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Carcass and Nutritional Traits of Stunted Catla (*Labeo catla,* Hamilton, 1822) Reared in Ponds

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Abstract

Seed stunting is widely practiced in aquaculture to ensure year-round availability of quality juveniles; however, its effects on carcass quality and biochemical composition during post-stunting grow-out remain inadequately understood. This study evaluated the influence of stunting on carcass traits and nutrient composition of catla (*Labeo catla*) during the compensatory growth phase. Stunted and non-stunted juveniles were produced through photoperiod manipulation using 6 h light:18 h dark (6L:18D) and 12 h light:12 h dark (12L:12D) regimes, respectively, and subsequently reared in earthen ponds for 240 days. At harvest, stunted fish attained a mean body weight of 590.33 ± 73.50 g, while non-stunted fish reached 753.33 ± 52.04 g. Stunted catla exhibited significantly lower ($p < 0.05$) dressed, headless dressed, and skinless dressed yields (82.64%, 50.76%, and 46.80%, respectively) compared to non-stunted fish (83.52%, 53.83%, and 50.70%). Among offal traits, stunted fish showed a higher head percentage (31.37%) and a lower digestive tract percentage (7.82%) ($p < 0.05$). Fillet cutability revealed marginally higher meat yield (72.12%) and lower bone content (19.53%) in stunted fish. The mid-body region contributed the highest edible meat proportion in both groups. Biochemical analysis indicated significantly lower moisture content in stunted fish, while crude protein and lipid levels were comparable between treatments. Overall, stunting did not adversely affect nutrient accretion or meat quality during compensatory growth, highlighting its potential for improving seed management without compromising product quality. These findings support improved stunting protocols and provide a reference for assessing nutritional effects in other cultured fish species.

Keywords: Compensatory growth, stunting, catla, carcass fillet traits, proximate composition, meat quality

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Introduction

Stunting in fish involves suppressing normal growth by manipulating environmental and husbandry factors. Stunted juveniles are often regarded as superior stocking material owing to their higher survival, compensatory growth potential, and resilience to predation and environmental stress (Babu et al., 2019; Babu et al., 2023). Stunting facilitates short-duration aquaculture cycles and ensures the continuous availability of high-quality seed for farmers (Pathan et al., 2022). The major factors influencing stunting include stocking density (Jena, Aravindakshan, & Singh, 1998; Das, Mishra, Mishra, & Jayasankar, 2016), food availability (Ali, Nicieza, & Wootton, 2003; Abdel-Hakim, State, Al-Azab, & El-Kholy, 2009), and photoperiod manipulation (Boeuf & Le Bail, 1999; Sahoo, Das, Nanda, Sahu, & Muduli, 2021). Indian major carps (IMC)- catla (*L. catla*), rohu (*L. rohita*), and mrigal (*Cirrhinus mrigala*)- collectively contribute over 85% of India's total inland fish production (National Fisheries Development Board, 2024). Among these, catla is the fastest-growing and widely cultured species across the Indian subcontinent. Carps generally exhibit their highest growth rate during the second year of culture, prompting farmers to adopt stunting during the juvenile phase-typically through restricted feeding and high stocking densities-to optimise production cycles and enhance profitability.

Although stunting is a common method adopted by farmers for year-round sale and availability of carp juveniles, it is necessary to understand the effect of seed stunting on the carcass quality and biochemical composition in post stunted grow-out phase to characterise the carcass traits (Lingam et al, 2018). Understanding the observed differences in carcass quality between stunted and normal fish holds significant practical implications for the aquaculture industry. Such insights will help to optimize stunting duration and feeding regimes and enhance market value of cultured fish. From an economic perspective, better carcass quality translates to higher profitability through improved consumer preference, because changes or improvement in nutrient content of fish influences the taste and texture quality of fish muscle (Lingam et al., 2019). In this context, the present study was undertaken to evaluate the effects of photoperiod-induced stunting on the carcass characteristics, and nutritional quality in catla.

Materials and Methods

Stunted juveniles used for the study were produced from fry of *L. catla* (Average size 0.84 g, 38.8 mm) by employing 6 hour light- 18 hour dark (6L:18D), and Control (Non stunted) group of juveniles were produced under the photoperiod regime of 12 hour light- 12 hour dark (12L:12D), respectively, in 1000 L capacity FRP tanks in triplicate with stocking density of 20 fish m^{-3} for a period of 150 days. Juveniles of catla from the two above groups of 12L:12D (27.8±1.3 g) and 6L:18D (19.1±2.2 g) were tagged and further grown for a period of 240 days in earthen ponds of 0.04 ha at ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, India (Latitude 20°11′06″ N to 20°11′45″ N, Longitude 85°50′52″ E). Supplementary feeding was done by using a commercial floating pellets (26% crude protein, 5% crude fat, 6% fibre and 11% moisture; ABIS, Indian Solvent Industry, Rajnandgaon, Chhattisgarh, India) once during morning hours (09:00 to 09:30 hours). Fishes were fed *ad libitum* and the actual daily feed amount of each pond was adjusted based on the consumption pattern of previous meal and prevailing weather conditions of the day (Das et al., 2016). The pre-stocking pond preparation included sun drying of ponds, application of lime ($CaCO_3$) at 200 kg ha^{-1} followed by basal fertilisation (3 ton of cow dung mixed with 30 kg of single super phosphate, SSP per ha). Post-stocking management included fortnightly application of cow dung at 500 kg ha^{-1} and inorganic fertilisers (10 kg urea and 15 kg SSP ha^{-1}), applied in alternate week, to maintain pond fertility (Jena et al., 2005). Interim liming at 200 kg ha^{-1} was also followed at 3 months intervals (Das et al., 2016). Ponds were covered with gillnet to avoid predation by birds and other animals. Seepage and evaporation loss in pond was topped up periodically to maintain the water depth. Final harvested body weight of 12L:12D and 6L:18D group (753.33 ± 52.04 g, 590.33 ± 73.5 g, respectively) were collected, bled and iced on the spot for further study. The fishes of 12L:12D and 6L:18D groups were designated as non-stunted and stunted, respectively in this study.

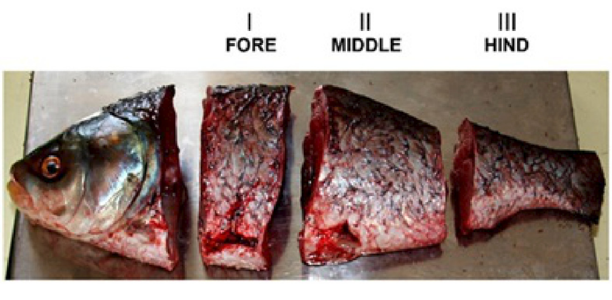

Fig. 1. Locations of three *Catla* carcass cuts (fore cut, middle cut and hind cut) (Sahu et al., 2000)

The measurements of morphometric characteristics were carried out using standard scale with 1.0 mm precision and weighing balance with 0.1 g precision. Condition factor (*K*) of catla was derived from the measured total fish weight (g) and standard length (cm). Fulton's condition factor (K) was calculated as:

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

Six fishes from each group (non-stunted and stunted) were dissected (eviscerated, removed head and fins) followed by cutting and dressing. Fish carcass weight, offal traits, dressed carcass traits, yield, and percentage were determined following a standard carcass evaluation technique (Sahu, Meher, Mohanty, Reddy, & Ayyappan, 2000). The gutted and dressed fish were segmented into three parts according to the fin location viz., fore cut [from near the head to the pectoral fin (HPF)], middle cut [anterior to dorsal fin (ADF)], and hind cut [anterior to anal fin (AAF)] (Fig. 1). The filleting traits of both 12L:12D and 6L:18D group fishes were calculated separately as per the cut portion. The cross sections of different cuts were used to estimate the total muscle area by taking an impression and drawing it on graph paper to express in square centimetre (Fig. 2).

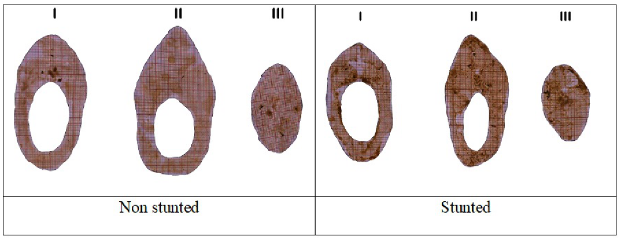

Fig. 2. Cross-sections of carcass cuts from normal and post-stunted *Labeo catla* (I- fore cut, II- middle cut and III- hind cut) (Sahu et al., 2000)

The three portions were weighed separately and dried in a hot air oven at 100 °C (AOAC International, 1990) to determine the moisture content. The dried samples from the three portions were then homogenized for further analysis. Protein percent was calculated by estimating nitrogen content using the micro-Kjeldahl method and multiplying by a factor 6.25. Lipid was determined by solvent extraction using petroleum ether (boiling point 40–60 °C) and ash content was determined by incinerating the sample at 550 °C for 6 h.

Parameter wise data sets were analysed using Analysis of Variance (ANOVA) and all possible pair wise treatments were compared using Tukey's Honestly Significant Difference (HSD). The data were statistically analysed by statistical package SAS version 9.3.

Results and Discussion

The analysis of the morphometric traits (Table 1) revealed a significantly higher values in non-stunted individuals (12L:12D) than stunted ones (6L:18D), except for condition factor (CF) and head length. There was no significant difference ($p > 0.05$) in condition factor, head length, and muscle area of AAF of both the groups, although the non-stunted fish exhibited slightly higher mean values (CF= 2.79 ± 0.07, HL= 9.33 ± 0.58 cm, Muscle area (AAF)= 20.55 ± 2.35 cm^2) than their stunted counterparts (CF= 2.73 ± 0.19, HL= 9.00 ± 0.50 cm, Muscle area (AAF)= 18.73 ± 0.81 cm^2). Compensatory growth refers to the accelerated growth that occurs when animals resume favourable conditions following a period of growth suppression caused by feed restriction, photoperiod manipulation, or some other unfavourable environmental condition (Jobling, 2010). Compensatory growth is often observed to bring about some recovery in body mass, but the degree of recovery depends upon the duration and severity of growth depression (Jobling, 1994; Ali et al., 2003). Our previous findings pertaining to compensatory growth of stunted catla show absence

Table 1. Body morphometrics of stunted and non-stunted catla for carcass traits

Traits	Non-stunted	Stunted
Fresh body weight (g)	753.33±52.04^a	590.33±73.55^b
Total body length (cm)	37.50±0.50^a	34.50±1.32^b
Standard length (cm)	30.00±0.50^a	27.83±0.58^b
Condition factor (K)	2.79±0.07	2.73±0.19
Head length (cm)	9.33±0.58	9.00±0.50
Mouth length (cm)	3.17±0.58^a	2.28±0.16^b
Vertical width of mouth (cm)	3.43±0.12^a	3.03±0.21^b
Girth at $^{\#}$HPF (cm)	24.77±0.68^a	22.83±1.04^b
Girth at $^{@}$ADF (cm)	26.40±1.22^a	24.17±1.26^b
Girth at $^{\Omega}$AAF (cm)	16.70±0.98^a	14.20±0.53^b
Muscle area at HPF (cm^2)	38.88±1.21^a	28.52±2.35^b
Muscle area of ADF (cm^2)	42.91±1.84^a	32.81±1.96 ^{b}
Muscle area of AAF (cm^2)	20.55±2.35^a	18.73±0.81^a

$^{\#}$HPF- Head to Pectoral Fin, $^{@}$ADF- Anterior to Dordal Fin, $^{\Omega}$AAF- Anterior to Anal Fin. Values are expressed as the mean ± SD of 6 samples from each group. In each row, mean values with different superscripts differ significantly ($p < 0.05$)

Table 2. Offal trait yields of stunted and non-stunted catla (percentile values on live weight basis)

Traits	Non-stunted	Stunted
Fresh body weight (g)	753.33±52.04[a]	590.33±73.55[b]
Head weight (g)	207.33±4.93[a]	184.67±17.62[b]
Head (%)	27.59±1.53[a]	31.37±1.54[b]
Fins and tail weight (g)	13.74±1.24[a]	10.00±1.00[b]
Fins and tail percentage (%)	1.82±0.11	1.71±0.21
Digestion tract weight (g) (Visceral weight)	74.33±9.29[a]	46.33±7.77[b]
Digestive tract percentage (%)	9.84±0.57[a]	7.82±0.34[b]
Scale weight (g)	33.44±3.86[a]	25.00±2.65[b]
Scales (%)	4.43±0.22	4.24±0.12
Gill weight (g)	32.33±2.89[a]	25.00±3.00[b]
Gill (%)	4.29±0.12	4.24±0.09
Skin weight (g)	24.38±1.53[a]	18.27±1.62[b]
Skin (%)	3.25±0.42	3.10±0.11

Values are expressed as the mean ± SD of 6 samples from each group. In each row, mean values with different superscripts differ significantly ($p < 0.05$)

Table 3. Dressed carcass traits of stunted and non-stunted catla (percentile values on live weight basis)

Traits	Non stunted	Stunted
Fresh body weight (g)	753.33±52.04[a]	590.33±73.55[b]
Dressed body weight (g)	558.67±58.14[a]	487.67±58.73[b]
Dressed percentage (%)	83.52±2.92	82.64±0.34
Headless dressed round weight (g)	405.67±31.09[a]	299.67±37.55[b]
Headless dressing Percentage (%)	53.83±0.66[a]	50.76±1.46[b]
Skinless dressed round weight (g)	382.29±33.39[a]	276.07±32.61[b]
Skinless dressed round percentage (%)	50.70±1.07[a]	46.80±1.46[b]

Values are expressed as the mean ± SD of 6 samples from each group. In each row, mean values with different superscripts differ significantly ($p < 0.05$)

of growth compensation in grow-out phase (Sahoo et al., 2021). It was reported that in the absence of full compensation, deprived individual fail to attain the same size as compared to their continuously growing counterparts at the same age. Koskela, Pirhonen, and Jobling (1997) observed that Baltic salmon and brown trout require several weeks to acclimate to new rearing environments following stress, suggesting that acclimatization may constrain growth recovery. Furthermore, compensatory growth may involve differential growth of specific body components without proportional changes in overall size (Ali et al., 2003). This likely explains the significant ($p < 0.05$) difference in most morphometric traits between stunted and non-stunted specimen after the recovery phase (Table 1). The CF is an indicator of body condition and nutritional status (Ali, Salam, Goher, Tassaduque, & Latif, 2004), with higher values generally reflecting better health and isometric growth desirable in aquaculture (Ayode, 2011). In the present study, the lack of significant difference ($p > 0.05$) in CF between the two groups suggests that photoperiod-induced stunting did not markedly affect nutrient deposition in muscle tissues (Johnsson & Bohlin, 2005). This contrasts with reports by Yengkokpam et al. (2014), who observed a significant decline in CF during compensatory growth in *L. rohita* following feed restriction. Since both groups of catla were provided with identical feeding regimes during grow-out, feed availability likely accounted for the uniform CF across the stunted and non-stunted groups.

In fish, the final dressed yield is influenced by the relative proportions of the head, viscera, scales, and fins (Fauconneau & Laroche, 1996). The present values (Table 2) were comparable to those reported by Sahu et al. (2000) for marketable-sized farmed catla. Stunted catla yielded significantly ($p < 0.05$) lower offal weights, consistent with their reduced body mass (590.33 ± 73.55 g), but exhibited a higher head weight percentage (31.37 ± 1.54 %) (Table 2). This is attributed to the naturally large head-to-body ratio in catla (Jankowska, Zakes, Zmijewski, Ulikowski, & Kowalska, 2007) and potentially slower muscular accretion in stunted individuals. Similar to findings in carps and catfishes, carcass yield and dressing percentage are strongly influenced by head and viscera weights (Fauconneau & Laroche, 1996; Sahu et al., 2012). The digestive tract weight reduced by 37.67% because of stunting (Table 2). The significantly ($p < 0.05$) lower digestive tract weight in stunted catla (46.33 ± 7.77 g) may reflect reduced feed intake and prolonged acclimatization following the photoperiod-induced stunting phase (Kiron, 2012).

Dressed carcass traits (Table 3) also differed significantly between stunted and non-stunted fish. Typically, the dressed yield of farmed fish averages around 60% depending on species (Fauconneau & Laroche, 1996). Lingam et al. (2019) reported a 67% dressed yield in post stunted milkfish (*Chanos chanos*), whereas the present study recorded slightly lower yields (< 60%) in both groups of catla. Stunted catla exhibited a significantly higher ($p < 0.05$) head weight percentage (31.37±1.54%), leading to a lower headless dressing yield (Table 2).

In fish, variations in muscle distribution across body regions influence meat and bone percentages (Fauconneau, Alami-Durante, Laroche, Marcel, & Vallot, 1995). In marketable-sized catla, Sahu et al. (2013) reported the highest fillet yield from the mid-cut, followed by fore and hind cuts- the findings which are consistent with the present study. The meat yield of mid cut (162.67 ± 24.09 g) and total weight (267.33 ± 20.6 g) in non-stunted catla was significantly higher ($p < 0.05$) than the corresponding values of stunted group (Mid cut weight=123.67

Table 4. Filleting traits of stunted and non-stunted catla. (Percentile values on the basis of skinless round weight)

Position of cut	Treatment	Weight (g)	Yield (%)	Meat yield (g)	Meat (%)	Bone yield (g)	Bone (%)	Meat: Bone ratio
Fore cut	Non stunted	108.00± 7.21	25.31± 4.46	70.00± 5.29	18.68± 1.90	29.00± 6.56	7.71± 1.59	2.48± 0.43
	Stunted	87.33± 19.86	27.91± 3.60	55.33± 12.66	19.08± 2.46	22.00± 6.56	7.54± 1.41	2.55± 0.21
Mid cut	Non stunted	231.33± 36.91^a	52.08± 3.83	162.67± 24.09 ^{a}	43.17± 4.60	31.00± 3.61^a	8.23± 0.51	5.25± 0.50
	Stunted	156.00± 11.14^b	50.89± 3.71	123.67± 5.69 ^{b}	43.29± 3.57	21.67± 3.51^b	7.51± 0.32	5.79± 0.74
Hind cut	Non stunted	66.33± 7.51	15.36± 2.75	34.67± 6.66	9.25± 1.89	21.33± 3.06^a	5.66± 0.53^a	1.66± 0.47
	Stunted	56.33± 7.77	17.20± 0.57	28.00± 3.00	9.75± 0.16	13.00± 3.00^b	4.48± 0.49^b	2.20± 0.28
Total weight	Non stunted	405.67± 31.09^a	92.76± 3.60	267.33± 20.6^a	71.10± 1.55	81.33± 11.02^a	21.6± 1.95	3.31± 0.26
	Stunted	299.67± 37.55^b	95.99± 0.64	207.00± 20.66^b	72.12 ±1.87	56.67± 13.05^b	19.53± 2.22	3.73± 0.52

Values are expressed as the mean ± SD of 6 samples from each group. In each row, mean values with different superscripts differ significantly ($p < 0.05$)

± 5.69 g and Total weight= 207.00 ± 20.66 g) (Table 4). During compensatory growth, there appears to be an initial accretion of lean body mass followed by accumulation of body fat (Harris, Kasser, & Martin, 1986; Wright & Russel, 1991; Hornick, Van Eenaeme, Gérard, Dufrasne, & Istasse, 2000; Johansen, Ekli, Stangnes, & Jobling, 2001; Mitchell, 2007; Martinez-Ramirez, Jeaurond, & de Lange, 2009).

Between both groups, no significant difference was found in bone percentage of different position of cuts except hind cut (Table 4). It has been reported that experimentally induced stunting greatly decreases bone formation through inactivation of osteoblasts (Takagi, Moriyama, Hirano, & Yamada, 1992; Persson, Johansson, Takagi, & Björnsson, 1997; Takagi, 2001). In the present experiment although there was partial compensation which happened to the growth of fish, perhaps there was no difference in bone formation which might have resulted in no significant difference ($p > 0.05$) in bone percentage (except hind gut) (Table 4). In the present study no significant difference ($p > 0.05$) was observed in meat to bone ratio in all three cuts including total weight for both the groups (Table 4). Similar results have been reported by Lingam et al. (2018) in post stunted milk fish.

Variation in biochemical composition of fish flesh in different anatomical locations of the body is well documented (Burke, 2011; Ganie, 2012). Nutritional status of the cultured fish influences the fat and water content which in turn determine flesh quality (Weatherley & Gill, 1987; Salam & Davies, 1998). Morphometric and biochemical adjustments accompanying compensatory growth can thus alter the proximate composition of post stunted fish (Jobling, 2010). In the present study, stunted *Catla* exhibited significantly lower ($p < 0.05$) moisture (69.96 ± 0.44%) but slightly higher protein (20.20 ± 0.72%) and lipid contents (17.32 ± 0.84%) ($p > 0.05$) compared to non-stunted fish (Table 5). Reduced moisture levels may reflect altered nutrient accretion dynamics during the recovery phase (Collins & Anderson, 1995). Conversely, Ali et al. (2004) reported elevated moisture in *L. rohita* under feed restriction due to tissue hydration and mobilization of nutrient reserves. The non-significant ($p > 0.05$) variations in proximate composition in the current study suggest minimal impact of photoperiod manipulation on metabolism and nutrient allocation. Similar results were observed in Persian sturgeon (*Acipenser persicus*) and silver pompano (*Trachinotus blochii*) by Zolfaghari, Imanpour, and Najafi (2011) and Babu et al. (2023), respectively. De Silva (1985) and Prabhakar, Sardar, and Das (2008) demonstrated that restricted feeding coupled with high-protein diets increases muscle protein concentration. As per Collins and Anderson (1995), fish would have to be put under severe food deprivation for a significant change to happen in the mobilisation of muscle protein. Given that both experimental groups in this study were fed identical diets during grow-out, nutrient accretion likely proceeded uniformly, resulting in minimal differences in body composition.

Across body cuts, proximate composition did not differ significantly ($p > 0.05$) between stunted and non-stunted catla, except for crude protein in the fore cut (Table 5). In both the groups, the fore cut exhibited the highest fat content, followed by mid

Table 5. Proximate composition of fresh meat from fore, mid and hind cuts of stunted and non-stunted

Position of cut	Treatment	Moisture (%)	Dry matter (%)	Protein (%)	Crude lipid (%)
Fore cut	Non stunted	69.36±0.84	31.48±0.96	19.38±0.96^{b}	25.48±1.32
	Stunted	68.27±0.95	32.16±0.85	21.11±0.62^{a}	25.23±1.06
Mid cut	Non stunted	71.41±0.49	30.40±0.76	19.69±1.54	16.19±0.95
	Stunted	70.95±0.54	31.10±1.02	21.45±0.92	17.48±0.58
Hind cut	Non stunted	73.26±1.00	27.62±0.68	20.09±1.68	8.47±1.24
	Stunted	72.93±0.72	27.71±1.33	21.62±0.44	8.61±0.72
Pooled	Non stunted	71.24±0.34^{a}	29.03±1.44	19.71±0.73	17.07±1.39
(all three cuts)	Stunted	69.96±0.44^{b}	29.85±0.65	20.20±0.72	17.32±0.84

Values are expressed as the mean ± SD of 6 samples from each group. In each row, mean values with different superscripts differ significantly ($p < 0.05$)

and hind cuts, consistent with the known pattern of lipid deposition around the dorsal fin region (Weatherley & Gill, 1983; Hancz, Romvari, Petrasi, & Horn, 2003; Sahu et al., 2013; Sahu et al., 2014). Although overall fat content did not differ significantly, slightly higher lipid levels (17.32 ± 0.84%) in stunted fish may be attributed to reduced moisture content (69.96 ± 0.44%) (Table 5), as decreased water proportion generally corresponds to higher lipid concentration (Fauconneau et al., 1995).

The present study demonstrates that photoperiodic manipulation (employing to 6-hour light- 18-hour dark; 6L:18D) effectively induces stunting in *L. catla*, resulting in significant reductions in most morphometric traits, offal yield, and dressed carcass yield during the subsequent compensatory growth phase. However, the potential alterations in body composition that may have occurred during the stunting period appeared to normalize during the recovery phase, indicating a partial restoration of physiological balance. This finding is relevant, as body composition plays a crucial role in determining flesh quality, consumer acceptance, and, ultimately, farm profitability. The results of this study contribute to a deeper understanding of the nutritional attributes of post-stunted fish and will assist in developing fillet products with enhanced dietary quality and improved consumer acceptability.

Although, the results provide a preliminary understanding of the nutritional quality and carcass characteristics of post-stunted catla reared under pond conditions, these insights can serve as a reference for evaluating the effects of stunting and compensatory growth on the nutritional attributes of other commercially important cultured fish species.

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