A, Uppal R. Length-weight relationships and condition factors of three freshwater fish species - *Bangana dero* (Ham.), *Cyprinus carpio* L., and *Sperata seenghala* (Sykes) - from the Sutlej River, India. Fisher. Aqua. Lif. 2024;31:225-32. 10.2478/aopf-2023-0022.
44. Ali APH, Prasad G, Balasubramanyam NK, Chandran LR, Raghav RP. Weight-length relation of an Asian catfish, *Horabagrus brachysoma* (Gunther, 1864), (Siluriformes: Horabagridae) from rivers of the Western Ghats, Kerala, India. ActaIchthyol Piscat. 2008;38(1):41-4.
45. Keyombe JL, Obegi B, Waithaka E. Length-weight relationship and condition factor of *Clarias gariepinus* in Lake Naivasha, Kenya. Int. J. Fisher. Aqua. Stud. 2015;2(6):382-5.
46. Komba EA, Munubi RN, Chenyambuga SW. Comparison of body length-weight relationship and condition factor for Nile tilapia (*Oreochromis niloticus*) cultured in two different climatic conditions in Tanzania. Int. J. Fisher. Aqua. Stud. 2020;8(3):44-8.
47. Ndiaye W, Diouf K, Samba O, Ndiaye P, Panfili J. The length-weight relationship and Condition Factor of white grouper (*Epinephelus aeneus*, Geoffroy Saint Hilaire, 1817) at the south-west coast of Senegal, West Africa. Int. J. Adv. Res. 2015;3(3):145-53.
48. Dambatta MA, Bilyaminu H, Zakari H, Umar AF, Abdulrashed I, Sogbesan OA. 2017. Length - weight relationship and condition factor of (*Oreochromis niloticus*) in Wudil River Kano State, Nigeria. 7th Int. Conf. Biol. Chem. Environ. Sci., (BCES-2017) 6-7, 2017 Budapest (Hungary) https://doi.org/10.17758/EAP.C0917047: 32-37.
49. Fafioye O, Ayodele O. Length-Weight Relationship and Condition Factor of Four Commercial Fish Species of Oyan Lake, Nigeria. Examines. Mar. Biol. Oceanogr. 2018; 2(4).EIMBO.000543.2018. DOI: 10.31031/EIMBO.2018.02.000543.
50. Ighwela KA, Ahmed AB, Ambok AM. Condition factor as an indicator of growth and feeding intensity of Nile Tilapia Fingerlings (*Oreochromis niloticus*) feed on different levels of maltose. American-Eurasian J. Agricult. Environ. Sci. 2011;11:559-63.
51. Ajibare AO, Loto OO. Length-weight relationship and condition factor of *Sarotherodon melanotheron* and *Tilapia guineensis* in Lagos lagoon, Nigeria. Agrosearch. 2022; 21(1&2):57-66.
52. Ragheb E. Length-weight relationship and well-being factors of 33 fish species caught by gillnets from the Egyptian Mediterranean waters off Alexandria. Egyp. J. Aqua. Res. 2023;49(3):361-7.
53. Yulianto D, Indra I, Batubara AS, Efizon D, Nur FM, Rizal S, Elvyra R, Muchlisin ZA. Length-weight relationships and condition factors of mullets *Liza macrolepis* and *Moolgarda engeli* (Pisces: Mugilidae) harvested from Lambada Lhok waters in Aceh Besar, Indonesia. F1000Res. 2020;9:259.
54. Kavya UM, Nandini NJ, Benjamin SG. Morphometric Study, Length-weight Relationship and Condition Factor of *Horabagrus brachysoma* (Günther, 1864), an Endemic Fish in the Rivers of Western Ghats of India. Biol. For. - An Int. Journ. 2023;15(1):540-4.
55. Yousuf T, Bakhtiyar Y, Andrabi S, Wani GB. Length-Weight Relationship and condition factor of Seven fish species in Manasbal Lake, Kashmir, India. Croat. J. Fisher. 2023;81:13-22.
56. Gupta B, Sarkar U, Bhardwaj S, Pal A. Condition factor, length-weight and length-length relationships of an endangered fish *Ompok pabda* (Hamilton, 1822) (Siluriformes: Siluridae) from the River Gomti, a tributary of the River Ganga, India. J. Appl. Ichthyol. 2011; 27.10.1111/j.1439-0426.2010.01625.x.
57. Nelly FN, Frank OM, James EB, Geraldine KM, Jacques WR, Mulongaibalu M. Influence of the changing environment on food composition and condition factor in *Labeo victorianus* (Boulenger, 1901) in rivers of Lake Victoria Basin, Kenya. Aquacul. Fisher. 2023;8(2):227-38.
58. Sahreen A, Fatima K, Zainab T. Changes in the level of oxidative stress markers in Indian catfish (*Wallago attu*) infected with*Isoparorchis hypselobagri*. Beni-Suef. Univ. J. Basic. Appl. Sci. 2021;10:85.
59. Sures B, Nachev M. Effects of multiple stressors in fish: how parasites and contaminants interact. *Parasitol*. 2022; 149 (14): 1822-1828.

60. Ziarati M, Zorriehzahra MJ, Hassantabar F, Mehrabi Z, Dhawan M, Sharun K, Emran TB, Dhama K, Chaicumpa W, Shamsi S. Zoonotic diseases of fish and their prevention and control. Vet Q. 2022;42(1):95-118.
61. Singh SK, Meitei MM, Choudhary TG, Soibam N, Biswas P, Waikhom G. Bacterial diseases in cultured fishes: an update of advances in control measures. Bacterial Fish Diseases, Academic Press, 2022; Chap-15: 307-335, ISBN 9780323856249, https://doi.org/10.1016/B978-0-323-85624-9.00019-1.
62. Senthamarai MD, Rajan MR, Bharathi PV. Current risks of microbial infections in fish and their prevention methods: A review. Microbial Pathogenesis, 2023; 185: 106400, ISSN 0882-4010, https://doi.org/10.1016/j.micpath.2023.106400.
63. Radwan M, El-Sharkawy MA, Alabssawy AN. The synergy between serious parasitic pathogens and bacterial infestation in the cultured Nile tilapia (*Oreochromis niloticus*): a severe threat to fish immunity, causing mass mortality and significant economic losses. Aquacult. Int. 2023;31:2421-49.
64. Canosa LF, Bertucci JI. The effect of environmental stressors on growth in fish and its endocrine control. Front. Endocrinol (Lausanne). 2023;14:1109461.
65. Mitra A, Abdel-Gawad FK, Bassem S, Barua P, Assisi L, Parisi C, *et al.* Climate Change and Reproductive Biocomplexity in Fishes: Innovative Management Approaches towards Sustainability of Fisheries and Aquaculture.*Water*. 2023;15(4):725.
66. Antunes DF, Silva BAF, Yamada FH. Effect of parasitism on the relative condition factor of *Astyanax bimaculatus* (Characiformes: Characidae) a freshwater fish from Caatinga domain, Brazil. Int. J. Aqua. Biol. 2022;10(5):370-7.

Cite this article: Vankara AP, Effect of Ectoparasitism on Length-Weight Relationship and Condition Factor of Five Fish Species in River Penna, Kadapa, Andhra Pradesh. Asian J Biol Life Sci. 2025;14(3):709-18.