Health Status Comparison of Blood Cockle (*Tegillarca granosa*) between Low and High Yield Farms in Selangor and Johor

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Abstract. This study aims to provide insight knowledge on the potential reason for low blood cockles (*Tegillarca granosa*) production in Sungai Buloh Selangor by comparing the condition indices and histology of the gills and gonad with samples from a high yield farm at Sungai Ayam, Johor. Samples were collected in September 2020 and grouped for histological analysis and for condition indices. About 60% individuals from Sungai Buloh and 20% of samples from Sungai Ayam found with degenerated gill filaments. The sex ratio were found identical (50%:50% male to a female) in samples from Sungai Ayam, while 40%:60% of male to female from Sungai Buloh. The gonad of males found at Stage 2 (developing) and Stage 3 (developed or ripe) and the ovaries at Stage 3 and Stage 4 (spawning) for Sungai Buloh, and between Stage 2 to Stage 4 from Sungai Ayam. The total condition index (CI Tot) was significantly differences between farms. Findings indicate sample from Sungai Buloh has low health status due to poor gill’s filaments condition, and ripe ovaries found in lightweight (2 g) *T. granosa*. Hence being the potential reason for low survival rate in the Sungai Buloh.

1. Introduction

*Tegillarca granosa* or previously known as *Anadara granosa* is a marine bivalve species in the family of Arcidae that often called blood cockle [1]. The blood cockle habitat is mostly in mangrove and the muddy environment along the coastline, and the west coast of Peninsular Malaysia extending from Kedah, Penang, Perak, Selangor and Johor States contain hot spots for spawning and growing of *T. granosa* [1, 2,]. The cockle seeds were reportedly found in sheltered coastal areas on the east coast of Peninsular Malaysia such as in Pahang [2,3]. Since 1948, this species has played an important economic role in the Malaysian fisheries sector because they have a fast growth rate, a wide area suitable for growing the cockles, easy farm management, and naturally abundant supply of seed or
known as cockle spat. However, based on the annual report by the Department of Fisheries, the general production trend of *T. granosa* in Malaysia is constantly decreasing since 2010 especially in Selangor but fluctuated patterns were reported in Johor [4]. The decreasing scenario was also reported in earlier years such as in the 1970s and 1986 due to a number of constraints including overharvesting and environmental deterioration [2]. An intensive investigation was done in recent years in battling the issues of low production and mass mortality especially in Selangor [5, 6, 7, 8]. The potential reasons identified in the latter years were due to the health condition of *T. granosa*, prey-predator relationship, parasitic effect, and pollution of land and water [5, 6, 9].

Despite the issues that shackled the *T. granosa* cultivation in Malaysia and the potential factors reported in the literature, something of interest is the continuous supply of *T. granosa* spat in Selangor regardless of the low yield production. This leading to several hypotheses such as either the environmental stressor interrupt the *T. granosa* growth and incomplete development of the gonad. Thus, the spawning season will less likely to occur, and consequently decreasing the population of blood cockle. Another hypothesis is, *T. granosa* reaches early maturity before their age, have high chances of spawning and fertilization rate as a reaction to environmental stressors. However, the spat or offspring produced due to this circumstance is expected to have low quality, thus leading to a low survival rate.

Knowledge of the reproduction cycle of *T. granosa* and their interaction with the environment was reported affected by the interaction between internal physiological factors and phytoplankton abundance as observed among *T. granosa* from the northern part of the Straits of Malacca (Penang, Malaysia, Banda Acheh and Lhokseumawe, Indonesia [1]. The same report stated other environmental stressors such as dissolved oxygen, nitrite, ammonia and turbidity variables have a diverse and complex effects on the reproduction cycle of *T. granosa* depending on the locality of the population [1]. Since the earlier report addressing population from different parts of the Strait of Malacca and receiving water from the Andaman Sea, their findings have limitation to represent the condition for *T. granosa* at much narrower area of the Strait of Malacca such as at Selangor.

In addition limited data addressing the current reproductive status and the health status of *T. granosa* [7, 8]. Integration of the gonad indices from badly affected farms with the health status of the organism will facilitate in understanding how the environmental stressors affect the organism, and how likely it will affect the gonad indices. Investigation of the health status of gill filaments and the gonad condition would serve as complete information to support the hypothesis. Therefore, this study aims to provide insight knowledge on the potential reason for low *T. granosa* production in Sungai Buloh Selangor by comparing the condition indices and histology of the gills and gonad with samples from a high yield farm at Sungai Ayam, Johor.

2. Method

2.1 Sampling Site

Sampling works were done in the middle of September 2020 at selected farm in Sungai Buloh, Selangor which is a representative of low yield farm in Selangor, and from Bagan Sungai Ayam, Johor as the reference site with high yield of *T. granosa* production (Figure 1). The coordinates for the sampling sites are 3°15’02.4”N 101°17’41.8”E for Sungai Buloh, Selangor and 1°44’54.8”N 102°55’39.7”E for Sungai Ayam, Johor.

2.1.1 Sampling Work

Samples of *T. granosa* were collect using hand dredge net of 1.5 cm mesh. A total 200 live *T. granosa* samples were collected with 100 individuals from each site. Samples were immediately transported alive to the laboratory in Universiti Putra Malaysia on the same date.
2.2 Morphometric Analysis

The morphometric techniques was carried out to identify the shell width, shell thick, shell height, total body weight, and empty shell weight. The shell thick, width, height and ridge were measured using a pair of Vernier calipers (±0.05 mm). Shell weight, total body weight, and fresh gonad weight was measured using an analytical balance (±0.01 g). The identification of morphological features of *T. granosa* are based on features shown in Figure 2.

**Figure 2.** (a) External appearance of *T. granosa* indicating the shell width, height, and shell thick. (b) Internal features of *T. granosa* indicating the mantle, foot, visceral mass, and gills. (c) Internal features of *T. granosa* indicating the posterior and anterior.
2.3 Histology
Twenty live individuals from each site were randomly selected, washed, and dissected. Gills and visceral mass were separate and preserved in Bouin's solution, followed by histological analysis for optical observation according to the standard histological procedures. Preserved samples were embedded in paraffin wax, followed by tissue sectioning into 5-10 µm thickness using a microtome, stained using Ehrlich’s hematoxylin, and counterstained with Eosin [10]. Each tissue section was examined at 100 and 400 magnification under a light microscope. The gill’s tissue structures were monitored according to [11, 12]. Identification of the sex and gametogenesis stages was based on the developmental stage of the ovary and testis [1, 13]. Particular description of each gametogenesis stages referred in this study is given in Table 1.

| Stages                        | Female                                                                                   | Male                                                                                     |
|-------------------------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Stage 1 (indeterminate)       | Undeveloped gonad’s content, no sign of testis nor ovary as the organ filled with connective tissues. | Gonad contain spermatogonia, spermatocyte, and a small quantity of spermatooza.           |
| Stage 2 (developing)          | Gonad contain multiple sizes and irregular shapes of Oocytes, presence of oogonia, vitellogonia oocyte and the nuclei of vitellogenic oocytes have uneven shapes. | Gonad contain spermatogonia, spermatocyte, and a small quantity of spermatooza.           |
| Stage 3 (developed or ripe)   | Mass presence of vitellogenic oocytes with a visibly large nucleus. Lumen space filled by the polyhedral shape of vitellogenic oocyte that detached from the follicle wall. The cytoplasm of the oocytes filled by a number of yolk granules. | Gonad filled with spermatooza, scarce number of spermatogonia and typically found on the side wall of the follicle. Inter follicular space experiencing constriction. |
| Stage 4 (spawning)            | The lumen contain post-vitellogenic oocytes with large, light nucleus and small basophilic nucleolus. | Loose and abundant connective tissue surrounding partially emptied acini, lumen mainly filled with mature spermatoozo |
| Stage 5 (spawned)             | Presence of residual oocytes and phagocytes. Empty follicle wall with sign of alteration. | Empty follicle with scarce number of spermatooza. No presence of spermatogonia.           |

2.4 Condition Indexes
The gonadosomatic index formula used in this study is by calculating the gonad mass of the total body mass [1]. Each sample was dissected, the visceral mass was removed from other flesh, and oven-dried at 60°C for 72 hours. Dried samples including empty shell were weighed using digital balances. The condition indices (CI) selected in this study were total condition index (CI\_Tot), visceral mass condition index (CI\_Vm), and Remaining soft tissues condition index (CI\_R). Each index was calculated and recorded using the following equation [16]

\[
CI_{\text{Tot}} = \left( \frac{DFW}{DshellW} \right) \times 100
\]

\[
CI_{\text{Vm}} = \left( \frac{DVMW}{DshellW} \right) \times 100
\]

\[
CI_{R} = \left( \frac{DRW}{DshellW} \right) \times 100
\]

Where \( CI_{\text{Tot}} \) is Total condition index, \( CI_{\text{Vm}} \) is visceral mass condition index, \( CI_{R} \) is the Remaining soft tissues condition index, DFW is the Dry Flesh Weight, DVMW is the Dry Visceral Mass Weight, DRW is the Dry Rest Weight and DshellW is the Dry shell Weight.
2.5 Statistical Analysis
Identification of the normal distribution of the dataset was conducted using Shapiro-Wilk Test. The variation of morphometric data and condition indexes was done using Mann Whitney U test, and Spearman’s correlation was performed to determine the relationship between biological attribute measurements within the population, and between the condition indexes.

3. Results and Discussion
3.1 Histological analysis
Determination of the reproductive status and the health status of *T. granosa* were done by comparing the histological analysis of the gonad and gills in sample from the badly affected farms with a reference farm. Knowledge on the health status of the organism as well the gametogenesis stages will facilitate in understanding how the environmental stressors affect the gonad indices and the organism.

3.1.1 Gonad Histology Analysis.
Identification of the gametogenesis stages was based on the developmental stage of the ovary and testis [1, 13]. The gonad of males *T. granosa* from both sites was found with gametogenesis stages between Stage 2 (developing) and Stage 3 (developed or ripe) stages in each testicular acinus. Stage 2 was identified based on the presence of spermatogonia, spermatocyte, and a small quantity of spermatozoa in the testicular acinus (Figure 3). Stage 3 was identified as the gonad filled with spermatozoa, scarce number of spermatogonia, spermatocytes and spermatid that typically found on the side wall of the follicle. Inter follicular space experiencing constriction. Description of each gametogenesis stages identified in the testis were shown in Table 2. The ovaries of samples from Sungai Buloh were found with maturity stages between ripe to spawning stages, while ovaries in samples from Sungai Ayam were found with developing to spawning stages (Figure 4). Description of each gametogenesis stages identified in the ovaries were shown in Table 3. Based on the histological observations, findings indicated sample in Sungai Buloh reached early spawning as the main spawning period was reported from November to March [7]. The gametogenesis stages identified in this study were comparative with the gonad maturity level *Anadara inaequivalvis* from Banjar Kemuning River, Sedati, Sidoarjo Indinesia [14]. Studies on the histology of gonad show the percentages of the sex ratio were identical between both genders (50%:50% male to female) in samples from Sungai Ayam, while a higher number of females (60%) as compared to the male (40%) in samples from Sungai Buloh (Figure 5). Thus suggesting each individual in Sungai Ayam has its own pair therefore has higher chances of successful fertilization during spawning as compared with the sample in Sungai Buloh, Selangor. Equal gender distribution is another factor to support the fertilization other than availability of food and additional environmental conditions [15].

| Site                | Total weight (g) | Stages                          | Male                                                                 |
|---------------------|------------------|---------------------------------|----------------------------------------------------------------------|
| P1                  | 2 – 3            | Stage 2 (developing)            | Gonad contain spermatogonia, spermatocyte, and a small quantity of spermatozoa. |
| Sungai Ayam, Johor  | 3 - 4            | Stage 3 (developed or ripe)     | Gonad filled with spermatozoa, scarce number of spermatogonia and typically found on the side wall of the follicle. Inter follicular space experiencing constriction. |
| P2                  | 2 - 3            | Stage 2 (developing)            | Gonad contain spermatogonia, spermatocyte, and a small quantity of spermatozoa. |
| Sungai Buloh, Selangor | 3 - 4         | Stage 3 (developed or ripe)     | Gonad filled with spermatozoa, scarce number of spermatogonia and typically found on the side wall of the follicle. Inter follicular space experiencing constriction. |
Figure 3. Gonadal structure of male *Tegilarca granosa* based on histological section stained with haematoxyline and eosin: (a) Stage 2 (Developing); (b) Stage 3 (Developed or ripe). FW: follicle wall; Lu: lumen; Spz: spermatozoa; Ss: Spermatocytes; Sd: spermatid; Sg: Spermatogonia.

Figure 4. Gonadal structure of female *Tegilarca granosa* based on histological section stained with haematoxyline and eosin: (a) Stage 2 (Developing); (b) Stage 3 (Developed); (c) Stage 4 (Spawning).

Abbreviations: FW: follicle wall; Lu: Lumen; EVO: early stage of vitellogenic oocyte; LVO: late stage of vitellogenic oocyte; MO: mature oocyte; Ni: nucleus; Og: Oogonia, FF: follicle fragment; EF: empty follicle; RO: residual oocyte; IS: interfolicular space; YG: yolk granule.
Table 3. Histological features of each gametogenesis stages in female T. granosa [1, 13].

| Site                | Total weight (g) | Stages                      | Female                                                                 |
|---------------------|------------------|-----------------------------|------------------------------------------------------------------------|
| P1 Sungai Ayam, Johor | 2 – 3            | Stage 2 (developing)        | Gonad contain multiple sizes and irregular shapes of Oocytes, presence of oogonia, vitellogonia oocyte and the nuclei of vitellogenic oocytes have uneven shapes. |
|                     |                  | 3 - 4 Stage 3 (developed or ripe) | Mass presence of vitellogenic oocytes with a visibly large nucleus. Lumen space filled by the polyhedral shape of vitellogenic oocyte that detached from the follicle wall. The cytoplasm of the oocytes filled by a number of yolk granules. |
| P2 Sungai Buloh, Selangor | 2 - 3            | Stage 3 (developed or ripe) | Mass presence of vitellogenic oocytes with a visibly large nucleus. Lumen space filled by the polyhedral shape of vitellogenic oocyte that detached from the follicle wall. The cytoplasm of the oocytes filled by a number of yolk granules. |
|                     |                  | 2 - 3 Stage 4 (spawning)    | The lumen contain post-vitellogenic oocytes with large, light nucleus and small basophilic nucleolus. |

Figure 5. Sex percentages between sampling site.

3.1.2 Gills filament Histology Analysis.

Tissues structure of gill filaments identified in this study are shown in Figure 6. Histology of the gills was divided into three sections, the basal zone (BZ) that connect the filament with gill’s arch, intermediate zone (IZ) and the frontal zone (FZ) [11]. Healthy gills are identified by distinctive lateral and frontal cilia and the gill filament appears in an almost square shape in one direction [12]. The same gills condition was observed in the sample taken from Sungai Ayam in the year 2018 [9]. Meanwhile, unhealthy gills were identified by presence of thin gill filaments, limited or absent of haemocytes, and not intact of epithelium cell (Figure 6). The poor gill’s filament condition were referred to the study of Cu exposure and the stated symptoms were identical [12]. Similar degenerated gill filament were reported in T. granosa taken from sungai Buloh in the year 2018 [9]. Based on the histology of gill’s filament, 60% of the individuals from Sungai Buloh have degenerates gill filament, meanwhile only 20% of samples from Sungai Ayam, observed with the poor filament’s condition. The potential reason of the poor gill condition is suspected due to high cell death either by necrosis or apoptosis in responds to the pollutants [12]
Figure 6. Gill’s filament structure of *Tegilarca granosa* based on histological section stained with haematoxyline and eosin: (a) thick and hemocytes filled filaments in sample from Sungai Ayam, (b) degenerated thin and empty filaments in sample from Sungai Buloh, (c) close up basal zone of thick filament filled with hemocytes in sample from Sungai Ayam, (d) close up basal zone of empty thin filament in sample from Sungai Buloh, (e) close up intermediate zone of thick filament filled with hemocytes in sample from Sungai Ayam, (f) close up intermediate zone of empty thin filament in sample from Sungai Buloh, (g) close up frontal zone of thick filament filled with hemocytes in sample from Sungai Ayam, (h) close up frontal zone of degenerated filament in sample from Sungai Buloh.

Abbreviation: DHF: Dilated Haemocytes-filled Filament, E: Epithelium, FZ: Frontal Zones, H: Hemocytes, HF: Hemocytes-filled Filament, IZ: Intermediate Zones, TEF: Thin-Empty Filament.

### 3.2 Biological Attributes

The average of all biological attributes measured in the samples from Sungai Buloh and Sungai Ayam are shown in Figure 7. The range value of whole body with shell weight in sample from Sungai Buloh and Sungai Ayam is within the range 3.1 – 7.2 g, and 1.5 – 15.8 g. Other identified measured weight are between 1-3 g and 1 - 4.75 g for whole flesh, 0.37 - 1.53 and 0.4 - 2 g for wet gonad, 1.6 - 6.6 g and 3.3 - 8.7 g of dried empty shell. The shell width was in the range 13.2 - 18.5 and 13.6 - 28.2 mm for Sungai Buloh and Sungai Ayam, The shell height are in the range 21 – 30.1 mm and 16.5 -37.1 mm, and shell thickness was in the range 15.8 -22.7 and 16 -29.6 mm in sample from Sungai Buloh and Sungai Ayam. Variation of the measured biological attributes between the two populations were done using the Mann Whitney U test. The difference between the randomly selected values of gonad wet weight between Sungai Buloh and the Sungai Ayam populations is significantly different at p < 0.05. Similar findings were found for shell width, shell height, and weight of dried shell between the two sites. Meanwhile no significantly differences observed for other parameters such as weight of whole body with shell, total flesh weight, and shell thickness between Sungai Buloh and the Sungai Ayam populations. The biological attributes were compared with sample collected in year 2018, and
findings contradicted as the previous study found sample from Sungai Ayam are rather smaller than sample from Sungai Buloh [9]. In this study, sample from Sungai Ayam either have higher measurement or identical value for all measured parameters.

Figure 7. Average measurement of the biological attributes (weight of whole body with shell, total of wet flesh, wet gonad, dried empty shell, and length of the shell width, height and thickness) of *T. granosa* between Sungai Buloh and Sungai Ayam

3.3 Condition Indices

There are numerous methods available for calculating the condition index, some formulas use the fresh weight and the others use dry weight. The condition indexes were accessed using dry weight to minimize interference due to water retention in the fresh tissue and bias in the weight measurement [16]. Therefore, the association between shell height, width, and thickness with dried indices within samples from Sungai Buloh are shown in Table 4 while the relationship among samples in Sungai Ayam was shown in Table 5. Results show the association between the variables was between middle to a strong relationship except for shell width and shell thickness in each population. Thus, indicating both samples of *T. granosa* in Sungai Ayam and Sungai Buloh that have heavier dried flesh weight tend to have heavier visceral mass, heavier dried remaining tissue and have higher shell height. The strong high association between each variable suggesting a low variation of sex between the sample populations.

Table 4. The correlation matrixes that show the biological attributes relationship of the *T. granosa* in Sungai Buloh, Selangor.

|                     | Dried flesh (g) | Dried visceral (g) | Dried rest (g) | Dried shell (g) | Shell height (mm) | Shell width (mm) | Shell thickness (mm) |
|---------------------|----------------|--------------------|----------------|----------------|-------------------|------------------|---------------------|
| Dried flesh (g)     | 1              |                    |                |                |                   |                  |                     |
| Dried visceral (g)  | 0.91559*       | 1                  |                |                |                   |                  |                     |
| Dried rest (g)      | 0.3962*        | 0.30282*           | 1              |                |                   |                  |                     |
| Dried shell (g)     | 0.81604*       | 0.79269*           | 0.51844*       | 1              |                   |                  |                     |
| Shell height (mm)   | 0.84891*       | 0.80268*           | 0.48205*       | 0.87735*       | 1                 |                  |                     |
| Shell width (mm)    | -0.01424       | 0.04421            | 0.1662         | 0.11074        | 0.09188           | 1                |                     |
| Shell thickness (mm)| -0.16496       | -0.09381           | -0.06797       | -0.09076       | -0.10321          | 0.47017*         | 1                   |

*Note * significant at p < 0.05
Table 5. The correlation matrixes that show the biological attributes relationship of the *T. granosa* in Sungai Ayam, Johor.

|                | Dried flesh (g) | Dried visceral (g) | Dried rest (g) | Dried shell (g) | Shell height (mm) | Shell width (mm) | Shell thickness (mm) |
|----------------|-----------------|--------------------|---------------|-----------------|-------------------|-------------------|---------------------|
| Dried flesh (g)| 1               |                    |               |                 |                   |                   |                     |
| Dried visceral (g) | 0.74382*          | 1                  |               |                 |                   |                   |                     |
| Dried rest (g)     | 0.78234*          | 0.55587*          | 1            |                 |                   |                   |                     |
| Dried shell (g)     | 0.8012*           | 0.61068*          | 0.78136*     | 1               |                   |                   |                     |
| Shell height (mm)  | 0.8003*           | 0.59012*          | 0.77298*     | 0.81758*        | 1                 |                   |                     |
| Shell width (mm)   | -0.05891          | 0.01754           | -0.0056      | -0.00814        | -0.06938          | 1                 |                     |
| Shell thickness (mm)| -0.04261         | -0.02096          | 0.01398      | 0.05056         | -0.00429          | 0.81*             | 1                   |

Note * significant at p < 0.05

Association between condition indexes within the sample population were shown in Table 6 for Sungai Buloh and Table 7 for sample from Sungai Ayam, Johor. In general, both population sample shows a strong association between the total condition index (CITot) and visceral mass condition index (CIVm) and no significant association with the remaining tissue condition index (CIR). Since gonad of *T. granosa* are disseminates in the visceral mass, therefore, with increasing gonadal developmental stages directly influence the visceral mass and total flesh thus led to rising in condition index, whereas the reduction of mass indicates gamete discharging [16].

Table 6. The correlation matrixes that show the condition indexes relationship of the *T. granosa* in Sungai Buloh, Selangor.

|                | CI R | CI Tot | CI Vm |
|----------------|------|--------|-------|
| CI R           | 1    |        |       |
| CI Tot         | 0.0836 | 1      |       |
| CI Vm          | -0.165 | **0.7172*** | 1   |

Note * significant at p < 0.05

Table 7. The correlation matrixes that show the condition indexes relationship of the *T. granosa* in Sungai Ayam, Johor.

|                | CI R | CI Tot | CI Vm |
|----------------|------|--------|-------|
| CI R           | 1    |        |       |
| CI Tot         | 0.3399 | 1      |       |
| CI Vm          | 0.0252 | **0.7021*** | 1   |

Note * significant at p < 0.05

The Mann Whitney U test analysis of the condition indexes between samples from both farms is shown in Figure 8. There is significantly different between the median value of total condition index (CITot) among sample from Sungai Buloh and the Sungai Ayam (p < 0.05), meanwhile no significant differences observed for visceral mass condition index (CIVm) and remaining soft tissues condition index (CIR) between the two populations. Based on the significant differences of total condition index (CITot), this strongly suggest other factors rather than volume of gonad alone that are affecting the mass of *T. granosa*. Meanwhile no variation of visceral mass condition index (CIVm) between the two sites is a sign of low sex variation of *T. granosa* between the two populations.

Figure 8. Median measurements of total condition index (CITot), visceral mass condition index (CIVm), and remaining soft tissues condition index (CIR) identified in *T. granosa* between Sungai Buloh and Sungai Ayam.
3.4 Tegillarca granosa Health Status

Results of the condition index is supporting the histological analysis of the gonad identified in T. granosa from Sungai Buloh and Sungai Ayam. Low variation of sexes, and the animal in the stage of intense growing for spawning season. Sample from Sungai Boloh was found with spawning stage (Stage 4) even though it is a bit earlier than the spawning season as it was reported between Novembers to March [7]. The discovery of 2 g-sized T. granosa with ovaries reaching the spawning stage gives a sign of two possibilities either the T. granosa in Sungai Boloh undernourished due to low food availability that limits the animals to grow bigger size, or that the environmental conditions result in the T. granosa reaching early reproductive maturity before their age. Higher T. granosa with poor or degenerate gill filament in Sungai Buloh as compared with Sungai Ayam suggesting, sample in Sungai Buloh was suffering from exposure to a polluted environment containing a high level of heavy metal and biocides [12, 17, 18], in addition to the extreme variation of salinity and turbidity [19]. These unpleasant environmental conditions expected lead the animals to have early gonad maturity stages and smaller in size thus answer the reason for continued supply of T. granosa spat but low survival in the vicinity of Sungai Buloh, Selangor. Sample from Sungai Ayam were found with optimum sizes, good gill filament condition and gonad in the growing stages thus indicating the population are healthy living in the nourishing environment.

4. Conclusion

Findings on the histology of the gonad and gill filaments along with the condition indices suggesting environmental stressor at Sungai Buloh potentially affecting the health of the gills as well as the size of T. granosa reaching breeding maturity. The sign and symptoms presented in this work revealed the reason of low yield production in the study area.

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