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Sperm Quality and Fecundity of Glass Carp (*Cyprinus carpio*) Strain Produced in the Rainy and Dry Seasons

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Abstract: Carp (*Cyprinus carpio*) is one of the most widely cultivated freshwater fish species worldwide. *C. carpio* is increasingly widespread with the presence of the *C. carpio* glass strain. This fish farming is inseparable from the influence of the season. The purpose of this study was to determine the sperm quality and fertility of glass carp strain produced in the rainy season and dry season. The method used in this research is descriptive. This research was conducted for 3 months (April - June 2024). Samples of glass strain carp *C. carpio* broodstock and research carried out at the Punten Aquaculture Fisheries Installation (IPB), with a total of 12 broodstock (6 males and 6 females with body size between 25-30 cm). The results showed that the sperm of *C. carpio* glass strain fish produced in different seasons showed different quality. The best sperm quality was produced in the rainy season with motility (70.44%), concentration (26.75 X 109 cells/ml), and viability (79.81%). However, the rainy season produced the highest abnormality (5.53%). Fecundity of *C. carpio* glass strain fish was highest in the rainy season reaching 10,875 grains. Further research is needed to determine the success of carp larvae in different seasons.

Keywords: *C. carpio*; Fecundity; Season; Sperm

Introduction

Several species in the Cyprinidae family contribute about 50% to the total production of finfish aquaculture in the world (Sotnikov et al., 2023). One of these fish species is the carp (*Cyprinus carpio*). In 2018, it accounted for 7.7% of global fish production (FAO, 2020). As a result, *C. carpio* ranks among the most widely cultivated freshwater fish globally, offering significant economic benefits (Tessema et al., 2020; Yaqoob, 2021). This species is native to Eastern Europe and Central Asia and is known for its adaptability to a wide range of water quality conditions (Andarz et al., 2022). It is widely consumed in various countries around the world (Xu et al., 2019). *C. carpio* are widely distributed in nutrient-rich freshwater ecosystems, such as lakes and large rivers in Europe and Asia (Piria et al., 2016). In their natural habitat, these fish are able to survive in environments with very cold water temperatures and low or very high dissolved oxygen levels (Rahman, 2015). Goldfish are known as an omnivorous species that consume animal food sources, such as aquatic insects, macro invertebrates, and zooplankton, as well as plant material, such as phytoplankton and aquatic plants. The species has a rapid growth rate, reaching sexual maturity at two years of age (Hossain et al., 2016).

C. capio farming in Indonesia began in the mid-19th century in the Galuh region of Ciamis, West Java. After the Ministry of Agriculture established the Jawatan Perikanan Darat in the early 20th century, the spread of carp expanded to various regions in Indonesia (Arisuryanti & Wibowo, 2016). In 1927, the Inland Fisheries Jawatan began importing goldfish strains from the Netherlands, including the Galician strain goldfish (known as elephant goldfish), followed in 1930 by the Franciscan strain (grass carp). Both strains were in high demand by breeders at the time due to their tasty, dense

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meat and fewer spines, in addition to faster growth than local strains that had been developed earlier.

Understanding fish reproductive biology is key to sustainably utilizing fish stocks and increasing their productivity (Lorenzen et al., 2016). This understanding provides a strong scientific basis to support effective management of fisheries resources (Hossain et al., 2017; Khatun et al., 2019). Fish reproductive success is influenced by various environmental factors that tend to fluctuate throughout the seasons (Lowerre-Barbieri et al., 2017). Seasonal changes affect changes in temperature, photoperiod, water quality, and food availability, which have a direct impact on physiological processes that trigger gametogenesis in fish (Suquet et al., 2016; Pratiwi et al., 2023). These external conditions greatly influence the quality of eggs and sperm produced, as they affect maturation, viability, and fertilization success (Aramli et al., 2014; Canosa & Bertucci, 2023). Several studies revealed that sperm motility parameters fluctuate during the spawning season in various species such as tilapia (*Oreochromis mossambicus*) (Kruger et al., 1984), rainbow trout (*Oncorhynchus mykiss*) (Munkittrick & Moccia, 1987), and barbel (*Barbus barbus*) (Alavi et al., 2008). Similar research has never been conducted on this species of fish, so the information generated in this study is very much needed in supporting the success of glass-starved *C. carpio* cultivation. The purpose of this study was to determine the sperm quality and fecundity of glass carp strains produced in the rainy season and dry season.

Method

This study was conducted for 3 months (April - June 2024), representing the rainy season and dry season. Samples of glass strain *C. carpio* broodstock and research were conducted at the Punten Aquaculture Fisheries Installation (IPB), with a total of 12 broodstock consisting of 6 male fish and 6 female fish, each having a body size between 25 to 30 cm. Observations were made on the quality of *C. carpio* strain glass fish (motility (%), concentration (cells/ml), viability (%), and abnormality (%)), fecundity and water quality.

Sperm motility was measured by taking a 0.01 ml sperm sample, which was then diluted with 0.1 ml Physiological NaCl solution. After that, the sperm sample was placed on a glass object and observed under a microscope with 400 times magnification. Sperm motility measurements were carried out as done by Muthmainnah et al. (2019), namely:

$$\text{Motility}=\frac{\text{Number of motile sperm}}{\text{Number of sperm observed}}\ x\ 100\% \quad (1)$$

Sperm concentration was calculated using a hemocytometer. A total of 0.01 ml of sperm was mixed with 0.1 ml of PBS solution in a glass beaker. Homogenization was carried out by repeatedly pulling and removing the mixture using a micropipette. After mixing evenly, 0.01 ml of the solution was dripped onto a Neubauer hemocytometer consisting of nine boxes. Sperm counting was performed under a microscope at 400 times magnification as done by Urabi et al. (2019):

$$\text{Sperm concentration}\ \frac{\text{million}}{\text{ml}} = n\ x\ k\ x\ FP\ x\ 10^4 \quad (2)$$

Description:
N : Number of sperm in 5 boxes
K : Number of boxes counted (5 boxes)
FP : Dilution factor (50)
10^4 : *Haemocytometer* chamber volume coefficient

To calculate sperm viability, 0.01 ml of sperm was dripped onto a glass slide, then eosin-negrosin solution was added near the sperm-drop. After that, the mixture was stirred until homogeneous and observed using a microscope with 400 times magnification. Sperm viability was calculated as done by Mangkunegara et al. (2019):

$$\text{Viability}=\frac{\text{Number of live sperm}}{\text{Number of dead sperm}}\ x\ 100\% \quad (3)$$

Observation of sperm abnormality is carried out in conjunction with viability evaluation using a microscope with a magnification of 400 times, aiming to assess sperm quality based on its morphology. Sperm that have normal morphology generally consist of three main parts: head, body, and tail. The percentage of abnormal sperm was calculated as done by Akbar et al. (2015):

$$\text{Abnormality}=\frac{\text{Number of abnormal sperm}}{\text{Number of sperm counted}}\ x\ 100\% \quad (4)$$

The fecundity of *C. carpio* glass strain was calculated using a gravimetric approach as done by Sinaga et al. (2023):

$$F = \frac{Bg}{Bs} \quad (5)$$

Description:
F : Total number of eggs (grains)
Bg : Weight of the whole gonad (g)
Bs : Weight of some gonads (g)

Rainfall data observations were obtained from the meteorological, climatological and geophysical agency (BMKG) Batu City (https://dataonline.bmkg.go.id). Water quality parameters monitored include temperature, pH, and dissolved oxygen (DO) levels.

Measurements were taken in the morning at 07.00 and in the afternoon at 16.00.

Data Analysis

The data obtained were analyzed using Microsoft Excel. To determine the effect of the treatment given, ANOVA analysis was carried out, which was then continued with the Duncan test using the SPSS version 26 application.

Result and Discussion

Sperm Quality

Spermatogenesis and final maturation of sperm in fish are influenced by the hypothalamic-pituitary-gonadal (HPG) system, where the hypothalamus controls gonadotropin secretion from the pituitary via gonadotropin-releasing hormone (GnRH). GnRH has an important role in fish reproduction, serving as a key neuropeptide that integrates various internal and external factors (Kowalski & Cejko, 2019). The sperm quality of *the C. carpio* glass strain fluctuates based on the season. Seasonal fluctuations in sperm quality have been observed in various fish species that have annual reproductive cycles (Cejko et al., 2018). In *C. carpio*, sperm production peaks between July and August (Koldras et al., 1990), with temperature being one of the main factors affecting the maturation and reproductive behavior of this species (Tessema et al., 2020; Chizinski et al., 2016; Banet et al., 2022).

The sperm obtained in this study through stripping was milky white with a distinctive aroma, and the volume varied from 1.9 ml to 4 ml. Overall, the results showed that the quality of *C. carpio* strain glass sperm produced in the rainy season was better than that produced in the dry season (Table 1).

Table 1. Sperm Quality of *C. carpio* Glass Strain

Sperm quality	Rainy season	Rainy season
Motility (%)	70.44	70.56
Concentration (cells/ml)	26.75 X 10^9	20.08 10^9
Viability (%)	79.81	76.28
Abnormality (%)	5.53	4.86

Sperm motility is one of the key factors in assessing sperm quality, this is because it reflects the ability of sperm to move and reach the egg in the fertilization process. The higher the level of motility, the better the potential reproductive outcomes that can be achieved (Judith Betsy et al., 2016; Zhang et al., 2022). The results of the research conducted showed that the sperm motility of *the C. carpio* glass strain was 70.44% (rainy season) and 70.54% (dry season) (Table 1). The percentage of motility that is more than 70% is considered an indicator that the sperm has good quality. Research conducted by Dewi et al. (2023) also showed that sperm with motility of more than 70% can be effectively used for short-term storage, which emphasizes the importance of this level of motility in maintaining sperm viability and function during the storage process. Sperm motility is essential for successful fertilization, but its duration is relatively short, usually lasting only a few minutes (Özgür, 2019). Factors such as ion composition and pH of the ambient medium strongly influence sperm motility, thus impacting the number of effectively viable sperm (Cejko et al., 2018).

Sperm motility is currently recognized as one of the most reliable biomarkers for assessing sperm quality in fish (Mylonas et al., 2017). There is a significant relationship between sperm motility and fertilization and hatching success rates in certain fish species (Gallego & Asturiano, 2018). The low motility of *C. carpio* may be triggered by oxidative stress. This can trigger cellular aging and reduce sperm quality. Fish sperm cells are highly susceptible to oxidative damage because, in the late stages of spermiogenesis, most of the cytoplasm is lost. This leads to a lack of enzymes needed to fight the damage caused by reactive oxygen species (ROS) (Merino et al., 2017; Sandoval-Vargas et al., 2020; Shaliutina-Kolešová & Nian, 2022). Oxidative stress occurs when the amount of ROS exceeds the antioxidant defense capacity of an organism, which can ultimately reduce sperm quality (Ulloa-Rodríguez et al., 2018). In normal cells, it is estimated that about 2% of oxygen is converted to ROS. In the male reproductive system, sperm cells produce relatively high amounts of ROS due to their aerobic metabolism. Aquatic animal sperm cells are more susceptible to oxidative damage due to weak antioxidant defenses and the high content of polyunsaturated fatty acids in their membranes (Merino et al., 2020; Pintus & Ros-Santaella, 2021). Polyunsaturated fatty acids are known to play a significant role in causing cellular dysfunction when exposed to oxidative stress, and their impact on fish is usually assessed through TBARS measurements (Shaliutina-Kolešová et al., 2014). The motility rate was almost the same in this study (70.44% rainy season) and (70.56% dry season) (Table 1) due to the fact that the environmental conditions in the two seasons were not very different. Studies have also shown that sperm plasma composition, particularly calcium (Ca^{2+}) and potassium (K^+) ions, have a significant influence and are known to play a major role in activating sperm motility in Cyprinidae. The optimal concentration required for Ca^{2+} was reported to be around 50 mM (Liu et al., 2018).

The results showed that there were differences in sperm concentration between the rainy season and the dry season. In the rainy season, the sperm concentration was higher, reaching 26.75 x 10^9 cells/ml, while in the dry season, it only reached 20.08 x 10^9 cells/ml (Table 1). Cheng et al. (2021) also showed that the best quality sperm samples were produced at the peak of the spawning season, where hormonal stimulation can increase sperm volume by five to ten times. Kruger et al. (1984) also showed that the sperm concentration of *C. carpio* decreased significantly in late spring, which was about 1.6 × 10^6 mm-^{3}, compared to early spring, which reached 8.2 × 10^6 mm-^{3}. This difference is thought to be due to the sperm hydration process during the late stage of maturation. Christ et al. (1996) also showed that the sperm volume of *C. carpio* reached its peak during the breeding season (May-June), with a range of 5.5-6.5 ml kg-^{1}, but reduced drastically to 2.8-3.0 ml kg-^{1} in the early maturation phase (March).

C. carpio glass strain has the highest sperm concentration among cyprinids, with a range of 16-30 × 10^9 spermatozoa/mL, while tench (*Tinca tinca*) has the lowest sperm concentration, which is about 3.3 × 10^9 spermatozoa/mL (Kowalski & Cejko, 2019). In teleosts, Eurasian perch (*Perca fluviatilis*) and turbot (*Psetta maxima*) were recorded to have the highest sperm concentration, reaching 70 × 10^9 spermatozoa/mL (Piironen & Hyvärinen, 1983), while perch (*Sander lucioperca*) showed a concentration of about 30 × 10^9 spermatozoa/mL. Sperm production, including volume, is influenced by various factors such as hormones and seasonality. The sperm volume of *C. carpio* is significantly higher in May compared to June Juni (Cejko et al., 2014).

Reproductive success in aquatic species is strongly influenced by fish sperm viability. The results showed that fish sperm viability is strongly influenced by the season. The study showed that the viability of *C. carpio* sperm was 79.81% (rainy season) and 76.28 (dry season) (Table 1). Fish sperm is said to have good viability if the percentage of live sperm exceeds 70% (Condro et al., 2012). The results also showed that during the rainy season, environmental conditions were most favorable for the survival of *C. carpio* offspring.

Seasonal differences in sperm abnormality in goldfish are low, ranging from 5.53% (rainy season) and 4.86 (dry season) (Table 1). The percentage value of abnormality in the rainy season is higher than in the dry season; this is thought to be due to rainwater runoff can carry pollutants such as pesticides and heavy metals into the water, which can harm sperm development. This is thought to occur because the research location is close to agricultural activities (Karim et al., 2022). Sumarmin (2016) also found that the sperm abnormality rate of 5% did not show a significant effect. The lower the abnormality rate, the better the quality. The increase in the number of abnormal larvae is also influenced by external environmental conditions, including water quality, temperature, oxygen levels, carbon dioxide, ammonia, and the strength of the water current used during the hatching process. Massar et al. (2011) also showed that *C. carpio* living in polluted lakes exhibited poor differentiation of the sperm head and neck and shortening of the sperm tail. Aberkane et al. (2022) also showed a significant decrease in sperm parameters such as straightness and linearity in barbel when sperm were activated in polluted water. Pizzol et al. (2021) also showed that pollutants can act as endocrine disruptors, causing impaired spermatogenesis and reproductive problems. Exposure to heavy metals also negatively affects sperm quality, fertilization rates, and embryo and larval survival (Gárriz & Miranda, 2020). In general, the results of this study on sperm quality are in accordance with research conducted by Kowalski et al. (2019). The study showed that the best quality of *C. carpio* sperm was produced in the spawning season (rainy season) and then decreased gradually as the season progressed.

Fecundity

Rainfall also impacts water temperature, which is also an important factor in supporting *C. carpio* reproduction. This species is known to spawn when water temperatures increase, usually in response to seasonal changes triggered by rainfall (Shahbaz et al., 2022). Research conducted by Tessema et al. (2020) showed that abundant rainfall, along with temperature, is able to increase the abundance of food sources such as plankton, macrophytes, and detritus, which in turn can stimulate *C. carpio* spawning in Hayq Lake. The combination of temperature and rainfall can also form a dynamic environment, which may enhance or hinder reproductive success depending on the intensity and timing of rainfall. Higher water temperatures, together with sufficient rainfall, can increase spawning productivity, while extreme weather conditions can have a negative impact (Kuchikhin et al., 2022).

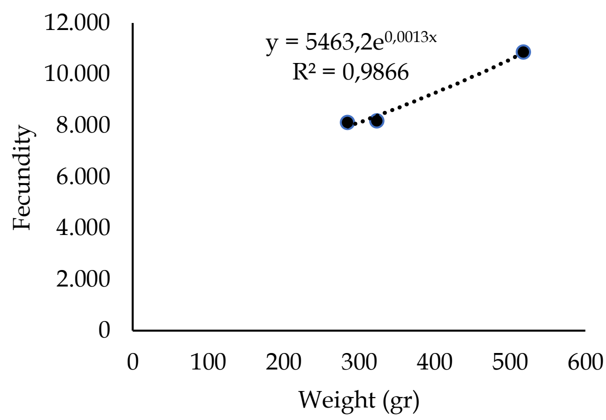

Figure 1. Fecundity of *C. carpio* glass strain in the rainy season

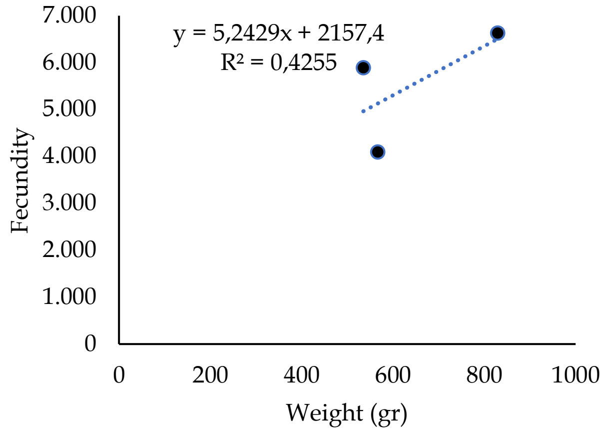

Figure 2. Fecundity of *C. carpio* glass strain in dry season

The results showed that the season affected the fecundity of the *C. carpio* glass strain. The highest fecundity of *C. carpio* glass stain in the rainy season reached 10,875 grains (Figure 1). Meanwhile, the fecundity of *C. carpio* stain glass in the dry season showed a fecundity of 6,620 grains (Figure 2).

The effect of different seasons shows that the rainy season produces the best fecundity of *C. carpio* strain glass. This is because, during the rainy season, the water temperature warms up. Water temperatures are optimal for spawning (generally above 16°C), where higher temperatures contribute to increased fertility and spawning frequency (Crichigno et al., 2016). In regions where summer temperatures reach around 25°C, the reproductive performance of *C. carpio* is significantly improved, allowing for multiple spawners in a season (Tessema et al., 2020). The study also showed that *C. carpio* was able to produce a fecundity of up to 28,100 eggs. Hossain et al. (2016), a female *C. carpio* fish can produce up to 2 million eggs, while research conducted by Marenkov (2016) in the Zaporozhian Reservoir showed the fecundity of *C. carpio* reached 114.67 to 2195.5 thousand eggs. Photoperiod is also a crucial factor affecting the reproductive cycle of *C. carpio*. Research shows that a photoperiod of more than 10 hours is required for oocyte maturation and ovulation in female carp (Britton et al., 2007). This requirement corresponds with seasonal changes, where the length of daylight in the wet and dry seasons coincides with increased reproductive activity.

Water Quality

Glass strain carp broodstock rearing ponds at the farm site are semi-permanent ponds, where the pond walls are made of concrete, while the bottom of the pond remains soil. Water flows continuously for 24 hours a day and 7 days a week with a discharge of up to 10 m^3 per second. In general, this pond is classified as a stillwater pond with one inlet that takes its water supply from the same source. Observations of water quality made in this *C. carpio* study tended to have relatively long water quality (Table 2).

Table 2. Water Quality of Glass Strain *C. carpio* Rearing

Parameters	Rainy season	Dry season	SNI 8293.3: 2016
Temperature (°C)	21.3 – 24.4	21.4 – 24.7	25 - 30
pH	6.14 – 7.29	5.65 – 6.19	6,5 – 8.5
DO (mg/L)	3.92 – 5.49	4.11 – 5.59	Min 3
Brightness (cm)	20 - 30	20 - 35	25 - 80

The results of observations on water temperature tend to be the same (21.3 - 24.4 °C) in the rainy season and (21.4 - 24.7 ° C) in the dry season; this is because the average daily air temperature in the Batu City area ranges from 20 - 27 °C.

Temperature impacts the endocrine system, hormone production, biological activity, and metabolism, all within the physiological limits of temperate and tropical fish species (Pankhurst & Porter, 2003; Pankhurst & King, 2010; Hainfellner et al., 2012). In this study, temperature was identified as the second most important environmental factor after rainfall that plays a role in triggering gonad maturation of *C. carpio* glass strain. This finding is in line with studies that have been conducted on fish such as *Cymatogaster aggregata*, *Gasterosteus aculeatus*, *Catla catla*, and *Clarias punctata* (Wiebe, 1968; Baggerman, 1980; Davies et al., 1986; Bhattacharyya & Maitra, 2006; Basak et al., 2016). Various factors, such as season, latitude, altitude from sea level, time of day, air circulation, cloud cover, and water flow and depth, influence the temperature of water bodies. Although the temperature in rearing ponds is usually more stable, it is still below the optimal range required for carp culture. This condition occurs because the height of the pond location is quite high above sea level, where Batu City is at an altitude of about 950 meters above sea level (masl), causing the air temperature in the region to tend to be lower. Research conducted by Kowalski et al. (2019) also showed that temperature affects the quality of *C. carpio* sperm. The study showed that potassium levels in fish seminal plasma decreased when exposed to high temperatures.

During the rainy season, the pH value of the rearing medium ranged from 6.14 to 7.29, which was slightly lower than the threshold but still relatively close to the expected range. In contrast, during the dry season, the pH value drops lower, ranging from 5.65 to 6.19, which is considered less than optimal for fish growth and development. This condition is thought to affect the metabolism and reproductive activities of fish. Salleh et al. (2017) also showed that exposure to overly acidic water conditions can disrupt the fish endocrine system, resulting in an imbalance of sex steroid hormone levels and inhibiting gonadal development, which is important for reproductive success. This disruption has the potential to inhibit oocyte maturation and reduce spawning success rates, as revealed in various studies on fish reproductive performance (Swain et al., 2020). In addition, pH outside the normal range can cause physiological stress that inhibits growth and reproductive success. Zahangir et al. (2015) also showed that extreme pH conditions can trigger mass mortality in fish farming and adversely affect physiology and reproductive function. This is also supported by the research of Kong et al. (2023), which indicated that too high or too low pH can be fatal to fertilized eggs and young fish, including interference with oxygen transport in the blood and increased mortality. In addition to direct physiological impacts, water pH also affects ecosystem dynamics that impact factors such as dissolved oxygen levels, which are critical for fish metabolism and reproductive success (Subba et al., 2020). Research shows a relationship between water pH and reproductive indices, where ideal pH conditions correlate with more successful gonad development and spawning (An et al., 2017).

During the rainy season, dissolved oxygen levels were in the range of 3.92 - 5.49 mg/L, while during the dry season, they ranged from 4.11 - 5.59 mg/L. This range falls within the optimal category for fish farming. Generally, lower temperatures will reduce dissolved oxygen levels in aquaculture media. However, this condition does not apply to glass carp broodstock rearing media, as the constant water flow with a discharge of 10 m³ per second for 24 hours a day, 7 days a week, keeps dissolved oxygen levels stable. Liu et al. (2014) also showed that flow dynamics are very important for oxygen stability. Changes in oxygen levels in flowing water are influenced by various environmental factors such as temperature and nutrient availability. According to Ishizu et al. (2013), there is a close relationship between temperature and oxygen saturation levels, where warmer water tends to have lower dissolved oxygen levels.

During the rainy season, the brightness of the research ponds was in the range of 20 - 30 cm, which was caused by the high level of dissolved particles in the water. This condition occurs due to the turbid water flow from the water source, which cannot fully settle in the settling pond. In contrast, during the dry season, brightness values increase to the range of 20 - 35 cm. Light plays an important role in influencing fish behavior, survival rate, and metabolism. Fish tend to show increased metabolism during the light phase due to intensification of behavioral interactions and increased activity (Biswas & Takeuchi, 2002). This is in line with Kalkhundiya et al.'s study, which showed that fish have a light-responsive circadian clock, which plays a role in regulating physiological functions through the hormone melatonin (Kalkhundiya et al., 2021). Such internal synchronization is critical for regulating the daily activity cycle of fish, which ultimately supports survival and reproductive success. Research Yi et al. (2022) also showed the role of light in improving production efficiency and success of farmed fish, where variations in light conditions can lead to differences in metabolic and behavioral responses.

Rainfall

The results of the rainfall analysis show a significant difference between the wet and dry seasons. In the wet season, the average rainfall reached the highest total of 2,546.87 mm, while in the dry season, rainfall was almost undetectable, with the highest figure being only 1.36 mm (Figure 3).

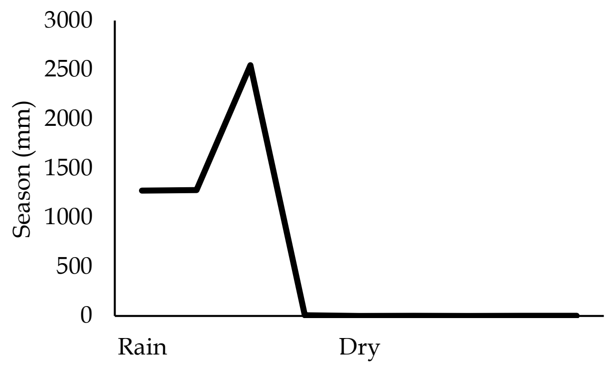

Figure 3. Rainfall during rearing of glass strain *C. carpio*

The results of the research conducted show that *C. carpio* fish spawn in the rainy season. This is in accordance with what was conveyed by Karnatak et al. (2018). The study shows that rainfall is the most influential factor in the spawning process. In particular, rainfall acts as the main environmental signal that regulates the gonadal cycle and stimulates spawning in various tropical and subtropical fish species (Bhattacharyya & Maitra, 2006). The impact of environmental factors on gonadal activity is thought to be mediated through the neuroendocrine system, in accordance with research conducted by Alvarado et al. (2015). Rainfall patterns, which are subject to changes due to climate change, are critical in determining the timing of fish spawning (Whitney et al., 2016). Studies have also shown a positive correlation between rainfall and spawning activity in many tropical and subtropical fish species (Basak et al., 2016). Agumassie (2019) also showed that *C. carpio* in Ethiopia showed a spawning season during the rainy season. Rain plays a role in stimulating spawning by creating a safer environment, which in turn favors fish growth and survival.

Rainfall plays an important role in influencing the physical and chemical characteristics of water bodies. Increased rainfall can increase water surface elevation and improve water flow conditions to favor spawning activities. Research shows that rainfall can expand the availability of ideal substrates for spawning and increase the productivity of aquatic ecosystems, which in turn facilitates increased fertilization rates and hatching success. Rainfall can create optimal spawning timing and increase fertilization rates (Shahbaz-Azhar et al., 2022).

Conclusion

The quality of sperm from the glass strain of *C. carpio* varied depending on the season in which it was produced. The best sperm quality was produced in the rainy season with motility (70.44%), concentration (26.75 X 10^9 cells/ml), and viability (79.81%). However, the rainy season resulted in the highest abnormality (5.53%). The highest fecundity of *C. carpio* stain glass in the rainy season reached 10,875 grains. Seasonal changes affect changes in temperature, photoperiod, and water quality, so it has a direct impact on physiological processes that trigger the gametogenesis of *C. carpio* strain glass.

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Author Contributions
Each author played a role in completing this research activity. The main author provided the basic idea and research materials. The second and third authors designed the research methods. All authors were involved in data collection, table preparation and data analysis, the review process, and writing the article.

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Conflicts of Interest
The author declares that there is no conflict of interest in this research.

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