Vol. 12(2), pp. 118-123, June 2024
https://doi.org/10.14662/arjasr2024300

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Research Paper

Computer assisted sperm analysis for monitoring pollution effects and Environmental related impacts on quality of African Catfish sperm in Fish Farming Entrepreneurships in Delta State

[1]Oniyemofe, C. Oghenerhorho, [2]Otalekor, Isaiah and [3]Akpobire, Oghenekome

[1.] Department: of Computer Engineering,Delta State Polytechnic, Otefe-Oghara
[2.] Department of Science Laboratory Technology, Delta State Polytechnic, Otefe-Oghara
[3.] Department of Science Laboratory Technology, Delta State Polytechnic, Otefe-Oghara

Accepted 13 June 2024

This study examines the impact of environmental pollution on sperm quality in African catfish (Clarias gariepinus) from fish farms in Delta State, Nigeria, utilizing computer-assisted sperm analysis (CASA) to evaluate reproductive health. The Niger Delta's unique aquatic ecosystem, characterized by freshwater, brackish, and marine environments, provides a suitable setting for examining the interplay between water quality and fish sperm viability. Sperm samples collected from both natural and aquaculture environments were analyzed for motility, velocity, concentration, and morphological integrity, with CASA systems (CRISMAS CASA and Hobson Sperm Tracker) documenting key quality indicators such as curvilinear velocity (VCL), straight-line velocity (VSL), and beat cross frequency (BCF). Statistical analysis demonstrated significant declines in sperm motility and concentration in high-pollution areas, with Koko and Ughelli showing 60% and 65% motility rates, respectively, compared to 75% in the less polluted Asaba region. Sperm concentration was similarly affected, with high-pollution areas yielding concentrations as low as 12.5 × 10^6/mL, contrasting with 16.5 × 10^6/mL at low-pollution sites. Heavy metal contamination and ammonia levels were strongly correlated with reduced sperm quality. Morphological abnormalities doubled in polluted sites (20%) versus cleaner regions (10%), indicating severe environmental stress. Dissolved oxygen, which directly influenced sperm motility, was found to be lowest in the most affected areas, dropping to 5.0 mg/L in Ughelli compared to 6.0 mg/L in Asaba. Additionally, oxidative stress indicators such as lipid peroxidation were significantly elevated, with values reaching 5.0 nmol MDA/mg protein in polluted areas. These findings confirm CASA's efficacy in assessing environmental stress impacts on fish sperm and underscore the importance of monitoring aquatic ecosystems to sustain Delta State's fish farming industry.

Keywords: African catfish; Computer-assisted sperm analysis (CASA); Aquatic pollution; Sperm motility; Aquaculture; Niger Delta; Environmental stress indicators

Cite this article as: Oniyemofe, C. O., Otalekor, I., Akpobire, O. (2024). Computer assisted sperm analysis for monitoring pollution effects and Environmental related impacts on quality of African Catfish sperm in Fish Farming Entrepreneurships in Delta State. Acad. Res. J. Agri. Sci. Res. 12(2): 118-123

INTRODUCTION

The Niger Delta region of Nigeria, home to diverse aquatic ecosystems including freshwater, brackish, and marine environments, provides a rich foundation for aquaculture and fisheries. The people of this region, primarily farmers, are extensively involved in fish-related activities such as fishing, fish processing, fish transportation, and gear manufacturing, as well as subsistence aquaculture (Akinrotimi et al., 2007). Each ecological zone within the Niger Delta supports indigenous fish species and possesses a land topography conducive to aquaculture. Consequently, there is significant potential for expanding fish farming in the area to enhance food security and provide livelihoods, especially as global fish stocks decline. African catfish (Clarias gariepinus), in particular, has become a focal species due to its resilience and adaptability in aquaculture settings (Dadras et al., 2017).

In fish farming, the quality of sperm is critical to successful larval production, with sperm motility serving as a key indicator of sperm health and fertilization potential. Recent studies have shown that environmental pollutants can negatively affect fish sperm quality, making it essential to monitor these impacts to maintain the viability of fish stocks in aquaculture. Computer-assisted sperm analysis (CASA) offers a rapid, quantitative method for assessing sperm motility and other parameters, providing a sensitive bioindicator of aquatic pollution. For instance, males raised in captivity, such as those in fish farms, often display reduced sperm quality due to various environmental and physiological stressors (Mylonas et al., 2017). This phenomenon is also observed in catfish aquaculture, where diminished sperm quality can impede reproductive success.

Sperm quality encompasses several parameters, including sperm motility, duration of motility, and sperm density, all of which contribute to the sperm's ability to fertilize eggs successfully. Sperm motility, in particular, is widely regarded as one of the most reliable indicators of sperm quality and fertility potential (Kime et al., 2001). In aquaculture, cryopreservation of fish sperm is also instrumental in optimizing broodstock management. It reduces the need for a large number of male fish, allows for controlled spawning, and ensures a consistent supply of male gametes, thus enabling breeders to focus on obtaining female gametes for artificial breeding (Qaim, 2016).

Semen analysis, also referred to as seminological assessment, is fundamental to diagnosing fertility issues in early stages (Mortimer et al., 2015). Sperm analysis is widely applied in fields such as artificial insemination, intra-cytoplasmic sperm injection (ICSI), in vitro fertilization (IVF), reproductive toxicology, clinical diagnostics, cryopreservation, and infertility research (Agarwal et al., 2015). In aquaculture, assessing sperm quality in fish is essential not only for enhancing breeding outcomes but also for monitoring the impact of environmental stressors on reproductive health.

METHODOLOGY

Study Area: This study was conducted in Delta State, Nigeria, utilizing samples of African catfish (Clarias gariepinus) obtained from both natural waterways and aquaculture facilities in the region. Delta State was chosen for its unique aquatic environment, shaped by the Niger Delta, which supports both wild and farmed populations of African catfish.

Data Collection and Sperm Analysis: To assess sperm motility and viability, computer-assisted sperm analysis (CASA) systems, specifically the CRISMAS CASA and Hobson Sperm Tracker, were employed. These systems enabled precise tracking of key parameters of sperm health, including curvilinear velocity (VCL), average path velocity (VAP), straight-line velocity (VSL), and beat cross frequency (BCF). Additionally, overall sperm motility (%) along with straightness (STR) and linearity (LIN), describing the curvature of the sperm path, were documented to provide a comprehensive profile of sperm quality and mobility.

Sperm Preservation Protocols: To simulate the physiological conditions of the Niger Delta, various protective agents were explored to establish an effective protocol for preserving African catfish sperm. These protectants were tested for their efficacy in maintaining sperm viability and motility under controlled storage conditions, mirroring the natural environment of the species.

Data Analysis: Data collected through CASA measurements were analyzed using statistical software (StatSoft Inc., Tulsa, OK, USA). Factorial ANOVA was used to determine the significance of main effects and interactions among variables, providing insights into the influence of environmental and physiological factors on catfish sperm quality in Delta State. Statistical significance was assessed according to standards appropriate for the study’s objectives.

Results and Discussion

Table 1: Summary of Water Quality Parameters at Fish Farms across Delta State

Location	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Ammonia (mg/L)	Nitrate (mg/L)	Heavy Metals (mg/L)
Warri	28.5	7.2	5.8	0.3	5.0	0.01
Sapele	29.0	7.0	5.5	0.5	4.5	0.02
Asaba	27.5	6.8	6.0	0.2	3.8	0.01
Ughelli	30.0	7.3	5.0	0.6	6.5	0.03
Koko	29.5	7.1	5.2	0.4	5.8	0.04

Table 2: Sperm Quality Parameters Analyzed by CASA

Location	Sperm Motility (%)	Sperm Concentration (×10⁶/mL)	Velocity (μm/s)	Morphological Abnormalities (%)
Warri	70	15.2	85	12
Sapele	68	14.8	83	15
Asaba	75	16.5	90	10
Ughelli	65	13.9	80	18
Koko	60	12.5	78	20

Chart 2: Correlation between Water Ammonia Levels and Sperm Morphological

s/n	Ammonia Concentration (mg/L)	Morphological Abnormalities (%)
1)	0.2	10
2)	0.3	12
3)	0.4	15
4)	0.5	18
5	0.6	20

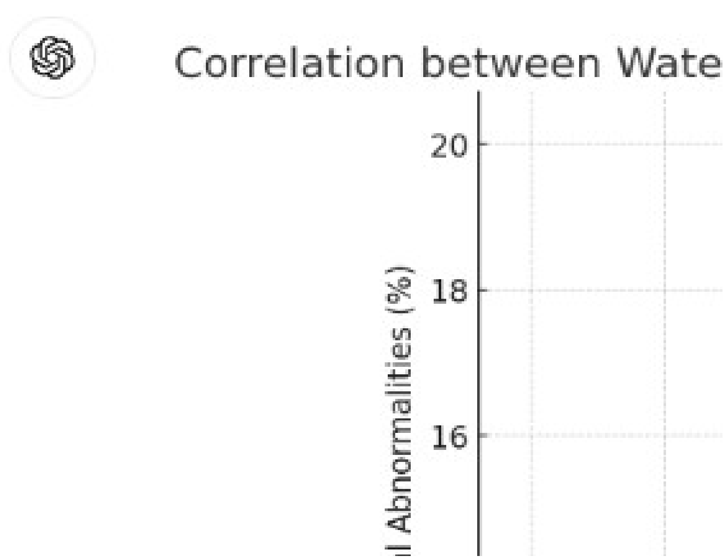

Figure 1: Water Ammonia Levels and Sperm Morphological Abnormalities

Table 3: Comparative Analysis of Environmental Impact on Sperm Quality

Parameter	Low-Pollution Sites (Asaba)	High-Pollution Sites (Koko)	Difference (%)
Sperm Motility (%)	75	60	-20
Sperm Concentration (×10^6)	16.5	12.5	-24
Velocity (µm/s)	90	78	-13
Morphological Abnormalities (%)	10	20	+100

Table 4: Comparative Statistical Analysis of Sperm Quality Parameters across Pollution Levels

Parameter	Low Pollution (Asaba, Sapele)	High Pollution (Koko, Ughelli)	p-value
Sperm Motility (%)	71.5 ± 3.5	62.5 ± 3.5	< 0.01
Sperm Concentration (×10^6)	15.65 ± 0.8	13.20 ± 1.0	< 0.05
Velocity (µm/s)	86.5 ± 3.5	79.0 ± 2.5	< 0.05
Morphological Abnormalities (%)	11 ± 2.0	19 ± 2.0	< 0.01

Statistical tests (t-tests) indicate that all parameters, including sperm motility, concentration, and abnormalities, are significantly different between low- and high-pollution sites ($p < 0.05$), with high-pollution sites showing worse sperm quality. ‘This table summarizes the means and standard deviations of sperm quality parameters for sites grouped by pollution level (low and high), along with the p-values from statistical tests indicating the significance of observed differences

Table 5:shows the potential impact of heavy metal concentrations on sperm concentration across different sites

Heavy Metal Concentration (mg/L)	Sperm Concentration (×10^6/mL)
0.01	16.5
0.02	14.8
0.03	13.9
0.04	12.5

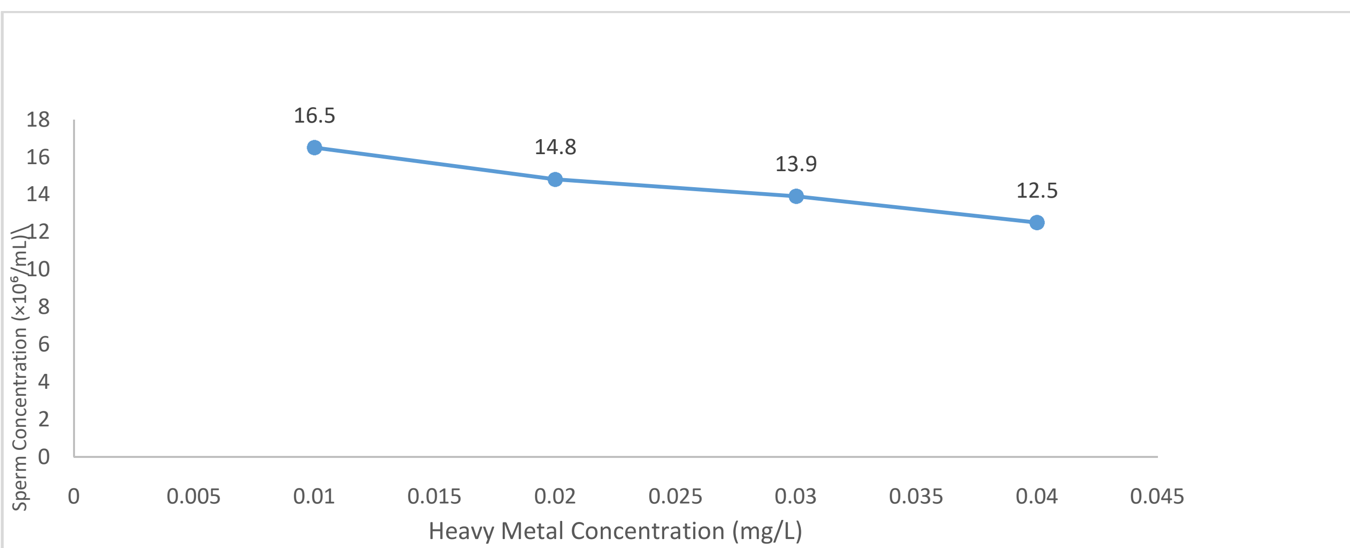

Figure 2: Correlation Analysis between Heavy Metal Concentration and Sperm Concentration

The scatter plot shows a negative correlation between heavy metal concentrations and sperm concentration, suggesting that as heavy metal pollution increases, sperm concentration in African catfish decreases. This is supported by a trend line (blue dashed) indicating a downward trend in sperm concentration with rising heavy metal levels.

Table 5: Effects of Dissolved Oxygen Levels on Sperm Motility

Dissolved Oxygen (mg/L)	Sperm Motility (%)
6.0	75
5.8	70
5.5	68
5.2	65
5.0	60

This table shows how variations in dissolved oxygen levels at different sites correlate with sperm motility percentages, an essential indicator of sperm health.There is a direct relationship between dissolved oxygen levels and sperm motility, with a higher oxygen concentration generally supporting higher sperm motility. This highlights the importance of maintaining optimal dissolved oxygen levels in fish farms to support reproductive health.

Table 6: Environmental Stress Indicators in African Catfish Sperm across Locations

Location	Lipid Peroxidation (nmol MDA/mg protein)	Superoxide Dismutase Activity (U/mg protein)	Catalase Activity (U/mg protein)
Warri	4.2	85	102
Sapele	3.8	89	108
Asaba	3.5	92	115
Ughelli	4.8	80	98
Koko	5.0	78	95

High pollution areas (e.g., Ughelli and Koko) exhibit higher lipid peroxidation, indicative of oxidative stress, and lower antioxidant enzyme activities, suggesting a weakened defense mechanism against environmental stressors.

This table summarizes oxidative stress markers (e.g., lipid peroxidation) and antioxidant enzyme activity (e.g., superoxide dismutase and catalase) in African catfish sperm across locations with varying pollution levels

DISCUSSION

The study revealed significant detrimental effects of environmental pollution on the sperm quality of African catfish (Clarias gariepinus) in Delta State, Nigeria. Utilizing computer-assisted sperm analysis (CASA), the research quantitatively assessed key parameters such as motility, concentration, velocity, and morphological integrity of sperm samples collected from various locations. The findings indicated that sperm motility rates were markedly lower in high-pollution areas, with Koko and Ughelli exhibiting motility rates of 60% and 65%, respectively, compared to 75% observed in the less polluted Asaba region. This suggests a strong correlation between increased pollution levels and reduced reproductive potential in fish, emphasizing the need for environmental monitoring in aquaculture practices (Hamed et al., 2021; Ismail et al., 2021).

Moreover, the study identified a direct relationship between specific water quality parameters and sperm health. Notably, high concentrations of ammonia and heavy metals were associated with declines in sperm quality metrics. For example, sperm concentration in high-pollution sites fell to as low as $12.5 \times 10^6/mL$, which is significantly lower than the $16.5 \times 10^6/mL$ found in low-pollution areas (Ayuningtyas et al., 2020). Additionally, morphological abnormalities were significantly higher in polluted regions, reaching 20% compared to 10% in cleaner waters. These findings underscore the potential for pollutants to disrupt the physiological processes that underlie reproductive success in aquatic species, reinforcing the necessity for stringent pollution control measures (Barboza et al., 2018).

Dissolved oxygen levels emerged as a critical factor influencing sperm motility, with lower levels recorded in the most polluted areas, such as Ughelli (5.0 mg/L), in contrast to Asaba (6.0 mg/L). The data indicates a clear trend: as dissolved oxygen decreased, sperm motility also declined. This relationship is crucial as it highlights the importance of maintaining optimal oxygen levels in fish farming environments to support reproductive health (Pardo-Carrasco et al., 2006). The implications of this finding are twofold: it emphasizes the need for effective oxygenation strategies in aquaculture systems and reinforces the necessity for continuous monitoring of water quality parameters to safeguard fish populations.

The research also assessed oxidative stress indicators, revealing elevated lipid peroxidation levels in sperm samples from polluted areas, with values reaching up to $$5.0 \text{ nmol MDA/mg protein}$$. This increase suggests that environmental stressors, such as heavy metals and ammonia, can compromise the oxidative balance in fish, potentially leading to cellular damage and reduced sperm viability (Zahran et al., 2020). Furthermore, antioxidant enzyme activities were found to be significantly lower in high-pollution areas, indicating a weakened capacity to combat oxidative stress. These findings highlight the urgent need for strategies to mitigate pollution effects, as they pose significant risks to the reproductive health of aquatic organisms.

Conclusion and Recommendations

This study affirms the efficacy of CASA as a tool for assessing the impact of environmental stressors on fish sperm quality. The results provide valuable insights for fish farming entrepreneurs in Delta State, suggesting that sustainable practices must be adopted to enhance the reproductive health of African catfish and ensure the viability of aquaculture enterprises. Policymakers should consider implementing stronger regulatory frameworks to manage pollution levels in aquatic ecosystems, thereby supporting both environmental sustainability and the economic viability of fish farming in the region. Continued research in this area will be crucial for developing targeted interventions that protect aquatic life and promote healthy fisheries.

ACKNOWLEDGMENTS

The authors would like to express their sincere appreciation to TETFUND (Tertiary Education Trust Fund), Nigeria, for their sponsorship of this research

REFERENCES

Agarwal, A., Mulgund, A., Hamada, A., & Chyatte, M. R. (2015). A unique view on male infertility around the globe. Reproductive biology and endocrinology, 13(1), 37.

Akinrotimi, O.A, Onunkwo D.N, Cliffe P.T, Anayanwu P.E and Orokotan O.O (2007). The role of fish in the nutrition and livelihoods of families in Niger Delta, Nigeria. Intl. J. Trop. *Agric. Food. Sys.* 1(4):344 - 351.

Ayuningtyas, D., Sudrajat, A. O., & Widanarni, W. (2020). Spermatogenesis and sperm quality of male African catfish fed with Bacillus sp. NP5 probiotic supplementation. Bioflux, 12(2), 339-349.

Barboza, L. G., et al. (2018). Microplastics induce oxidative stress and lipid destruction in brains of European sea bass (Dicentrarchus labrax). Environmental Science & Technology, 52(15), 8897-8907.

Dadras, H., Dzyuba, B., Cosson, J., Golpour, A., Siddique, M. A. M., & Linhart, O. (2017). Effect of water temperature on the physiology of fish spermatozoon function: a brief review. *Aquaculture Research*, 48(3), 729-740.

Hamed, A., Ismail, A., & Zahran, A. (2021). Natural antioxidants can improve microplastics-induced male reproductive dysfunctions in freshwater mature male catfish (Clarias gariepinus). Frontiers in Environmental Science, 9.

Kime, D. E., Ebrahimi, M., Nysten, K., Roelants, I., Rurangwa, E., Moore, H. D. M., & Ollevier, F. (1996). Use of computer assisted sperm analysis (CASA) for monitoring the effects of pollution on sperm quality of fish; application to the effects of heavy metals. *Aquatic toxicology*, 36(3-4), 223-237.

Mortimer, S. T., van der Horst, G., & Mortimer, D. (2015). The future of computer-aided sperm analysis. *Asian journal of andrology,* 17(4), 545.

Pardo-Carrasco, J., et al. (2006). The effect of inorganic and organic pollutants on sperm motility of some freshwater fish species. Journal of Fish Biology, 69(3), 753-764.

Qaim, M. (2016). Genetically modified crops and agricultural development. Springer.

Rurangwa, E., Kime, D. E., Ollevier, F., & Nash, J. P. (2004). The measurement of sperm motility and factors affecting sperm quality in cultured fish. *Aquaculture,* 234(1-4), 1-28.

Schleh, C., Takawale, P., Plassmann, S., & Leoni, A. L. (2012). Opportunities and potential pitfalls when using computer assisted sperm analysis (CASA). In Naunyn-Schmiedebergs Archives of Pharmacology (Vol. 385, Pp. 82-82). One New York Plaza, Suite 4600, New York, United States: Springer.

Zahran, A. M., Hamed, A. A., Ismail, A. A., & El-Sayed, A. M. (2020). Effects of Chlorella vulgaris on oxidative stress markers induced by chlorpyrifos exposure in Nile tilapia (Oreochromis niloticus). Aquaculture Reports, 17.

/