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A N I N T E R N A T I O N A L J O U R N A L

Gonadosomatic index and some hematological parameters in African catfish *Clarias gariepinus* (Burchell, 1822) as affected by feed type and temperature level

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ABSTRACT

The purpose of the current study was to examine the effects of different feeds/nutrients and temperature on the gonadal development of Clarias gariepinus. The gonadosomatic index (GSI) and blood parameters including red blood cell count (RBCs), white blood cell count (WBCs), hemoglobin (Hgb) level, hematocrit (HCT), platelets (PLT) and mean corpuscular volume (MCV) were investigated. Four types of fish feed of 36% protein content [D1(fish meal), D2 (soybean meal), D3 (peameal) and D4 (commercial tilapia feed)] and 3 different levels of temperature (T1(24℃), T2(28℃) and T3(32℃) were tried in this study for a duration of 4 months. The mean values were as follows: female GSI (14.68 ± 4.86), male GSI (0.70 ± 0.32), RBCs x 106(2.45± 0.64), WBCs x 103(9.28 ± 2.34), Hgb (12.42± 2.21g/dl), HCT (29.06 ± 3.54%), PLT (90.75 ± 9.18/mm3), and MCV (118.08 ± 10.3 g/l). Fish meal diet revealed the most significant (p<0.05) increase in weight gain, female GSI, and also exerted significant increases on most of the blood parameters. This study revealed that animal-based protein diet and temperature around 28℃ were the critical requirements for the physiological performance and relative gonadal weight of C. gariepinus. GSI and blood parameters were useful indicators of stress exerted by nutrition and temperature on fish, and their study is critical for fish health and mass production of viable seeds for aquaculture enterprise.

Key words: Feed, Temperature, Clarias gariepinus, Hematology, GSI.

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INTRODUCTION

Clarias gariepinus (African sharp tooth catfish), is a typical air-breathing scaleless catfish with an elongated body with long dorsal and anal fins. It is the second most important freshwater fish, after tilapia, in Africa. According to [1], *C. gariepinus*, despite being native to Africa, has been introduced to other parts of the world including Asia and the Middle East. It has been reported that it is spreading around the world particularly due to aquaculture [2]. The African catfish *C. gariepinus* is a disease resistant, with high fecundity, and ease of reproduction in captivity which makes the fish one of the most important species in aquaculture [3.]
Traditionally, aquaculture depends on fishmeal as a primary source of protein in fish feeds, since it comprises of high protein percentage, well-adjusted amino acids and high palatability [4.] The fishmeal provides an adequate balance of amino acids. Growth, health, and reproduction of fish primarily depend on quantity and quality of protein supply in their diet [5]. The increased demand for fishmeal with aquaculture expansion could lead to overexploitation of captured fish species that are used in feed production, [6]. The high demand for fishmeal could also be associated with an increase in its price, innovation in fish feeds, improvement in fish management practices and lesser amount of fishmeal in fish feeds. [7]; [8]. However, aquaculture development in the developing countries is mainly hindered by a limited supply of good quality fish seed, a high cost of fishmeal as well as negative impacts of some feed ingredients [9]. However, to cope with the fast paces of aquaculture development in the world and the mass production of fingerlings for aquaculture, fishmeal should be partially replaced by cheaper plant ingredients [10,] and water temperature should be adjusted to match the physiological requirements of *C. gariepinus*.
Water temperature has some effects on fish health and welfare [11]. Water temperature is a major factor that directly affects feed intake, metabolic rates and energy consumption of catfish [12]; [13]. At low temperatures, carbohydrates are the sources of energy while at high temperatures, proteins are the primary sources. [11]. [14] stated that water temperature has a direct effect on the growth of fish.
The knowledge of hematological characteristics is a vital tool that can be used as a good indicator for monitoring physiological and pathological changes in fishes [15]. [16] indicated that hematological evaluation of fish blood provides valuable information about the physiological response of fish to external environmental variation. A direct relationship between blood indices and the health condition of aquatic animals exists. These indices reveal reliable information about metabolic disorders, deficiencies and chronic stress of the animals [17]; [18]. Changes in blood composition always come as a result of exogenous factors such as management, diseases and stress. [19]; [20]; [21]. [22] stated that biochemical parameters are affected by stocking regime and stocking density.
The gonadosomatic index is an important indicator of the general health of an organism. It is used to estimate or measure reproductive capacity. Reproduction is the most critical stage in the life cycle of a species, which determines its survival and success. The gonadosomatc index (GSI) is a reliable indicator of changes in nutritional and energy condition of fish [18.]
This study was conducted to investigate the effect of partial replacement of fishmeal by plant protein sources on gonadosomatic index and hematological factors of African catfish *C. gariepinus* maintained at different temperatures.

MATERIALS AND METHODS

A total of 720 *C. gariepinus* specimens of mean weight (101.87± 0.9g) were obtained from the KACST research station, Riyadh, Saudi Arabia. Fish were transported to King Saud University laboratory in plastic bags filled with air and water. In the laboratory, the fish were acclimatized to laboratory conditions for two weeks and starved for 24 hours before commencing the experiment. The fish were distributed into 36 Glass aquaria of 120-liter capacity each at a rate of 20 fishes per tank in three replicates and fed with four diets (D1, D2, D3, D4). Three diets were formulated with 36% protein level of different ingredients for each menu. D1 was based on fish meal, D2 and D3 were based on plant protein (soybean and peameal, respectively) to replace the fishmeal, while diet (D4) is the commercial tilapia feed of 36% protein level obtained from (ARASCO, Riyadh, Saudi Arabia) being used as a reference. The three formulated diets (Table 1) and D4 were tested at three different temperatures T1, T2 and T3 as (24, 28 and 32 °C, respectively). The aquaria were supplied with aquarium filters to clean the tanks and heaters to adjust different temperatures and covered with mosquito screens to prevent fish from jumping out. Fish were fed at 2% body weight per day for four months. Fishes were fed twice per day. The initial and final fish weights were taken using a digital balance. At the end of the experiment, a total of 120 fishes from all treatments were dissected, and the whole ovaries and testes were excised, and their weights were recorded.

Table1 Composition of dietary feeds/100g

Fishmeal %	47.42	25.50	40.61
Soybean meal %	Nil	25.50	Nil
Pea meal %	Nil	Nil	40.61
Wheat %	36.71	34.45	2.94
Vitamin and Mineral premix %	2.98	2.71	2.97
Binders %	2.98	2.71	2.97
Fat %	9.91	9.04	9.90
Total %	100%	100%	100%

D1= Fishmeal, D2= Soybean meal, D3= Peameal,

Weight gain (g) was calculated as Final weight – Initial weight. [23].
Gonadosomatic index (GSI) was calculated according to [24] and [25] using the following formula:

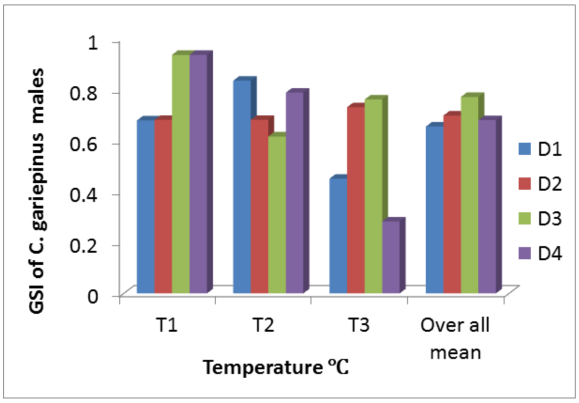
$$GSI = \frac{\text{Weight of gonad (g)}}{\text{Body weight(g)}} \times 100$$

Haematological examination: Blood samples were collected by severing the caudal peduncle of *C. gariepinus* using a syringe containing sodium citrate as an anticoagulant. Samples were examined for erythrocytes (RBCs) and Leukocytes (WBCs) count using improved Neubauer Haemocytometer. Hemoglobin (Hgb) concentration was estimated using the cyanmethemoglobin method [26]. Hematocrit (HCT) or packed cell volume (PCV), platelets (PLT) and mean corpuscular volume (MCV) were estimated according to [27].

In all the above contrasting groups, the significance of difference was checked statistically by the two-way ANOVA using [28]. Statistical analyses were performed at 0.05 significance level.

RESULTS

The results clearly showed the effect of feed/nutrient type and temperature change on gonadal maturation and physiological parameters. Table (2) showed quantitative values expressed as means of the gonasosomatic index (GSI) for males and females and blood parameters at the end of the experimental period for the diets (D1, D2, D3, and D4) and temperatures (T124°C, T228°C, and T332°C). Figs. (1) and (2) showed the mean final results of (GSI) for females and males, respectively and blood parameters as affected by diets and temperature.



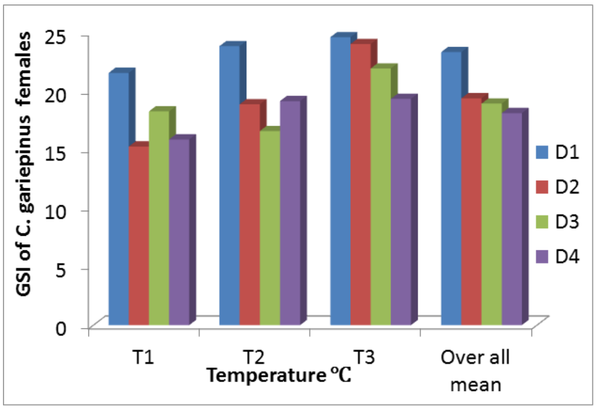


Table 2 Overall mean values (±SE) of Gonadosomatic GSI Index and blood parameters of *C garipinus* for different diets and temperature

Parameters	D1	D2	D3	D4	T1	T2	T3	Overall mean
GSI Male	0.654 ± 0.26	0.697 ± 0.29	0.77 ± 0.4	0.679 ± 0.33	0.807 ± 0.37	0.729 ± 0.26	0.561 ± 0.28	0.7 ± 0.32
GSI female	16.706 ± 5.91	14.209 ± 5.68	14.122 ± 3.81	13.698 ± 3	13.402 ± 4.2	14.693 ± 4.84	15.957 ± 5.24	14.684 ± 4.86
RBC x 10^6	3.020 ± 0.424	2.258± 0.569	5.695± 0.188	6.949± 0.1884	2.368± 0.516	2.53± 0.965	2.450± 0.144	2.450± 0.641
WBC x 10^3	10.90± 3.212	8.56± 2.064	9.06± 1.320	8.648 ± 1.179	9.469± 2.804	8.091± 1.643	9.860 ±1.943	9.289 ± 2.347
Hemoglobin Hgb g/dl	11.834± 2.43	12.0 ± 2.09	13.42± 1.74	12.192± 2.185	13.67 ± 2.35	12.830± 2.8	12.843 ± 2.53	12.423 ± 2.21
Hematocrit (HCT) or (PCV) %	31.65 ± 1.39	25.295 ± 0.13	26.032 ± 0.23	28.628 ± 3.48	27.901 ± 3.09	31.05 ± 3.81	28.236 ± 2.92	29.063 ± 3.54
Platelets PLT	95.333 ± 13.8	88.000 ± 6.26	88.167 ± 6.63	91.500 ± 6.46	90.000 ± 6.69	98.625 ± 9.5	83.625 ± 2.67	90.750 ± 9.18
MCVg/l	127 ± 5.42	105.67 ± 10	118.33 ± 4.09	121.33 ± 5.37	115.5 ± 10.6	119.75 ± 10.2	119 ± 9.9	118.08 ± 10.3

D1,D2,D3 and D4 = fishmeal, soybean mealpea meal and commercial tilapia feed.; T1,T2and T3 =temperature 24 ℃, 28℃ and 32℃. GSI=gonadosomatic index, RBCs= red blood cells, WBCs= white blood cells, Hgb= blood hempglobin, HCT= hematocrit , PLT= platelets, MCV= Mean corpuscular volume

Weight gain

Table (3) Shows growth performance of male and female *C. gariepinus* expressed as weight gain (g) during the experimental period. The highest value of weight gain was that of D1 and T2(28℃) (192.42) which was significantly (p<0.05) greater than other values. All treatments showed an increase in weight gain at T2(28℃) and a decline of weight gain at T3(32℃) for all diets.

Gonadosomatic index (GSI)

The results in Table (4) showed no effect of diet on male GSI, but water temperature has demonstrated a significant difference (p<0.05) on male GSI. The highest value of male GSI (0.834±0.24) was obtained at D1-T2(28℃), and the lowest value of male GSI (0.282±0.13) was recorded at D4 -T3(32℃). On the other hand, the female GSI was affected by both food and temperature variation. It showed a significant difference (p<0.05) for both diet and temperature. The highest result of female GSI (17.266± 6.89) occurred at D1-T2(28℃), while the lowest value (11.728± 5.33) appeared at D2 and T1(24℃), (Table 4).

Blood parameters

The result of erythrocytes (RBCs) number at the end of the experiment showed a significant difference (p<0.05) exerted by diets on *C. gariepinus* and the combined effect of diet and temperature also revealed a significant difference (p<0.05) on RBCs. There was no significant difference of temperature on RBC's count. D1-T2(28℃) showed the highest count of RBCs (3.560 x 106± 0,26) and the lowest count of RBCs (1,1644 x 106± 0,10) was found in D3 -T2(28℃), (Table 4).

The number of white blood cells (WBCs) at the end of the experiment was found to be affected by diet and temperature where a significant difference (p<0.05) in (WBCs) number was exerted by food, temperature and a combined effect of both food and temperature. The highest number of (WBCs) was fond at D1 – T3(32℃) as (12.758 x 103 ±2,460) and the lowest number (5,980 x 103 ± 0,48) was shown at D2- T1(24℃), (Table 4). Generally, WBC increases with an increasing water temperature.

Table 4. The effect of different diets (D1,D2,D3, and D4) and temperature (T1,T2,T3 and T4) on gonadosomatic index GSI, and some blood parameters of *C.gariepinus*, (ANOVA two ways).

		Different Diets			
Chemistry Characterization	Water temperature (°C)	D1	D2	D3	D4
Gonadosomatic index GSI (Male)	$T_{1\text{-}(24)}$	0.67^{aX} ±0.21	0.68^{aX} ± 0.3	0.935^{aX} ± 0.6	0.935^{aX} ±0.19
	$T_{2\text{-}(28)}$	0.834^{a}Y ±0.24	0.68^{aX} ± 0.29	0.615^{aY} ± 0.25	0.787^{aY} ±0.22
	$T_{3\text{-}(32)}$	0.45^{cZ} ± 0.2	0.73^{cZ} ± 0.29	0.76^{cY} ± 0.17	0.282^{c}Z ±0.13
Gonadosomatic index GSI (Female)	$T_{1\text{-}(24)}$	15.864^{aX} ± 4.58	11.728^{b}x ± 5.33	13.89^{cz} ± 3.1	12.126^{dz} ± 2.17
	$T_{2\text{-}(28)}$	16.98^{aY} ± 6.45	14.287^{bY} ± 4	12.892^{cY} ± 4.4	14.605^{bx} ± 3.7
	$T_{3\text{-}(32)}$	17.266^{aY} ± 6.89	16.612^{bz} ± 6.72	15.584^{c}x ± 3.62	14.364^{dx} ± 2.48
Red blood cell count RBCs X 10^6/mm^3	$T_{1\text{-}(24)}$	2,869^{ax} ± 0,26	1,901^{bY} ± 80	2,147^{ax} ± 0,96	2,557^{ax} ± 0,17
	$T_{2\text{-}(28)}$	3,560^{bx} ± 0,17	2,433^{aY} ± 0,64	1,1644^{cx} ± 0,10	2,970^{ax} ± 0,11
	$T_{3\text{-}(32)}$	2,631^{ax} ± 0,13	2,438^{aY} ± 0,45	2,340^{ax} ± 0,18	2,391^{bx} ± 0,17
White blood cell count WBCs X 10^3/mm^3	$T_{1\text{-}(24)}$	11,954^{ax} ± 3,50	5,980^{bx} ± 0,48	10,21^{cx} ± 0,54y	9,724^{dx} ± 1,83
	$T_{2\text{-}(28)}$	8,000^{aY} ± 1,09	10,675^{bY} ± 0,19	7,561^{c} ± 1,13	7,921^{cY} ± 1,73
	$T_{3\text{-}(32)}$	12.758^{az} ± 2,460	9,025^{bz} ± 0,31	9,356^{bz} ± 1,04	8,300^{dz} ± 0,11
Hemoglobin, Hgb g/d	$T_{1\text{-}(24)}$	10.917^{ax} ± 3.37	11.25^{a}x ± 1.82	12.95^{a}x ± 1.92	12.95^{a}x ± 0.327
	$T_{2\text{-}(28)}$	11.6^{ax} ± 1.44	13.35^{ax} ± 0.152	16.05^{ax} ± 3.24	13.7^{ax} ± 0.901
	$T_{3\text{-}(32)}$	13.65^{ax} ± 2.8	11.65^{ax} ± 2.799	14.25^{ax} ±1.38	11.8^{ax} ± 3.51
Hematocrit, HTC%	$T_{1\text{-}(24)}$	31.65^{ax} ± 1.39	25.295^{bx} ± 0.13	26.032^{bx} ± 0.23	28.628^{cx} ± 3.48
	$T_{2\text{-}(28)}$	35.265^{aY} ± 1.71	32.082^{bY} ± 2.949	28.465^{c}y ± 3.63	28.39^{cx} ± 1.64
	$T_{3\text{-}(32)}$	27.562^{az} ± 2.92	28.402^{bz} ± 4.46	27.415^{a}z ± 2.55	29.567^{cY} ± 0.84
Platelets, PLT	$T_{1\text{-}(24)}$	90.5^{ax} ± 12.6	90.5^{ax} ± 3.271	87^{bx} ± 3.74	92^{cx} ± 2.37
	$T_{2\text{-}(28)}$	110^{aY} ± 8.88	91^{bx} ± 7.874	95.5^{cY} ± 3.94	98^{dY} ± 4.6
	$T_{3\text{-}(32)}$	85.5^{az} ± 1.87	82.5^{bY} ± 2.429	82^{bz} ± 2.83	84.5^{az} ± 2.35
Mean corpuscular volume MCV/l	$T_{1\text{-}(24)}$	123^{ax} ± 4.82	101^{bx} ± 10.02	120^{cx} ± 4.6	118^{dx} ± 4.6
	$T_{2\text{-}(28)}$	132^{aY} ± 2.37	106^{bY} ± 2.366	119^{cY} ± 3.03	122^{dY} ± 6.81
	$T_{3\text{-}(32)}$	126^{az} ± 4.56	110^{bz} ± 14.46	116^{cz} ± 4,00	124^{dz} ± 2.83

D1,D2,D3 and D4 = fish meal, soybean mealpea meal and commercial tilapia feed.; T1,T2and T3 = temperature 24 °C, 28°C and 32°C. *All values are expressed as means ± S.E. in triplicate measures. Columns compare results between different water temperature. Rows compare results between different diets. Means in same column or row with the same superscript were not significantly different otherwise, they were significantly different ($p < 0.05$).

The effect of diet and temperature on hemoglobin level (Hgb) of *C. gariepinus* was shown in (Table 3). Both food and temperature showed a significant increase ($p<0.05$) in (Hgb) level. The highest level of (Hgb) 16.05 3.24 was shown at D3-T2(28°C). The lowest value (10.917± 3.37) was recorded at D1-T1(24°C). Diet type had no significant effect on (Hgb).

The hematocrit (HTC) of *C. gariepinus* was affected by diet, temperature and by a combined action of both diet and temperature as well. All factors revealed a significant difference ($p<0.05$) on hematocrit level. D1-T(28°C) showed the highest value (35.265 ± 1.71) of (HTC), while D1-T1(24°C) gave the lowest value (25.295 0.13(± of (HTC).

The number of blood platelets (PLT) of *C. gariepinus* was affected by diet and temperature. The statistical results showed a significant difference ($p<0.05$) of diet, temperature and their interaction on platelets (PLT) of *C. gariepinus*. The highest number of (PLT), (110 ± 8.88/µl x 103), was found at D1- T2 (28℃) and the lowest platelets number, (82.0/µl ± 2.8382), was found at D3-T3(32℃).

Mean corpuscular volume (MCV) of *C. gariepinus* was affected by diet and temperature. Both food and temperature exerted a significant difference ($p<0.05$) on (MCV). The highest number of MCV, (132/µl x 103 ± 2.37) was found at D1-T2(28℃) and the lowest number (101/µl x 103/µl ± 10.02) was obtained at D2 – T1(24℃) The combined effect had no significant effect on (MCV).

DISCUSSION

Aquaculture research is mainly focused on replacing fishmeal by a cheaper protein source since there is a scarcity of fishmeal supply and a continuous rising of its cost as a result of high demand in the competitive markets [29]. Among the many studied protein sources, plants seem to be the best alternative source of proteins for aquatic organisms [30]; [31]. [29] reported that plant proteins are the most appropriate to replace fishmeal because they can be easily produced since land and adequate environmental conditions are available. Many workers have investigated partial or complete replacement of fish meal with different sources of plant protein [32]; [33]; [29]. Growth, health, and reproduction of fish primarily depend on quantity and quality of protein supply in their diet [5].

In this study, fishmeal has been partially replaced by soybean meal and peameal. Fishmeal was significantly ($p<0.05$) better in *C. gariepinus* weight gain, (GSI), and fish health in term of hematological factors, followed by Soybean meal and Peameal respectively because fishmeal provides all essential amino acids in preferred amounts required for farmed fish [34]. Soybean meal and peameal were selected for this study because soybean meal provides most of the core amino acids at a reasonable cost and contains high protein percentage, but its use is restricted by antinutritional substances [35]. On the other hand, Peameal has been suggested by [36]; [37] to be used in animal feed for their protein content and high digestible energy level.

Weight gain

Although growth performance was not the main issue in this study, data of weight gain were shown here for comparison purposes. Different Diets and different temperature levels (T1(24℃), T2(28℃) and T3(32℃) were tried here to examine their effects on GSI and some blood parameters of *C. gariepinus*. However, *C. gariepinus* weight-gain results were found to be significantly ($p<0.05$) affected by different diets and temperature levels. The highest weight gain was observed at D2 – T2(28℃). In this study, weight gain increased with an increasing water temperature up to T2(28℃), then reduced again towards Temperature T3(32℃). Other findings of different authors stated that water temperature has a direct effect on feed intake, metabolic rates and energy consumption of catfish [12]; [13]. Similar results on the effect of temperature on fish growth were recorded by [14], who stated that water temperature has a direct effect on fish growth performance.

Gonadosomatic Index (GSI)

The GSI is the ratio of the mass of gonads relative to total body weight; it is one of the indices in monitoring changes in nutritional and energy status [38]; [39]. The result showed that female GSI increased with increasing temperature up to 28℃ and decreased towards temperature 32℃. T2(28℃) was considered to be the optimum temperature for catfish with regards to GSI and mass production of viable seeds. Similarly, [40] stated that gonadal development could be improved by raising and marinating temperature at 26.5 ±0.5 for *Oreochromis karongae*. GSI varied between individuals of the same species but was measured on average. It is usually higher in females than males of the same size, because ovaries are larger than testis. Males also have less well-defined stages of gonadal maturation [41]. Older and larger individual exhibited higher (GSI). This study shows that water temperature and quality of fish feed could be considered as the main factors that affect GSI and good health of the catfish. It was reported that GSI is a reliable indicator of the fish health condition, [18].

Blood parameters.

Clinical diagnoses of various diseases of human and domestic animals depend on hematology. In fishery biology, hematological characteristics are used to assess the health condition of fish. Also, they are routinely used in toxicology, monitoring of the environment as well as the fish health status [42]. Diets and temperature exerted different effects on blood parameters (RBCs), (WBCs) Hematocrit (HCT), Hemoglobin (Hgb), platelets, and MCV) at various degrees.

The result of erythrocytes (RBCs) count showed significant differences (p<0.05) exerted by diets on *C. gariepinus* and a combined effect of diet and temperature as well. There were no significant differences induced by temperature alone on the number of RBCs. Fishmeal-based diet showed a higher number of RBCS while plant-based diet showed a lesser number of (RBCs), (Table 4). [43] stated that erythrocyte count is one of the first parameters to be affected by stress. The WBCs were significantly (p<0.05) affected by diet, temperature and also by a combination of diet and temperature as well. The increase in water temperature influences the count of WBC as a result of stress. The RBC number increases with temperature where temperature T3(32℃) showed the highest number of WBCs.

Hematocrit is used to define the ratio of erythrocytes to plasma. The range of 30 -45% is considered as normal for fish in general [44]. Hematocrit level was found in the range between 25.295± 0.13 and 35.265± 1.71 which is below the normal according to [44]. This reduction in hematocrit may be due to protein level of 36% against a 40% protein requirement by *C. gariepinus*. According to [45], the dietary protein content of *C. gariepinus* is more than 40% for maximal growth regardless of dietary energy content. This result revealed that D1-T2(28℃) exerted a significant (p<0.05) increase in hematocrit (HCT) level of *C. gariepinus* which means that fishmeal based protein induced more effect on hematocrit than plant-based protein (D2 and D3), (Table 4).

The results clearly showed a significant increase in hemoglobin Hgb level (p<0.05) at D3-T2(28℃) as a consequence of both temperature and diet. Peameal diet showed a higher hemoglobin level than other food ingredients. The mean hemoglobin concentration in this study (12.423± 2.21) was greater than that obtained by [46] in the South African *C. gariepinus* (5.8 g/dl). This deviation suggests different conditions such as temperature and type of feed/nutrients. Further studies might be required to identify the effect of temperature and higher protein levels from various plant sources on GSI and blood parameters of *C. gariepinus.*

D1 (fishmeal-based diet) and temperature T2(28℃) reveal a significant increase in platelets (PLT) number of *C. gariepinus*, while peameal-based diet D3 and temperature T3(32℃) show the lowest value which means that fishmeal-based diet and optimum temperature of 28℃ can raise the (PLT) count of *C. gariepinus*.

Table (4) shows a significant increase (p<0.05) in mean corpuscular volume (MCV) as a result of both diet and temperature. The results revealed that fishmeal-based protein with TemperatureT2(28℃) gave the higher count of (MCV) while peameal-based diet gave the lowest number of (MCV) for *C. gariepinus.*

Effect of temperature on fish growth

[47] stated that the key (abiotic) factor that affecting fish growth is water temperature. In this study, the growth rate of *C. gariepinus* was significantly higher at the temperature of 28℃ as reported by [48].The temperature of 28 ℃, was found to be optimum for the growth of *C. gariepinus* while the lowest growth performance was shown at temperature 30℃. Similar results were found by [49] who stated that the favorable temperature of the Clarias is between 25 – 30 ℃, he also reported that fish would grow faster with the increase in temperature to a certain level, then growth will reduce with further rises in temperature. The poor growth performance at a temperature higher than the optimum was also reported for Japanese yellowtail by [47] as a result of a significant decrease in food intake coupled with an increased demand for energy at such higher temperatures.

CONCLUSION

In conclusion, fish diets, and aquatic temperature significantly affect gonadal development (GSI) and hematological parameters such as RBCs, WBC and MCV, Platelets (PLT), Hematocrit (HCT) and Hemoglobin concentration (Hgb). Animal protein content is one of the critical requirements of *C. gariepinus* diet for normal physiological performance. GSI depends mainly on feed quantity and quality. The physiological state of *C. gariepinus* can be predicted by hematological studies. Hematocrit might be considered a general indicator of fish health. Temperature is an important regulating factor of gonadal maturation in *C. gariepinus*. Raising and maintaining temperature level at (28°C) significantly increase GSI and hematological parameters and may be the most suitable range for the physiological performance of *C. gariepinus*. The study of blood hematology in combination with gonadosomatic index are crucial indicators of the health condition of *C. gariepinus* and can lead to the right way of mass production of viable seeds for aquaculture development.

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