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Original Research Paper

Haematological Profile and Basic Biochemical Characteristics of Wild-Caught Nile Tilapia (*Oreochromis niloticus*) from the Vellar Estuary

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Abstract

Nile tilapia (*Oreochromis niloticus*) is an important fish species widely distributed in freshwater and estuarine environments. The present study was conducted to assess the basic haematological and serum biochemical characteristics of apparently healthy wild-caught Nile tilapia from the Vellar Estuary, Parangipettai, Tamil Nadu, India. A total of 30 apparently healthy fish were collected and examined for morphometric characteristics, selected water-quality parameters, haematological indices and serum biochemical parameters. The total length of the fish ranged from 15.3 to 24.5 cm, while body weight ranged from 92 to 203 g. During sampling, the water temperature, pH, dissolved oxygen and salinity were 26°C, 7.2, 4.6 mg L^{-1} and 21 ppt, respectively. The mean RBC count, WBC count, haemoglobin concentration and PCV were $2.08 \pm 0.28 \times 10^6$ cells mm^{-3}, $50.72 \pm 8.81 \times 10^3$ cells mm^{-3}, 7.86 ± 0.82 g dL^{-1} and $31.60 \pm 2.48\%$, respectively. Serum glucose and total protein concentrations showed mean values of 75.97 ± 8.16 mg dL^{-1} and 4.30 ± 0.39 g dL^{-1}, respectively. The findings provide baseline information on the haematological and biochemical characteristics of apparently healthy wild-caught *O. niloticus* inhabiting the Vellar Estuary. These baseline observations may be useful for future assessment of seasonal variation, environmental stress and health-related changes in Nile tilapia populations.

Keywords: Nile tilapia, *Oreochromis niloticus*, Vellar Estuary, haematology, serum biochemistry, glucose, total protein, fish health.

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1.Introduction

Nile tilapia (*Oreochromis niloticus*) is one of the most widely cultured and commercially important fish species in tropical and subtropical regions. Its rapid growth, adaptability to different environmental conditions, efficient feed utilisation, and economic importance have contributed to its widespread use in aquaculture (El-Sayed, 2006; FAO, 2022). In addition to its importance in aquaculture, *O. niloticus* is frequently used in studies evaluating the physiological responses of fish to environmental variations.

The physiological condition of fish is strongly influenced by environmental factors such as temperature, salinity, dissolved oxygen, pH, food availability and water quality. Estuarine ecosystems are particularly dynamic because of the continuous interaction between freshwater and seawater, resulting in considerable fluctuations in physicochemical conditions (Elliott and Whitfield, 2011). Fish inhabiting estuarine environments must therefore maintain physiological homeostasis under changing environmental conditions. Monitoring physiological indicators can provide useful information regarding the health and adaptive status of fish populations.

Haematological parameters are widely recognized as sensitive indicators of the physiological condition and general health of fish (Wedemeyer et al., 1990; Hrubec et al., 2000). Blood parameters such as red blood cell count, white blood cell count, haemoglobin concentration and haematocrit are associated with oxygen transport, immune function and maintenance of physiological homeostasis. Variations in these parameters may occur in response to environmental stress, nutritional status, disease, reproductive condition and other physiological factors (Fazio, 2019). Erythrocyte indices, including mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration, provide additional information regarding erythrocyte characteristics and oxygen-transport capacity.

Biochemical parameters also provide valuable information regarding the metabolic and physiological status of fish. Blood glucose is an important indicator of energy metabolism and may increase or decrease in response to environmental stress and changes in energy demand (Mommsen et al., 1999). Total protein is associated with nutritional status, protein metabolism and immune-related functions and has therefore been widely used as an indicator of fish health (Kori-Siakpere et al., 2009). The combined assessment of haematological and biochemical parameters can consequently provide a more comprehensive evaluation of the physiological condition of fish.

The Vellar Estuary, located along the southeast coast of India, is an ecologically important estuarine system supporting diverse aquatic organisms and fisheries resources. Fish inhabiting estuarine environments are exposed to naturally variable conditions associated with tidal fluctuations, freshwater inflow and changes in salinity and other water-quality parameters (Elliott and Whitfield, 2011). However, baseline information on the haematological and basic biochemical characteristics of wild-caught *O. niloticus* from the Vellar Estuary is limited. Establishing baseline physiological information is important for assessing the general condition of fish populations and may provide useful reference information for future environmental and fish-health studies.

Therefore, the present study aimed to assess the haematological profile and basic biochemical characteristics of wild-caught Nile tilapia (*Oreochromis niloticus*) from the Vellar Estuary, with particular emphasis on erythrocytic and leukocytic parameters, haemoglobin, haematocrit, erythrocyte indices, glucose and total protein.

2. Materials and Methods

2.1 Study Area and Fish Collection

The study was conducted in the Vellar Estuary, Parangipettai, Cuddalore District, Tamil Nadu, India. Wild Nile tilapia (*Oreochromis niloticus*) were collected from the estuarine region during the study period. A total of 30 apparently healthy fish were selected for the study. Fish were considered apparently healthy based on their normal external appearance, active swimming behaviour, intact body surface and absence of visible lesions, ulcers, haemorrhages, fin damage or other abnormalities. Fish showing any visible signs of disease or physical injury were excluded from the study. The selected fish were transported to the laboratory in aerated containers containing estuarine water and processed immediately.

2.2 Morphometric Measurements

The total length and body weight of each fish were recorded before blood collection. Total length was measured to the nearest 0.1 cm using a measuring scale, and body weight was recorded to the nearest 0.1 g using a digital weighing balance.

2.3 Water Quality Parameters

The physicochemical characteristics of the sampling site were recorded during fish collection. Water temperature, pH, dissolved oxygen and salinity were measured using appropriate calibrated instruments. These parameters were recorded to describe the environmental conditions under which the apparently healthy fish were collected.

2.4 Blood Collection

Blood samples were collected individually from the caudal vein using sterile disposable syringes. Blood intended for haematological analysis was immediately transferred into EDTA-containing tubes and gently mixed to prevent clotting. Samples were maintained under appropriate refrigerated conditions and processed promptly.

2.5 Haematological Analysis

Haematological assessment was performed on the apparently healthy fish. Red blood cell (RBC) and white blood cell (WBC) counts were determined using the Neubauer improved haemocytometer method following appropriate dilution with standard diluting fluids. Haemoglobin (Hb) concentration was estimated using the cyanmethemoglobin method (Drabkin, 1946). Packed cell volume (PCV) was determined using the microhaematocrit method. The erythrocyte indices, including mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC), were calculated from the corresponding haematological values following standard procedures (Dacie and Lewis, 2017).

2.6 Biochemical Analysis

Blood samples collected without anticoagulant were allowed to clot and centrifuged to obtain serum. Serum samples were carefully separated and stored under appropriate refrigeration until analysis.

Serum glucose was measured by the glucose oxidase–peroxidase (GOD-POD) method, and total protein by the Biuret method, using commercially available diagnostic kits according to the manufacturer's instructions.

2.7 Statistical Analysis

The individual observations obtained from the apparently healthy fish were expressed as mean ± standard deviation (SD). Minimum and maximum values were also calculated. The results were used to establish the baseline haematological and biochemical characteristics of apparently healthy wild-caught *O. niloticus* from the Vellar Estuary. Where applicable, Pearson's correlation analysis was performed to examine relationships between morphometric and physiological parameters. Statistical significance was considered at $p < 0.05$.

3. Result

3.1 Morphometric Characteristics

The morphometric characteristics of the 30 apparently healthy wild-caught Nile tilapia (*Oreochromis niloticus*) collected from the Vellar Estuary are presented in **Table 1**. The total length of the examined fish ranged from 15.3 to 24.5 cm, with a mean length of 20.48 ± 1.88 cm. Body weight ranged from 92 to 203 g, with a mean value of 135.00 ± 31.16 g. The observed variation represents the natural size range of the sampled wild population.

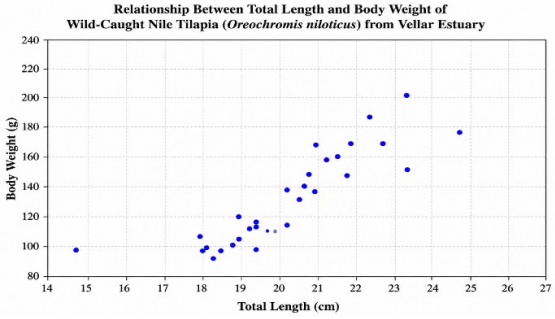

Figure 1. Relationship between total length and body weight of wild-caught Nile tilapia (*Oreochromis niloticus*) from the Vellar Estuary.

3.2 Water Quality Parameters

The physicochemical characteristics of the Vellar Estuary recorded during the collection of apparently healthy wild-caught Nile tilapia (*Oreochromis niloticus*) are presented in **Table 2**. The water temperature was 26°C, with a pH of 7.2. The dissolved oxygen concentration was 4.6 mg L^{-1}, while the salinity was 21 ppt. These values represent the environmental conditions prevailing at the sampling site during fish collection.

3.3 Haematological Parameters

The haematological characteristics of the 30 apparently healthy wild-caught Nile tilapia (*Oreochromis niloticus*) collected from the Vellar Estuary are presented in **Table 3**. The RBC count ranged from 1.62 to 2.82 × 10^6 cells mm^{-3}, with a mean value of 2.08 ± 0.28 × 10^6 cells mm^{-3}. The WBC count ranged from 20.20 to 63.80 × 10^3 cells mm^{-3}, with a mean of 50.72 ± 8.81 × 10^3 cells mm^{-3}. Haemoglobin concentration varied from 6.50 to 9.60 g dL^{-1}, with a mean of 7.86 ± 0.82 g dL^{-1}.

The PCV values ranged from 26.40 to 36.50%, with a mean of 31.60 ± 2.48%. The MCH ranged from 32.40 to 45.20 pg, with a mean of 40.72 ± 1.90 pg, whereas MCHC ranged from 23.50 to 26.90%, with a mean of 26.23 ± 0.75%.

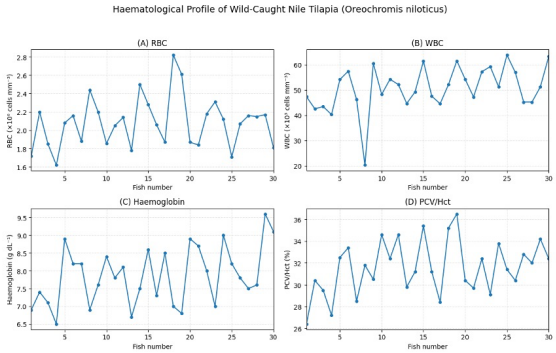

Figure 2. Haematological profile of wild-caught Nile tilapia (*Oreochromis niloticus*) from the Vellar Estuary. (A) Red blood cell (RBC) count, expressed as ×10^6 cells mm^{-3}, showing the variation among the 30 apparently healthy fish. (B) White blood cell (WBC) count, expressed as ×10^3 cells mm^{-3}, showing the individual variation in leukocyte counts among the sampled fish. (C) Haemoglobin (Hb) concentration, expressed as g dL^{-1}, showing the

observed variation in haemoglobin levels among the fish. (D) Packed cell volume/haematocrit (PCV/Hct), expressed as %, showing the variation in the proportion of erythrocytes in the blood of the sampled fish.

3.4 Serum Biochemical Characteristics

The serum biochemical characteristics of the 30 apparently healthy wild-caught Nile tilapia (*Oreochromis niloticus*) are presented in **Table 4**. Serum glucose concentrations ranged from 62 to 93 mg dL^{-1}, with a mean value of 75.97 ± 8.16 mg dL^{-1}. Serum total protein ranged from 3.6 to 4.9 g dL^{-1}, with a mean value of 4.30 ± 0.39 g dL^{-1}. The observed values provide a baseline description of the serum biochemical characteristics of apparently healthy *O. niloticus* collected from the Vellar Estuary.

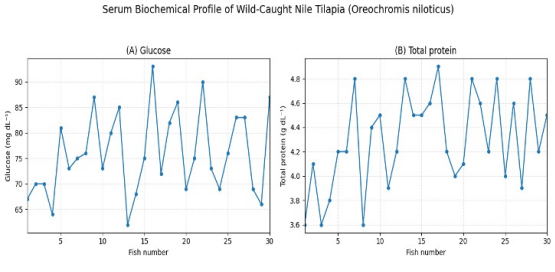

Figure 3. Serum Biochemical Profile (A) Serum glucose concentration (mg dL^{-1}) of the 30 apparently healthy wild-caught Nile tilapia. (B) Serum total protein concentration (g dL^{-1}) of the 30 apparently healthy wild-caught Nile tilapia.

4. Discussion

The present study provides baseline information on the morphometric, haematological and basic biochemical characteristics of apparently healthy wild-caught Nile tilapia (*Oreochromis niloticus*) from the Vellar Estuary. The fish examined showed a total length ranging from 15.3 to 24.5 cm and body weight from 92 to 203 g, indicating variation in the size of the sampled population. Such variation may be related to differences in age, growth rate, feeding condition and habitat characteristics. Morphometric characteristics are important when interpreting physiological parameters because blood characteristics may vary with fish size and developmental stage.

During sampling, the Vellar Estuary recorded a temperature of 26°C, pH 7.2, dissolved oxygen of 4.6 mg L^{-1} and salinity of 21 ppt. These values represent the environmental conditions prevailing during fish collection. The relatively high salinity reflects the estuarine nature of the sampling environment, while the recorded dissolved oxygen indicates the availability of oxygen for normal metabolic activity. Environmental factors including temperature, salinity, dissolved oxygen and pH can influence metabolic activity, osmoregulation and haematological characteristics in fish (Wedemeyer et al., 1990; Fazio, 2019).

The mean RBC count recorded in the present study was 2.08 ± 0.28 × 10^6 cells mm^{-3}, while the mean haemoglobin concentration and PCV were 7.86 ± 0.82 g dL^{-1} and 31.60 ± 2.48%, respectively. These parameters are important indicators of oxygen transport and erythrocyte status in fish. The observed values were within the range reported for healthy Nile tilapia in previous studies, although differences among populations can occur because of environmental conditions, fish size, season, nutrition and methodological differences (Azizoğlu and Cengizler, 1996). The mean WBC count was 50.72 ± 8.81 × 10^3 cells mm^{-3}. Leukocytes are important components of the fish immune system and their abundance can be influenced by physiological condition and environmental factors. Since the fish examined in the present study were apparently healthy, these values can provide useful baseline information for the sampled population.

The serum glucose concentration ranged from 62 to 93 mg dL^{-1}, with a mean of 75.97 ± 8.16 mg dL^{-1}. Glucose is an important metabolic indicator in fish and may respond to changes in energy demand and environmental conditions. The observed variation among individuals may reflect differences in feeding status, metabolic activity and natural physiological variation. Serum total protein ranged from 3.6 to 4.9 g dL^{-1}, with a mean of 4.30 ± 0.39 g dL^{-1}. Total protein is associated with protein metabolism, nutritional status and physiological functions, and therefore provides useful complementary information when assessing the general condition of fish (Kori-Siakpere et al., 2009).

Overall, the haematological and biochemical values obtained in this study provide a preliminary baseline physiological profile of apparently healthy wild-caught *O. niloticus* inhabiting the Vellar Estuary. These baseline observations may be useful for comparison with future studies involving seasonal variation, environmental stress, disease conditions or other physiological alterations in Nile tilapia. Because the present investigation represents a single sampling period and location, the reported values should be considered site-specific reference observations rather than universal normal ranges.

5. Conclusion

The present study established a basic physiological profile of apparently healthy wild-caught Nile tilapia (*Oreochromis niloticus*) from the Vellar Estuary. The observed morphometric, haematological and serum biochemical characteristics showed natural variation among the sampled fish. The recorded water-quality conditions, together with the haematological parameters and serum glucose and total protein levels, provide useful baseline information for the sampled population. These findings can serve as reference data for future investigations of seasonal changes, environmental stress and health status of *O. niloticus* inhabiting the Vellar Estuary. Further studies involving larger

sample sizes and different seasons are recommended to establish more comprehensive reference ranges.

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Conflict of Interest

The authors declare that they have no conflicts of interest regarding the research, authorship, or publication of this article.

Author Contributions

Kokila Sumathi: Conceptualization, Methodology, Sample collection, Experimental work, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review and editing. Praveena Durairaj: Methodology, Data interpretation. Eesa Elaiyavanan: software analysis. B. Deivasigamani: Conceptualisation, Supervision, Validation, Scientific guidance, Writing – review and editing. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Statement

Because this study involved the collection of wild-caught fish from the Vellar Estuary, you should add an ethical statement only if you actually obtained institutional/field collection approval. Do not claim an approval number if you do not have one.

Table 1. Morphometric characteristics of wild-caught Nile tilapia (*O. niloticus*) from the Vellar Estuary (n = 30).

Parameter	Minimum	Maximum	Mean ± SD
Total length (cm)	15.3	24.5	20.48 ± 1.88
Body weight (g)	92	203	135.00 ± 31.16

Table 2. Physicochemical parameters of the Vellar Estuary during collection of wild-caught Nile tilapia (*Oreochromis niloticus*)

Parameter	Value
Temperature	26 °C
pH	7.2
Dissolved oxygen	4.6 mg L^{-1}
Salinity	21 ppt

Table 3. Haematological characteristics of wild-caught Nile tilapia (*O. niloticus*) from the Vellar Estuary (n = 30)

Parameter	Minimum	Maximum	Mean ± SD
RBC ($\times 10^6$ cells mm^{-3})	1.62	2.82	2.08 ± 0.28
WBC ($\times 10^3$ cells mm^{-3})	20.20	63.80	50.72 ± 8.81
Hb (g dL^{-1})	6.50	9.60	7.86 ± 0.82
PCV/Hct (%)	26.40	36.50	31.60 ± 2.48
MCH (pg)	32.40	45.20	40.72 ± 1.90
MCHC (%)	23.50	26.90	26.23 ± 0.75

Table 4. Serum biochemical characteristics of wild-caught Nile tilapia (*O. niloticus*) from the Vellar Estuary (n = 30)

Parameter	Minimum	Maximum	Mean ± SD
Glucose (mg dL^{-1})	62	93	75.97 ± 8.16

Total protein (g dL^{-1})	3.6	4.9	4.30 ± 0.39