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Comparative Study of Growth and Carcass Traits in a Genetically Improved Strain of Jayanti Rohu Cultured in Freshwater and Low-salinity Pond Conditions

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ABSTRACT

Background: The study evaluated the effects of family, pond, sex and culture system on growth and carcass traits in genetically improved strain of Jayanti rohu under freshwater and low-salinity conditions, with relevance for expanding aquaculture into salinity-affected areas.

Methods: A total of 1,252 fingerlings from 42 full-sib families (2021 year-class, 12th generation) were stocked at 5,000 fingerlings/ hectare (ha) in two freshwater and two low-saline (4-7 ppt) ponds for 12 months. Growth traits were measured at tagging, mid-culture (6 months) and harvest (12 months), while seven carcass traits were recorded on 711 harvested fish, with crude muscle fat evaluated in 600 specimens.

Result: The mean harvest weight was 865.43±4.17 g with 89.1% survival. Crucially, no significant differences in mean body weight were observed between the culture systems, indicating strong adaptability of the strain. Crude muscle fat was significantly higher in low-salinity ponds (10.63%) than freshwater (9.67%) ($p<0.05$). Average carcass composition included 61.06% dressing yield, 21.7% head weight, 17.25% carcass waste and 10.03% crude fat. Sex significantly influenced traits from mid-culture onward, with females achieving 9.4% higher harvest weight and superior dressing yields ($p<0.05$). Pond and culture system had minimal effects, while strong positive correlations between harvest weight and carcass traits confirmed proportional relationships ($p<0.05$). Overall, these findings demonstrate the substantial potential of Jayanti rohu for low-saline ponds without compromising growth or carcass quality.

Key words: Carcass trait, Growth, Jayanti rohu, Low saline aquaculture, Non-genetic factors.

INTRODUCTION

Indian major carps (IMCs), namely catla (*Labeo catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*), constitute the backbone of freshwater aquaculture in India and are widely reared in polyculture systems to maximize pond productivity. Among these, rohu is an economically predominant freshwater aquaculture species in South Asia, contributing over 60% of carp production due to its high consumer preference and market demand (Rasal and Sundaray, 2020; Kumar *et al*., 2022).

With capture fisheries stagnant and facing climate change challenges, aquaculture must meet expanding global demand for aquatic food, projected at 109 million tonnes by 2030 (FAO, 2020; Singh *et al*., 2025). In this scenario, genetic improvement has significantly enhanced aquaculture productivity and farmer profitability through superior growth, better feed efficiency and higher yield. Despite delivering ~12.5% growth gain per generation, only 10-20% of global aquaculture currently relies on genetically improved stocks (Houston *et al*., 2022). The Jayanti rohu, is a genetically improved strain of rohu, widely adopted across more than 100,000 ha of culture area in India, due to its superior growth performance and disease resistance against *Aeromonas hydrophila* (Mahapatra *et al*., 2017; Saikia *et al*., 2020; Rasal *et al*., 2023).

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India currently contends with approximately 6.74 million hectares (ha) of salt-affected land, with its extent expanding by 10% annually (Kumar and Sharma, 2020). Converting these salt-affected areas into commercial aquaculture hubs offers a strategic pathway toward economic profitability and land restoration (Tarolli *et al*., 2024). The Jayanti rohu has

shown immense potential for culture in low-salinity zones (<6.0 ppt), with acceptable survival and growth (Murmu *et al*., 2019; Hoque *et al*., 2020).

Carcass traits are critical economic indicators influencing fillet yield, flesh quality and market value (Neira *et al*., 2004). Fernandes *et al.* (2015) reported carcass yield of 56-59% in Nile tilapia (*Oreochromis niloticus*) at different ages while Saillant *et al.* (2009) stated total viscera (10.5±2.3%), visceral fat (6.9±2.0%), fillets (33.7±2.4%), fish head (20.7±1.9%) and filleting waste products (34.3±2.0%) in *Dicentrarchus labrax.* To date, no study has simultaneously evaluated growth performance and carcass traits of genetically improved carp strains under both freshwater and low-salinity pond conditions. Therefore, the present study aim to know the effects of different non-genetic and genetic factors on growth and carcass trait of Jayanti rohu and also to compare growth potential of Jayanti rohu in freshwater and low saline pond condition.

MATERIALS AND METHODS

Fingerlings were derived from 42 full-sib families of the 2021 year-class Jayanti rohu (12th generation) from the ongoing selective breeding program at ICAR-CIFA, Bhubaneswar, India. A total of 1,252 fingerlings (39.25±0.82 g) were individually tagged using Passive Integrated Transponder (PIT) tags after seven months of separate nursery rearing. The tagged fish were randomly stocked in two freshwater ponds (0.1 ha each) at ICAR-CIFA and two low-salinity ponds (4-7 ppt; 0.1 ha each) at Brahmagiri, Odisha @ of 5,000 fingerlings/ha comprising 80% Jayanti rohu (400 numbers) and 20% catla (100 numbers) and reared for 12 months (April 2022-April 2023) following standard aquaculture practices. Before stocking the fingerlings to low saline ponds they were acclimatized for one hour in the same pond by adding pond water (low saline) in the oxygen packed bag slowly and then released them in the pond. The sampling conducted at 6 months and final harvest after 12 months of communal pond rearing. The water quality parameters were monitored monthly and remained within suitable ranges (Table 1). Fish were fed with CIFA-Carp Grower™ feed (28% Protein and 4% Fat) at 5% of body weight during the initial two months and 3% thereafter. The feeding ration was adjusted by sampling the fishes (50 no.) from each pond on monthly basis and estimating average biomass considering 90% survival.

Condition factor 'K' was estimated using Froese, 2006 equation *i.e*.,

$$K = W \times 100/L^3$$

Where,
K = Condition factor.
W = Observed body weight (g).
L = Observed length of fish (cm).

At harvest, 711 fish were sacrificed with overdose of 2-phenoxy ethanol (1 ml/L) and the sex was recorded by visual inspection of gonads and for remaining fish based on secondary sexual characters like roughness of pectoral fin. Carcass traits measured were calculated as:

CW = Live weight (BW3) minus total viscera, head, fin and scale weight

$$\text{Dressing } \% = \frac{\text{Carcass weight}}{\text{Live weight (BW3)}} \times 100$$

Carcass waste (CaWa) = Weight of viscera, fins and scales

$$\text{Head weight } \% = \frac{\text{Head weight}}{\text{BW3}} \times 100$$

$$\text{Ca Wa } \% = \frac{\text{Carcass waste}}{\text{BW3}} \times 100$$

The crude fat estimation was done using Soxhlet apparatus.

$$\text{Muscle crude fat } \% = \frac{\text{Weight of extract}}{\text{Weight of sample}} \times 100$$

The statistical data analysis was performed using SAS OnDemand for Academics (https://welcome.oda.sas.com/). A general linear model (PROC GLM) was fitted to estimate least square means and the significant effects of various genetic and non-genetic factors. For analysis of BW2 and BW3, body weight at stocking (tagging), for TL2 and TL3, total length at stocking and for carcass traits body weight at harvest was used as covariate employing model 1. Pairwise comparison of means was carried out using the Tukey-Kramer test, with a significance threshold established at 0.05.

$$Y_{ijklm} = \mu + BW1_i + f_j + c_k + s_l + p(c)_{mk} + e_{ijklm}$$

....model 1

Where,
Y_{ijklm}: mth record of fish belonging to jth full-sib family and kth culture system, mth pond and lth sex.
μ: Mean.
$BW1_i$: Effect of body weight at tagging used as a covariate.
f_j: Fixed effect of full-sib family (f1……..f42).
c_k: Fixed effect of culture system (freshwater and low saline).
s_l: Fixed effect of sex (male, female).
$p(c)_{mk}$: Nesting effect of pond by culture system.
e_{ijklm}: Error.

The Pearson correlation coefficients (r) among traits were estimated by PROC CORR.

RESULTS AND DISCUSSION

Descriptive statistics and variability of growth and carcass traits in Jayanti rohu

The descriptive statistics for growth and carcass traits have been presented in Table 2. At tagging, the mean total length (TL1) and body weight (BW1) were 148.87±0.70 mm and 39.25±0.82 g, at six month sampling 346.11±0.53 mm and 543.11±2.33 g (TL2, BW2) and at harvest 402.68±0.65 mm and 865.43±4.17 g (TL3, BW3) respectively, with 89.1% survival (Table 3) indicating consistent growth. The harvest

weight falls within the reported range of 800-1000 g for improved rohu within one year culture (Mahapatra *et al*., 2017; Shukla and Tripathi, 2022). Carcass traits revealed a mean dressing percentage of 61.06±0.05%, head weight and carcass waste contributing 21.70±0.03% and 17.25±0.04%, respectively (comprising 9.41% viscera, 5.62% scales and 2.23% fins), closely matching values reported by Sahu *et al*. (2012) for rohu, indicating favorable processing yield. The mean muscle crude fat content was 10.03±0.07%, within the typical range of 8-12% as reported for carps, influenced by feeding and culture conditions (Asghar *et al.,* 2023). Overall, Jayanti rohu demonstrates desirable growth and carcass characteristics for enhanced aquaculture productivity.

Effect of genetic and environmental factors on growth and carcass traits

The mean square and R^2 values for growth traits are presented in Table 4 and least squares means in Table 5. Significant differences were observed in the growth traits (TL1, TL2, TL3, BW1, BW2 and BW3) among families ($p<0.05$), indicating substantial genetic variability, consistent with earlier reports on improved carp strains (Dey *et al*., 2013). Sex had no significant effect at tagging ($p>0.05$), however, it became significant during six months and at harvest ($p<0.05$). Females exhibited 9.4% higher harvest weight (BW3: 913±4.35 g) than males (834±4.47 g). The condition factor for females (1.34±0.004) was significantly higher compared to males at harvest ($p<0.05$). Similar sexually dimorphic growth patterns, with higher growth and feed efficiency in females, have been reported in carps and other fish species (Sutthakiet *et al*., 2024). Pond effect was non-significant ($p>0.05$), suggesting uniform culture conditions and consistent feeding regime. The significant influence of initial body weight (BW1) on harvest weight (BW3) ($p<0.05$) highlights the importance of stocking size, as also reported earlier (Taher *et al*., 2021). The culture system has no significant effect on harvest

Table 1: Water quality parameters recorded from freshwater and low salinity ponds.

Water parameters	Freshwater pond	Low salinity pond
pH	7.5-8.0	8-8.5
Total alkalinity (ppm)	90-110	150-200
Total hardness (ppm)	80-90	200-250
Dissolved oxygen (ppm)	4-6	6-8
Salinity (ppt)	0	4-7
Temperature (°C)	24-30	24-30

Table 2: Descriptive statistics of growth and carcass traits in the Jayanti strain of rohu.

Trait	N	Min	Max	Mean±SE	CV (%)
TL1 (mm)	1252	95.00	230.00	148.87±0.94	22.23
BW1 (g)	1252	10.00	129.00	39.25±0.82	73.55
TL2 (mm)	1108	300.00	395.00	346.11±0.53	5.10
BW2 (g)	1108	400.00	750.00	543.11±2.33	14.28
TL3 (mm)	1118	340.00	465.00	402.68±0.65	5.43
BW3 (g)	1118	525.00	1331.00	865.43±4.17	16.17
CF	1118	0.99	1.91	1.32±0.01	9.60
HW (g)	711	121.00	285.00	186.16±1.04	14.96
CW (g)	711	329.00	789.00	525.08±3.18	16.17
CaWa (g)	711	84.00	263.00	148.87±1.07	19.11
CaWa %	711	14.51	21.57	17.25±0.04	6.51
HW %	711	18.50	24.92	21.70±0.03	4.17
Dressing %	711	57.05	67.92	61.06±0.05	2.13
Muscle crude fat %	600	5.80	15.20	10.03±0.07	16.34

Table 3: Culture system and pond wise survival of 2021 year class Jayanti rohu.

Culture system	Pond	Survival %	Overall survival %
Freshwater	Pond 4	90.4	90.38
	Pond 5	90.3	
Low saline	Pond 6	88.2	87.88
	Pond 7	87.5	

Table 4: Mean squares and R^2 values of model parameters for growth trait at tagging (TL1, BW1), sampling (TL2, BW2) and final harvest (TL3, BW3) in Jayanti rohu.

Source	DF	TL1 (mm)	BW1 (g)	TL2 (mm)	BW2 (g)	TL3 (mm)	BW3 (g)	CF
Body weight or total length at tagging	1	-	-	6.3568	62.212	0.7394	5177.096	-
Culture system	1	399.311	115.462	1766.2730*	13874.635*	4835.5778*	5185.308	0.00125185*
Pond (Culture system)	2	15.231	8.4909	23.3566	255.369	33.9282	34704.574	0.00010820
Sex	1	91.141	1.1689	3001.8649*	20550.270 *	26862.7747*	1736973.221*	0.00038751*
Family	41	28258.515*	22072.280*	4027.7664*	83010.260*	4616.9542*	192295.624*	0.00015972*
Error	1071	52.190	21.2806	102.0290	1209.056	197.8561	5902.40	0.00002317
R^2 %		95.5	97.6	68.03	80.3	60.3	70.9	25.29

Table 5: Pond, culture system and sex wise least squares means and their standard errors for the growth traits at stocking (TL1 and BW1), at sampling (TL2 and BW2) and at harvest (TL3 and BW3) in Jayanti rohu.

		At stocking			At sampling			At harvest			
Effects		N	TL1 (mm)	BW1 (g)	N	TL2 (mm)	BW2 (g)	N	TL3 (mm)	BW3 (g)	CF (K)
Overall		1252	155±0.24	45±0.15	1108	347±0.50	549±1.72	1118	404±0.57	874±3.75	1.32±0.003
Pond (Culture system)	Pond 4 FW	356	155^{a}±0.40	45^{a}±0.26	306	345^{a}±0.72	554^{a}±2.48	322	406^{b}±0.87	861^{a}±5.22	1.28^{a}±0.006
	Pond 5 FW	351	155^{a}±0.41	45^{a}±0.26	313	348^{a}±0.70	552^{a}±2.43	317	406^{b}±0.87	881^{a}±5.22	1.31^{a}±0.006
	Pond 6 LS	272	154^{a}±0.49	44^{a}±0.31	244	346^{a}±0.78	545^{a}±2.71	240	401^{a}±1.0	873^{a}±5.82	1.35^{a}±0.007
	Pond 7 LS	273	154^{a}±0.49	45^{a}±0.31	245	345^{a}±0.80	545^{a}±2.75	239	402^{a}±1.0	879^{a}±5.91	1.35^{a}±0.007
Culture system	FW	707	155^{a}±0.29	45^{a}±0.18	619	349^{b}±0.57	553^{b}±1.97	639	406^{b}±0.67	871^{a}±4.25	1.30^{a}±0.004
	LS	545	154^{a}±0.37	45^{a}±0.23	489	346^{a}±0.63	545^{a}±2.17	479	401^{a}±0.77	876^{a}±4.69	1.35^{b}±0.005
Sex	F	576	154^{a}±0.31	45^{a}±0.20	519	349^{b}±0.58	553^{b}±2.02	576	409^{b}±0.69	913^{b}±4.35	1.34^{b}±0.004
	M	542	155^{a}±0.33	45^{a}±0.21	497	345^{a}±0.60	544^{a}±2.06	542	399^{a}±0.73	834^{a}±4.47	1.31^{a}±0.005

(p-value <0.05) LS means with same superscript within the class effect are not significantly different from each other.

body weight in Jayanti rohu ($p>0.05$) indicating potential of Jayanti rohu for low saline aquaculture. During the initial six months, Jayanti rohu showed higher growth in freshwater ponds, whereas growth in low-salinity ponds became comparable at later stages, indicating acclimation. Initial reduced growth in low-salinity ponds likely reflects a transient increase in osmoregulatory energy expenditure and physiological stress (Shukla *et al.,* 2024). Over the time, due to acclimation resulted enhance osmoregulatory efficiency, lowering maintenance

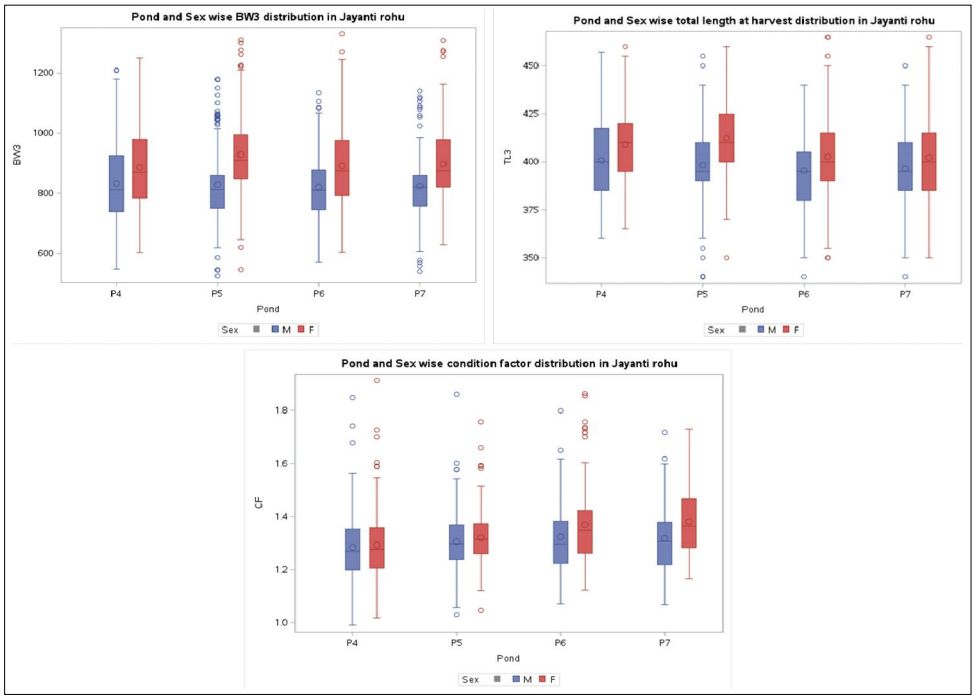


Fig 1: Boxplots showing distribution of growth trait at harvest in Jayanti rohu cultured in freshwater and low saline ponds.

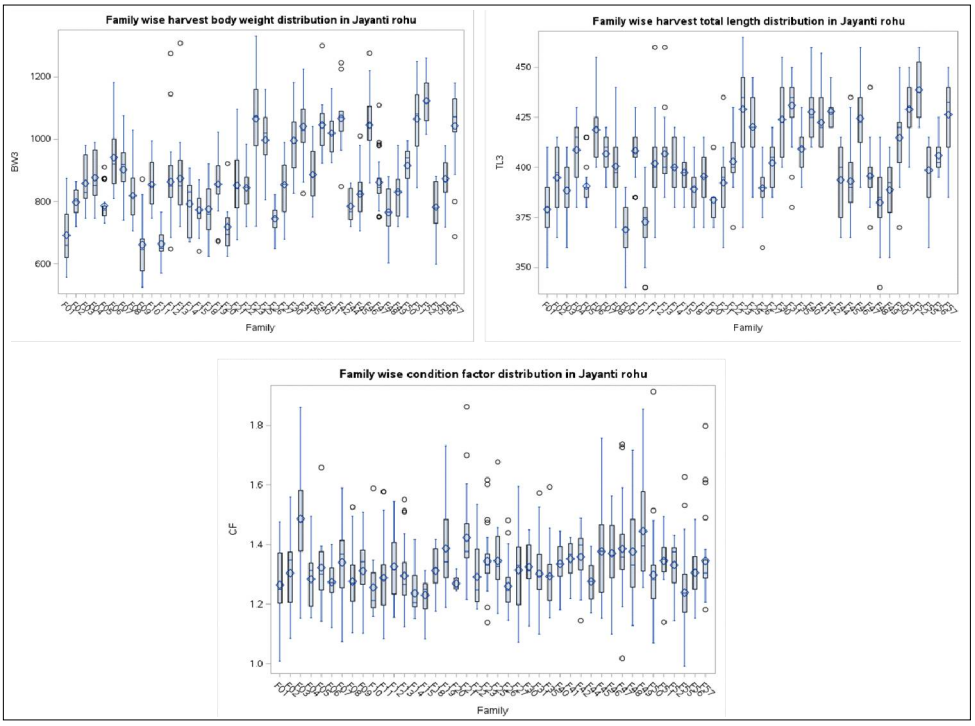


Fig 2: Boxplots showing family wise distribution of growth trait in Jayanti rohu at harvest.

Table 6: Mean suares and R^2 values of model parameters for carcass trait at harvest in Jayanti rohu.

Source	DF	HW (g)	HW %	CW (g)	Dressing %	CaWa (g)	CaWa %	Muscle crude fat %
Body weight at harvest (BW3)	1	135512.25*	0.0053740*	1522773.24*	0.0019933*	131425.291*	0.0007347	0.00039519
Culture system	1	1008.094*	0.0020455*	229.840	0.0003765	270.924	0.0008070	0.03331426*
Pond (Culture system)	2	0.4640	0.00000146	142.442	0.0002838	181.266	0.0004784	0.00081109*
Sex	1	243.4475*	0.00030507	21478.477*	0.0301547*	17125.923*	0.0422294*	0.03740532*
Family	41	240.7656*	0.0003945*	470.785*	0.0006400*	249.087*	0.0006152*	0.00672434*
Error	969	45.1097	0.00008319	75.921	0.0001001	41.476	0.0000907	0.00014969
R^2 %		94.5	35.6	99.01	47.3	95.2	61.05	81.24

*(p-value <0.05).

Table 7: Pond, culture system and sex wise least squares means and their standard errors for the carcass traits at harvest in Jayanti rohu.

Effects		N	HW (g)	HW %	CW (g)	Dressing %	CaWa (g)	CaWa %	Muscle crude fat %
Overall		711	186.27±0.27	21.70±0.03	525.25±0.35	61.06±0.03	148.55±0.26	17.22±0.03	10.15±0.03
Pond (Culture system)	Pond 4 FW	201	187.56^{b}±0.47	21.85^{b}±0.05	525.43^{a}±0.61	61.09^{a}±0.06	147.03^{a}±0.45	17.03^{a}±0.05	9.70^{a}±0.05
	Pond 5 FW	201	187.52^{b}±0.48	21.85^{b}±0.05	523.87^{a}±0.62	60.90^{a}±0.06	148.75^{a}±0.46	17.24^{a}±0.05	9.64^{a}±0.05
	Pond 6 LS	154	185.05^{a}±0.57	21.56^{a}±0.06	526.24^{a}±0.74	61.17^{a}±0.08	148.73^{a}±0.55	17.25^{a}±0.06	10.49^{b}±0.06
	Pond 7 LS	155	184.96^{a}±0.57	21.54^{a}±0.06	525.47^{a}±0.74	61.07^{a}±0.08	149.68^{a}±0.54	17.37^{a}±0.06	10.78^{c}±0.06
Culture system	FW	402	187.54^{b}±0.33	21.85^{b}±0.03	524.65^{a}±0.43	61.00^{a}±0.04	147.89^{a}±0.32	17.14^{a}±0.03	9.67^{a}±0.04
	LS	309	185.00^{a}±0.42	21.55^{a}±0.04	525.86^{a}±0.55	61.12^{a}±0.06	149.20^{a}±0.41	17.31^{a}±0.04	10.63^{b}±0.05
Sex	F	359	186.95^{a}±0.41	21.76^{a}±0.04	518.86^{a}±0.54	60.31^{a}±0.06	154.25^{b}±0.40	17.90^{b}±0.04	9.61^{a}±0.04
	M	352	185.598^{b}±0.3	21.64^{a}±0.04	531.64^{b}±0.50	61.80^{b}±0.05	142.84^{a}±0.37	16.54^{a}±0.04	10.70^{b}±0.04

(p-value <0.05) LS means with same superscript within the class effect are not significantly different from each other.

Table 8: Pearson's correlation coefficients between growth and carcass traits at harvest in Jayanti rohu.

Trait	TL3	CF	HW	CW	CaWa
BW3	0.85246**	0.19682**	0.96169**	0.99072**	0.94623**
TL3		-0.31824**	0.82666**	0.83242**	0.79516**
CF			0.19041**	0.22018**	0.22090**
HW				0.93008**	0.90417**
CW					0.90450**

**Correlation is significant at the 0.01 level.

costs and enabling growth rates to recover to levels comparable with freshwater conditions. The distribution of growth traits at harvest for Jayanti rohu by pond, sex and culture system (Fig 1) and among families (Fig 2) further supports the combined influence of genetic and environmental factors.

Mean squares and R^2 values for carcass traits are presented in Table 6 and least squares means in Table 7. Significant family-wise variation was observed for all carcass traits in Jayanti rohu ($p<0.05$), indicating genetic variability. Effect of culture system was non-significant for most carcass traits ($p>0.05$); however, it significantly influenced muscle crude fat ($p<0.05$), with higher values in low saline ponds (10.63±0.05) compared to freshwater ponds (9.67±0.04). This may likely reflect altered energy allocation under osmotic stress and aligns with reports of increased lipid deposition under mild salinity; improved feed conversion efficiency after acclimation in low-salinity environments may also promote greater lipid retention in muscle improving fillet quality and consumer acceptability (Wang *et al*., 2022; Zhou *et al*., 2024). Sex significantly affected CW, dressing%, CaWa, CaWa% and muscle crude fat% ($p<0.05$). Males exhibited higher muscle crude fat (10.70±0.04%) than females (9.61±0.04%), due to less mobilization of lipid reserves from muscle for sperm production compared to egg production in female (Kumar *et al.,* 2011). Males also displayed higher dressing percentage (61.81±0.05) compared to females (60.33±0.06) ($p<0.05$ likely due to less carcass waste. Comparable trends have been reported in carps, where females tend to have higher viscera and gonadal proportions (Ismiyanto *et al.,* 2025).

Correlation among growth and carcass trait at harvest and implications under salinity

Pearson's correlation coefficients among growth and carcass traits are presented in Table 8. Body weight at harvest (BW3) revealed strong positive correlations with total length at harvest (r= 0.85) and carcass weight (r= 0.99). These results indicate that carcass traits vary proportionately with growth and selection for body weight can indirectly enhance carcass yield, consistent with earlier findings in fish breeding programs (Schlicht *et al.,* 2019). The strong correlation observed between these traits suggests that integrating these traits in fish breeding programs can simultaneously lead to the production of high-yield, high-quality and market-preferred fish, ultimately enhancing the sustainability and profitability of aquaculture systems.

CONCLUSION

In the era of global climate change and increased salinization of freshwater resources, genetic enhancement can help develop fish strains that are more resilient to changing environmental conditions, such as increased temperatures, salinity or fluctuating water quality parameters. The present study demonstrates that the genetically improved Jayanti rohu exhibits promising growth performance and favorable carcass traits under both freshwater and low saline pond conditions. Moreover, the strong correlations between final body weight and carcass traits reaffirm that growth-based selection remains an effective approach for improving both yield and processing traits. Overall, this study reinforces the superiority of Jayanti rohu for diversified aquaculture owing to its stable growth, favourable carcass profile and enhanced crude muscle fat % under mild salinity stress, underscoring its utility in expanding aquaculture beyond conventional freshwater systems.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Ethical statement

The present study followed strict ethical guidelines for handling, sacrificing and measuring fish and all the studies performed complied with ICAR-Central Institute of Freshwater Aquaculture Institute Animal Ethics Committee guidelines approval No. F.No.ICAR-CIFA/Eth.Comm,/2025-26/07.

Conflict of interest

The authors declare that there is no conflict of interest.

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