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HEPATOSOMATIC AND GONADOSOMATIC INDICES OF HYBRID CATFISH (*HETEROBRANCHUS LONGIFILIS* × *CLARIAS GARIEPINUS*) UNDER DIFFERENT FEEDING LEVELS AND STOCKING DENSITIES

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ABSTRACT

Hepatosomatic index (HSI) and gonadosomatic index (GSI) are widely used indicators of physiological condition, energy allocation, and reproductive development in fish. This study evaluated the effects of feeding level and stocking density on HSI and GSI of hybrid catfish (Heterobranchuslongifilis × Clariasgariepinus) under controlled culture conditions. Five stocking densities (100, 75, 38, 18, and 9 fish per 0.25 m³) and three feeding levels (1.0%, 1.5%, and 2.0% body weight) were tested in a completely randomized design. Fish were fed three times daily using a commercial diet. At the end of the experiment, liver and gonad weights were recorded and HSI and GSI calculated using standard methods. Results showed that HSI was significantly affected by both feeding level and stocking density, with higher values generally observed at higher stocking densities and feeding levels. In contrast, GSI exhibited limited variation across treatments and was not consistently influenced by feeding or density. These findings indicate that liver condition in hybrid catfish is more responsive to short-term changes in feeding regime and stocking density than reproductive investment. The study provides practical information for optimizing feeding and stocking strategies to support metabolic health without compromising reproductive development in hybrid catfish culture.

KEYWORDS: Feeding Levels, Stocking Densities, Hybrid Catfish, Hepatosomatic Index, Gonadosomatic Index

INTRODUCTION

The assessment of physiological health, energy allocation, and reproductive development in fish commonly relies on somatic indices such as the hepatosomatic index (HSI) and gonadosomatic index (GSI) (Oke and Goosen, 2019; Ekpo et al. 2025). The liver is a central metabolic organ involved in nutrient storage, detoxification, and energy regulation, while gonadal development reflects reproductive investment and maturation status. Variations in HSI and GSI have been associated with changes in feeding intensity, stocking density, environmental conditions, and physiological stress in cultured fish species (Rahman et al., 2021; Shoko et al., 2022).

In aquaculture systems, feeding level and stocking density are among the most important management factors influencing growth, feed utilization, health status, and survival of fish(Moustafa and Sadek, 2019; Babmann et al. 2023). Excessive stocking density

can increase competition for feed and space, elevate stress levels, and alter metabolic processes, whereas inadequate or excessive feeding may disrupt energy balance and organ development (Adeogun et al., 2019; Munguti et al., 2022). These factors often interact to influence physiological indices such as HSI and GSI, which serve as sensitive indicators of sub-lethal stress and nutritional condition. Hybrid catfish (*Heterobranchuslongifilis* × *Clariasgariepinus*) is widely cultured in Africa because of its fast growth rate, hardiness, efficient feed conversion, and tolerance to relatively high stocking densities. Despite its commercial importance, information on how combined feeding level and stocking density affect key physiological indices in hybrid catfish remains limited, particularly under controlled experimental conditions. Previous studies on African catfish and related species have shown that increased feeding levels often enhance liver development and energy reserves, reflected by higher HSI values, whereas reproductive indices such as GSI tend to remain stable unless fish reach advanced stages of sexual maturation (Rahman et al., 2021; Munguti et al., 2022). Sustainable aquaculture practices therefore emphasize the need to maintain feeding and stocking regimes that support optimal physiological function without compromising fish welfare or reproductive potential(Shoko et al., 2022). This study examined the effects of varying feeding levels and stocking densities on the hepatosomatic and gonadosomatic indices of hybrid catfish under controlled culture conditions.

EXPERIMENTAL PROCEDURES

- **Study Area and Experimental Fish**

The experiment was conducted at the University of Uyo greenhouse facility in AkwaIbom State, Nigeria. Hybrid catfish fingerlings were produced via controlled breeding and reared under standard conditions prior to the study.

- **Experimental Design**

A completely randomized design was employed. The two independent variables were:

Stocking Density: Five levels (100, 75, 38, 18, and 9 fish per 0.25 m^3).

Feeding Level: Three levels (1.0%, 1.5%, and 2.0% of body weight) fed commercial diet three times daily.

- **Data Collection and Analysis**

At the conclusion of the experiment, fish were sampled and dissected to weigh the liver and gonads. Indices were calculated using the following formulas:

$$\text{HSI}(\%) = (Liver\ \frac{weight}{Body}\ weight\ \times 100)$$

$$\text{GSI}\ (\%) = \frac{(Gonad\ weight)}{\text{Body weight}} \times 100$$

Data were analyzed using ANOVA with significance set at ($p < 0.05$).

RESULTS AND DISCUSSION

From Table 1, hepatosomatic index was significantly higher at stocking density 100 fish / 0.25 m^3 (1.09 ± 0.07) and stocking density 38 fish / 0.25 m^3 (1.00 ± 0.11). And the maximum weight of the liver was 1.68. Gonadosomatic index showed no significant difference ($p>0.05$) among the stocking densities.

TABLE 1: HEPATOSOMATIC INDEX (HSI) AND GONADOSOMATIC INDEX (GSI) OF HYBRID CATFISH (*HETEROBRANCHUS LONGIFILIS* × *CLARIAS GARIEPINUS*) REARED AT DIFFERENT STOCKING DENSITIES AND FED AT 1.0% BODY WEIGHT

	100 fish /0.25 m3 Higher density	75 fish /0.25 m3 High density	38 fish /0.25 m3 Medium density	18 fish /0.25 m3 Low density	9 fish /0.25 m3 Lower density
HSI	1.09 ± 0.07 [a]	0.73 ± 0.07 [b]	1.00 ± 0.11 [a]	0.85 ± 0.08 [ab]	0.89 ± 0.05 [ab]
Minimum-maximum	0.69 - 1.68	0.06 - 0.97	0.66 - 2.47	0.21 - 1.40	0.62 - 1.31
GSI	0.74 ± 0.07 [a]	0.49 ± 0.07 [a]	0.65 ± 0.07 [a]	0.70 ± 0.12 [a]	0.71 ± 0.10 [a]
Minimum-maximum	0.40 - 1.21	0.87	0.00 - 0.89	0.00 - 1.62	0.00 -1.64

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$).Minimum and maximum values indicate the observed range within each treatment.

While treatment effects were negligible at the 1.5% feeding level ($p > 0.05$), stocking density significantly influenced reproductive indices; GSI values peaked at (0.69 ± 0.07 and 0.70 ± 0.14 in the high-density groups.

TABLE 2:HSI AND GSI OF HYBRID CATFISH (*H. longifilis* × *C. gariepinus*) REARED AT DIFFERENT STOCKING DENSITIES AND FED AT 1.5% BODY WEIGHT

	100 fish /0.25 m3	75 fish /0.25 m3	38 fish /0.25 m3	18 fish /0.25 m3	9 fish /0.25 m3
	Higher density	High density	Medium density	low density	Lower density
HSI	0.70 ± 0.05 [a]	0.75 ± 0.05 [a]	0.69 ± 0.04 [a]	0.79 ± 0.07 [a]	0.66 ± 0.03 [a]
Minimum – maximum	0.45 - 1.08	0.51 - 1.17	0.33 - 0.92	0.40 - 1.18	0.43 - 0 .87
GSI	0.69 ± 0.07 [a]	0.70 ± 0.14 [a]	0.30 ± 0.05 [b]	0.41 ± 0.08 [b]	0.21 ± 0.06 [b]
Minimum – maximum	0.17 - 1.06	0.00 - 1.64	0.00 - 0.56	0.00 - 0.82	0.00 - 0.68

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$) Minimum and maximum values indicate the observed range within each treatment.

High stocking density (100 fish / 0.25 m^3) recorded significantly ($p<0.05$) the highest HSI mean. For GSI, the mean weight was not significantly ($p<0.05$) different among the stocking densities (Table 3).

TABLE 3: HEPATOSOMATIC INDEX (HSI) AND GONADOSOMATIC INDEX (GSI) OF HYBRID CATFISH *(HETEROBRANCHUS LONGIFILIS* × *CLARIAS GARIEPINUS*) REARED AT DIFFERENT STOCKING DENSITIES AND FED AT 2.0% BODY WEIGHT

	100 fish/ 0.25m3 Higher density	75 fish/ 0.25m3 High density	38 fish/ 0.25m3 Medium density	18 fish/ 0.25m3 low density	9 fish/ 0.25m3 Lower density
HSI	0.86 ± 0.03 [a]	0.62 ± 0 .06 [c]	0.66 ±0 .06 [bc]	0.78 ± 0.03 [ab]	0.78 ± 0.03 [ab]
Minimum maximum	0.70 - 1.07	0.08 - 0.88	0.27 - 1.19	0.55 -0 .96	0.53 - 1.02
GSI	0.74 ± 0.12 [a]	0.68 ±0 .13 [a]	0.57 ± 0.09 [a]	0.69 ± 0.14 [a]	0.52 ± 0.17 [a]
Minimum – maximum	0.00 - 1.25	0.00 - 1.58	0.00 - 1.06	0.00 - 1.60	0.00 - 2.03

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$) Minimum and maximum values indicate the observed range within each treatment.

Mean HSI increased significantly with higher feeding levels ($p < 0.05$), while GSI showed no such trend(Table 4).

TABLE 4: EFFECTS OF FEEDING LEVEL ON HEPATOSOMATIC INDEX (HSI) AND GONADOSOMATIC INDEX (GSI) OF HYBRID CATFISH (*HETEROBRANCHUS LONGIFILIS* × *CLARIAS GARIEPINUS*) AT A STOCKING DENSITY OF 100 FISH PER 0.25 M³

	Feeding level 1.0%	Feeding level 1.5%	Feeding level 2.0%
HIS	1.09 ± 0.07 [a]	0.70 ± 0.05 [c]	0.86 ± 0.03 [b]
Minimum – maximum	0.69 - 1.68	0.45 - 1.08	0.70 - 1.07
GSI	0.74 ± 0.07 [a]	0.69 ± 0.07 [a]	0.74 ± 0.12 [a]
Minimum – maximum	0.40 - 1.21	0.17 -1.06	0.00 -1.25

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$) Minimum and maximum values indicate the observed range within each treatment.

Mean HSI was significantly higher at the 1.0% feeding level (0.87 ± 0.04) compared to both the 1.5% (0.72 ± 0.03) and 2.0% (0.69 ± 0.03) levels ($p<0.05$; Table 5). Similarly, the GSI at 1.5% differed significantly from the values observed at the 1.0% and 2.0% feeding levels ($p < 0.05$$)."

TABLE 5: INFLUENCE OF FEEDING INTENSITY ON HSI AND GSI OF HYBRID CATFISH (*HETEROBRANCHUS LONGIFILIS* × *CLARIAS GARIEPINUS*) AT A STOCKING DENSITY OF 75 FISH PER 0.25 M³

	Feeding level 1.0%	Feeding level 1.5%	Feeding level 2.0%
Hepatosomatic index	0.87 ± 0.04 [a]	0.72 ± 0.03 [b]	0.69 ± 0.03 [b]
Minimum – maximum	0.06 - 2.47	0.33 -1.18	0.08 - 1.19
Gonadosomatic index	0.64 ± 0.05 [a]	0.41 ± 0.05 [b]	0.65 ± 0.07 [a]
Minimum – maximum	0.00 - 1.64	0.00 - 1.64	0.00 - 1.60

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$) Minimum and maximum values indicate the observed range within each treatment.

At Table 6, the mean HSI of feeding level 1.0% (1.0 ± 0.11) was significantly ($p<0.05$) different from feeding levels 1.5% (0.69 ± 0.04) and feeding level 2.0% (0.78 ± 0.05). Mean GSI showed significant difference at feeding level 1% (0.65 ± 0.07) and feeding level 2% (0.57 ± 0.09) ($p>0.05$).

TABLE 6: RESPONSE OF HYBRID CATFISH TO VARYING FEEDING LEVELS ON HEPATOSOMATIC INDEX AND GONADOSOMATIC INDEX AT A STOCKING DENSITY OF 38 FISH PER 0.25 M³

	Feeding level 1.0%	Feeding level 1.5%	Feeding level 2.0%
Hepatosomatic index	1.0 ± 0.11[a]	0.69 ± 0.04[b]	0.78 ± 0.05[b]
Minimum – maximum	0.66 – 2.47	0.33 – 0.92	0.27 – 1.19
Gonadosomatic index	0.65 ± 0.07[a]	0.30 ± 0.05[b]	0.57 ± 0.09[a]
Minimum – maximum	0.00 – 0.89	0.00 – 0.56	0.00 – 1.06

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$) Minimum and maximum values indicate the observed range within each treatment.

Table 7 showed that the mean HSI was not significantly different ($p<0.05$) among the feeding levels. Mean GSI showed no significant difference among the feeding levels ($p>0.05$).

TABLE 7: IMPACT OF DIETARY RATION ON HIS/GSI OF HETEROBRANCHUS LONGIFILIS × CLARIAS GARIEPINUS AT A STOCKING DENSITY OF 18 FISH PER 0.25 M³

	Feeding level 1.0%	Feeding level 1.5%	Feeding level 2.0%
Hepatosomatic index	0.84 ± 0.08^{a}	0.79 ± 0.06^{a}	0.77 ± 0.03^{a}
Minimum – maximum	0.21 – 1.40	0.40 – 1.18	0.55 – 0.96
Gonadosomatic index	0.09 ± 0.12^{a}	0.40 ± 0.08^{a}	0.68 ± 0.13^{a}
Minimum – maximum	0.00 – 1.62	0.00 – 0.82	0.00 – 1.60

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$) Minimum and maximum values indicate the observed range within each treatment.

The mean HSI of feeding levels 1.0% and 2.0% were significantly different ($p<0.05$) from feeding level 1.5%. The mean GSI of feeding levels 1.0% and 2.0% were significantly different ($p<0.05$) from feeding level 1.5%. (Table 8)

TABLE 8: EFFECTS OF FEEDING LEVEL ON HEPATOSOMATIC INDEX (HSI) AND GONADOSOMATIC INDEX (GSI) OF HYBRID CATFISH (HETEROBRANCHUS LONGIFILIS × CLARIAS GARIEPINUS) AT A STOCKING DENSITY OF 9 FISH PER 0.25 M³

	Feeding level 1.0%	Feeding level 1.5%	Feeding level 2.0%
Hepatosomatic index	0.88 ± 0.05^{a}	0.65 ± 0.03^{b}	0.78 ± 0.03^{a}
Minimum – maximum	0.62 – 1.31	0.43 – 0.87	0.53 – 0.96
Gonadosomatic index	0.71 ± 0.10^{a}	0.21 ± 0.06^{b}	0.52 ± 0.17^{a}
Minimum – maximum	0.00 – 1.64	0.00 – 0.68	0.00 – 2.03

Values represent mean ± SE. Means in the same row followed by different superscripts differ significantly ($p < 0.05$) Minimum and maximum values indicate the observed range within each treatment.

DISCUSSION

The present study demonstrated that hepatosomatic index in hybrid catfish was significantly influenced by both feeding level and stocking density, whereas gonadosomatic index showed relatively limited variation across most treatments. These findings confirm that liver condition in hybrid catfish is more responsive to short term changes in feeding regime and rearing density than reproductive investment.

Higher hepatosomatic index values observed at higher stocking densities, particularly at feeding levels of 1.0 percent and 2.0 percent body weight, suggest increased metabolic activity and energy storage in the liver. Under conditions of increased competition and crowding, fish tend to allocate a greater proportion of assimilated energy to metabolic processes and reserve storage, which is reflected in increased liver size. Similar responses have been reported in African catfish and other cultured species, where elevated hepatosomatic index was associated with increased glycogen and lipid deposition in the liver under intensive culture conditions (Munguti et al., 2022).

The significant differences in hepatosomatic index observed among feeding levels further highlight the sensitivity of liver development to nutritional input. Fish fed at higher feeding levels generally exhibited higher hepatosomatic index values, indicating improved energy availability and storage. This supports previous observations that adequate feeding

enhances liver development and metabolic capacity, while restricted feeding may limit energy reserves and organ growth (Rahman et al., 2021). However, the absence of a consistent linear increase in hepatosomatic index across all feeding levels suggests that excessively high feeding may not always result in proportional increases in liver condition, possibly due to limits in metabolic efficiency or increased energy expenditure. Kingdom and Allison (2011) reported the mean HSI values between male (1.14 ± 0.78) and female (0.87 ± 0.04) and they attributed the absence of significant variability in the mean monthly and seasonal HSI values to the fact that *Pellonulaleonensis* has an all year round reproductive pulse. The HSI value obtained in this work was lower than 1.5 – 3.8 reported by Yildiz*et al.*, (2007). Kiriratnikom and Kiriratnikom (2012), obtained value of 0.89 for 32% protein and 1.01 – 1.17 for 36 – 44% protein. The value of 0.89 was within the range of value recorded in this study.

In contrast, gonadosomatic index showed no consistent significant differences across most stocking densities and feeding levels. This indicates that gonadal development in hybrid catfish was relatively stable and not strongly affected by the feeding and density regimes applied during the experimental period. The low variability in gonadosomatic index suggests that energy allocation during the study was directed primarily toward somatic maintenance and metabolic functions rather than reproductive development. This pattern is typical of juvenile or immature fish and has been reported for other tropical species reared under controlled conditions, where reproductive investment remains minimal unless fish reach advanced stages of sexual maturation (Shoko et al., 2022).

Kingdom and Allison (2011) reported mean GSI values between male (3.82 ± 1.62 and female (7.33 ± 0.70) of *P. leonensis*. High GSI were also observed from other studies; the bastard grunt *Pellonulla incises* had GSI range of 0.159 to 7.88 from July to September (Fehri-bedoui and Gharbi 2008), the GSI of *P. commersonnii* ranged from 0.4 – 5.5 for both sexes from July to November (Al Nahdi*et al.*, 2010), the GSI of *P. jubelini* ranged from 0.07 – 7.30 from July to September (Adebiyi, 2013).

The limited response of gonadosomatic index to feeding level and stocking density also suggests that moderate adjustments in these management factors can be implemented without negatively affecting reproductive potential. This finding is particularly relevant for intensive aquaculture systems, where maintaining high productivity while preserving fish physiological balance is essential. Adeogun et al. (2019) similarly reported that changes in stocking density influenced growth and physiological performance without causing marked alterations in reproductive indices in African catfish.

Overall, the results of this study indicate that feeding level and stocking density primarily affect liver condition rather than reproductive development in hybrid catfish over the short term. Monitoring hepatosomatic index can therefore provide a useful early indicator of nutritional status and metabolic response to culture conditions, while gonadosomatic index may be more informative in longer term studies involving sexually mature fish (Ahmed and Sheikh, 2017).

CONCLUSION

This study shows that hepatosomatic index of hybrid catfish is significantly influenced by feeding level and stocking density, while gonadosomatic index remains largely unaffected. Higher stocking densities and increased feeding levels promote greater liver development, indicating enhanced metabolic activity and energy storage. However, reproductive investment remains stable across treatments. These findings suggest that moderate adjustments in feeding and stocking density can improve physiological condition without negatively affecting reproductive health.

RECOMMENDATIONS

- Fish farmers should manage feeding levels carefully to support metabolic health without excessive energy accumulation.
- Moderate to high stocking densities can be used safely for hybrid catfish without adverse effects on gonadal development.
- Hepatosomatic and gonadosomatic indices should be included as routine indicators in aquaculture management and research.
- Further studies should examine long term reproductive performance under varying feeding and density regimes.

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