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Effects of Artificial UVB Radiation on Growth, Survival, and Pigmentation of African Catfish (*Clarias gariepinus*) Fingerlings

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ABSTRACT

Ultraviolet radiation B (UVB) is known to be detrimental to aquatic habitat; therefore, it's critical to understand how UVB affects *Clarias gariepinus,* which is widely cultured in Nigeria, in order to promote healthy growth of the fish. Two hundred fingerlings of *the cat fish* samples were obtained and divided into four equal groups, (A, B, C, and D) and kept in artificial ponds, and were respectively exposed to different UVB conditions [UVB-L (low)] 2.4×10^{-7} mW/cm^2, UVB-M (moderate) 6.0×10^{-7} mW/cm^2, UVB-H (high) 1.2×10^{-6} mW/cm^2] and group D was used as a control. The exposure period was 16 days and 51 days, respectively for the short and long term. The results of short and long-term exposure depict that UVB-L does not cause significant changes to the sample, while UVB-M rapidly increases the weight and growth but decreases mortality rate of the cat fish sampled, and UVB-H retarded weight and growth but increases mortality rate of the *Clarias gariepinus.* The result on color change indicated that, the control, UVB-L, and UVB-M samples maintained their dark color throughout the period of the experiment, while UVB-H sample undergoes morphological and functional changes resulting in a complete change from dark to pink color. UVB-M was found to be highly beneficial to the cat fish for both short and long terms, it can therefore, be adopted by fish farmers to improve the healthy fish growth of their farm.

Keywords:
Ultraviolet radiation,
Catfish,
Color change,
Weight,
Growth,
Mortality rate.

INTRODUCTION

Ultraviolet radiation (UVR) is a stressor that has a wide range of effects on ecological and human systems (Barnes *et al.,* 2023). Globally, it has been observed that UVR presents several difficulties for both human and aquatic ecosystems (Alloy *et al.,* 2016; Braun, Reef & Siebeck., 2016). Effects of UVR exposure in fish include a decrease in growth, impaired development, and behavioral changes (Hader, Helbling, Williamson & Worrestd, 2015), as well as an increase in the mutation rate in fish eggs and larval stages (Cubillos, 2015; Ricardo & Susana, 2020; Sayed & Mitani, 2016). UV-A, which is moderately energetic and less dangerous (UV-A, 320–400 nm) (Lara, Carlos & Susana 2020), UV-B, which is very energetic and moderately harmful (UV-B, 280–320 nm), and UV-C, which is highly harmful (UV-C, 200–280 nm), are the three spectral bands that are used to classify UV radiation (Hader & Barnes, 2019; Ravinder, Brijender, Ankit, Ajay & Pawitar, 2020).

The lifecycle stages of fish where UVR damage is most likely to occur are those during early development (Khan, Aldosari, & Hussain, 2018); however, juvenile and adult fish are highly sensitive to all UV bands at later development. Recent meta-analyses have further confirmed the detrimental effects of UVR on aquatic organisms (Kazerouni, Franklin & Seebacher, 2016), despite the fact that fish species can adapt a variety of defense mechanisms against UVR's negative effects.

Different authors have conducted a number of research on the effects of UV light on aquatic ecosystems, and some of these studies are reviewed. Ichaver et al, (2024) worked on effects of UVR on Some Stages of *Clarias gariespinus* growth and observed that UV-B may be responsible for rapid increase in the weight, growth, and life span of the *Clarias gariespinus*, Studer, Lamare & Poulin, (2012) determine the harmful effects of ultraviolet B (UV-B) and A (UV-A) radiation on fish at various lifecycle stages, and observed the increase in mortality as the most noticeable adverse effect during the early development stages. Maricela *et al.* (2019) assessed the effects of ultraviolet light treatment on quagga mussel settlement and veliger survival and discovered that mortality rates differed depending on the UV intensity examined. In the review of ultraviolet radiation's effects on domestic animals, according to Sherri, Pucherelli & Renata (2017), UV-B had some beneficial effects on domestic animals, such as preserving the proper internal body temperature for the metabolism of some homoeothermic creatures, maintaining vitamin D metabolism, which is crucial for bone maintenance and growth regulation, hormonal functioning, organ development, and embryogenesis. The absence of information in the literature regarding the effects of UVB on *Clarias gariepinus* in north-central Nigeria necessitated this study.

This study aims to ascertain the positive and negative impacts of ultraviolet B radiation doses on *Clarias gariepinus* growth, weight, mortality rate, and skin in north central Nigeria. Gaining further understanding of how UVB affects catfish in north-central Nigeria would increase fish production there, which will in turn give the country access to another regional resource base. In north-central Nigeria, the effects of UVB on *Clarias gariepinus* have not been studied in any previously published, comparable research. Similar studies conducted in other nations either focused on the effects of UVR on mammals or other species of fish without due attention to *Clarias gariepinus* that is widely grown and consumed in North Central Nigeria, suggesting a critical knowledge gap that is likely to be a major contributing factor to the low production of *Clarias gariepinus* in North Central Nigeria.

MATERIALS AND METHODS

Ethics Statement

The research was carried out in the Department of Fisheries and Aquiculture's experimental laboratory facilities at Joseph Sarwuan Tarka University Makurdi (JOSTUM), Nigeria. With permission from the JOSTUM Institutional Animal Care and Use Committee and in compliance with the Nigerian Institute for Oceanography and Marine Research (NIOMR) code of practice, we conducted the UVB exposure experiments with catfish (Clarias gariepinus) fingerlings from September to November 2023. [IACUCMT(NIG)#20-06-2023]

Animals and Experimental Design

Samples of dark-colored *Clarias Garriespinus* fingerlings, weighing an average of 1.40 g and measuring 5.1 cm, were procured from a commercial fish farm located in Makurdi. The fish's health profile was provided by the JOSTUM Fish Health and Safety Laboratory. Before the experiment started, fish were moved to the quarantine section in the experimental laboratory facilities and held there for four days. Four plastic ponds labeled A, B, C, and D were used to randomly and fairly distribute fifty specimens each of 200 specimens with identical biometric features. Groups A, B, and C were respectively exposed to UVB-L (low), UVB-M (moderate) and UVB-H (high) from UV lamps and shielded using dark blinds (thick polythene sheets) so as to prevent the interference of external UV irradiance, while sample D was kept as control. The plastic ponds were made such that flow through system was ensured throughout the experiment, and the water flow rate was fixed at 0.3 m^3/h and checked every 5 days to ensure tank self-cleaning. The ponds were filled up to 75 cm deep, and the artificial UV lamp sources were kept at heights of 40 cm from the water surface. The exposure period was 16 and 51 days, respectively, for the short and long term, from 6:30 a.m. to 6:30 p.m. daily.

The samples were given equal treatment and the ponds were emptied and cleaned every five days to ensure sanity for the fish. Mean temperature, pH, UVB irradiance were recorded every five days and absolute dose computed. Growth rate was measured using a meter rule; the weight of the samples was measured using electronic weighing balance; mortality rate was determined by physical counting and color change was determined by physical observation of the samples.

Body conditions of Samples

The percentage weight gains rate (WGR), specific growth rate, and mortality (survivor) rate of *Clarias gariepinus* were respectively computed using equations 1, 2, and 3 (Ricardo, Asaad, Jorge, Abdulaziz & Susana, 2020).

Percentage weight gain rate (WGR) =

$$100\,\frac{Final\ body\ weight\ (g) - initial\ body\ weight(g)}{initial\ body\ weight\ (g)} \quad (1)$$

Percentage specific growth rate (cm) =

$$100\,\frac{Final\ length\ (cm) - initial\ length(cm)}{number\ of\ days} \quad (2)$$

Percentage mortality rate =

$$100\,\frac{initial\ number\ of\ species - Final\ number\ of\ species}{Final\ number\ species} \quad (3)$$

RESULTS AND DISCUSSION

Measurement of pH, Temperature and UVB in Ponds

The mean pH, temperature, UVB irradiance, daily dose, and absolute dose used on the *Clarias gariepinus* were measured, computed, and the results are presented in Table 1.

Table 1: Mean pH, Temperature UVB Irradiance, Daily dose and Absolute dose used on the *Clarias gariespinus*

Treatment	Water parameters		Irradiance (mW/cm^2)	Daily dose (mW/cm^2)	Absolute dose (mW/cm^2)16 days exposure	Absolute dose (mW/cm^2) 71 days exposure
	pH	TEMP (°C)				
Control	6.56	26.0	0.000±00	0.000±00	0.000±00	0.000±00
UVB-L	6.56	26.0	0.046±04	2.4×10^{-7}	3.84×10^{-6}	1.70×10^{-5}
UVB-M	6.56	26.5	0.058±09	6.0×10^{-7}	9.60×10^{-6}	4.26×10^{-5}
UVB-H	6.56	27.0	0.067±02	1.2×10^{-6}	1.92×10^{-5}	8.52×10^{-4}

Mean pH, water temperature, UVB Irradiance, Daily dose and Absolute dose used on the irradiated *Clarias gariepinus*

The mean UVB irradiance, daily and absolute UVB doses, pH, and temperature of water for each treatment are presented in Table 1. The highest UVB irradiance obtained in the experiment was for UVB-H (0.067±02 mW/cm^2). UVB-H-treated fish were exposed to a daily dose of 1.2×10^{-6} mW/cm^2, and the absolute dose for this treatment was 1.92×10^{-5} mW/cm^2at a temperature of 27 °C for 51 days of exposure. There was a high mortality rate, retarded growth, loss of weight, and an unexpected change in skin color observed for UVB-H treatment, the result was in line with the findings of Studer, Lamare & Poulin, (2012) who observed a high increase in mortality during the early development stages in fish exposed to UVB. UVB-M-treated fish were exposed to irradiance of 0.058±09 mW/cm^2 with an average daily dose of $6.0 \times 10^{-7} \pm 26.5$ $mW/cm^2$and an absolute dose treatment of 9.60×10^{-6} and 4.26×10^{-5} mW/cm^2respectively, for short and long-term exposure. Accelerated growth and a high increase in weight were observed in UVB-M treatment, the result agreed with that of Ichaver et al., 2024, who observed high growth of cat fish exposed to UVB. But disagreed with that of Studer, Lamare & Poulin, (2012) who observed a high increase in mortality during the early development stages in fish exposed to UVB.

Percentage growth, weight gain and survival rates of *Clarias gariepinus S*ample

Tables 2: Percentage growth, weight gain and survival rates of *Clarias gariepinus* S*ample*

	Total length (TL, cm)	Total weight (TW, g)	Survival Rate	Specific growth rate (%)	Specific weight gain rate (%)	Mortality rate (%)
Initial						
Control	5.1	1.40	50	--	--	--
UVB-L (mW/cm^2)	5.1	1.40	50	--	--	--
UVB-M (mW/cm^2	5.1	1.40	50	--	--	--
UVB-H (mW/cm^2)	5.1	1.40	50	--	--	--
Day 16						
Control	7.9	5.32	42	54.90	24.50	19.05
UVB-L (mW/cm^2)	8.1	5.38	44	58.82	24.88	13.65
UVB-M (mW/cm^2	8.9	9.34	48	74.51	49.50	4.17
UVB-H (mW/cm^2)	6.9	3.13	32	35.29	14.38	38.89
Day 51						
Conrtol	14.1	43.81	40	60.23	69.71	5.00
UVB-L (mW/cm^2)	14.8	49.41	43	60.87	80.53	0.00
UVB-M (mW/cm^2)	19.5	60.23	48	89.32	89.45	0.00
UVB-H (mW/cm^2)	11.6	27.21	16	50.65	41.37	87.50

Effects of UVB on Growth, Weight, and Mortality rate of *Clarias gariepinus*

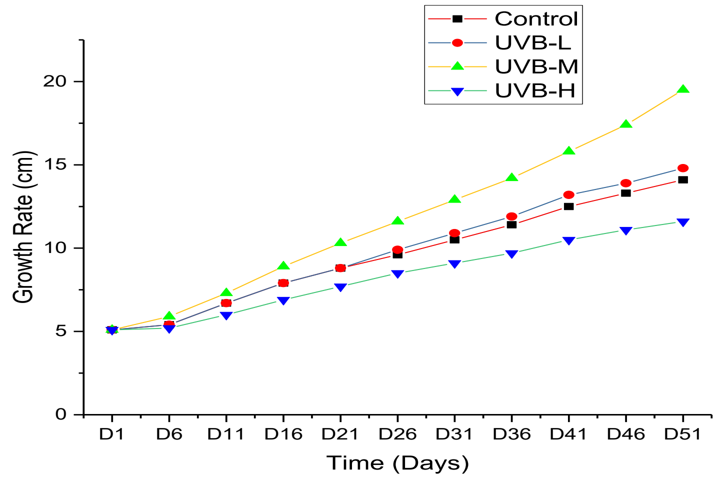

Figure 1: Growth rate of *Clarias gariepinus Sample* in every 5 days
D1, D5, D11…D51 means day 1, day 6, day 11… day 51

Effects of UVB on the growth rate (cm) of *Clarias gariepinus*

Figure 1 and Table 2 shows the effects of UVB on the growth rate of *the* fingerlings for both short (D16) and long (D51) terms exposure, for the control sample, UVB-L, UVB-M, and UVB-H samples. A careful observation of Figure 1 for short-term exposure on day sixteen (D16) depicts that the UVB-M sample has an accelerated growth of 8.9 cm compared to that of the control sample (7.9 cm), while that of the UVB-L sample is insignificant (8.1 cm) compared to that of the control sample, and UVB-H causes a delay in the growth of the sample (6.9 cm). Also, Figure 1 for long-term exposure, day fifty-one (D51), shows that the UVB-M sample has accelerated growth (19.5 cm) compared to that of the control sample (14.1 cm), while the UVB-L sample (14.8 cm) is slightly above the control sample, and the UVB-H sample has a slower growth (11.6 cm) compared to that of the control sample. The faster growth rate of the UVB-M sample could be attributed to the moderate energy in UVB-M, which is responsible for hormonal functioning, organ development, and embryogenesis (Vitt et al 2017). The delay in the growth rate of the UVB-H sample could be a result of the damaging effect of UVB-H energy on DNA structure (Overmans, &Agustí, 2019). This result is in line with the findings of Megan et al. (2014) who carried out an evaluation on the clinical and physiological effects of long-term ultraviolet B radiation on guinea pigs (Cavia procellus) and suggested that providing guinea pigs with exposure to moderate UVB energy will be an important husbandry consideration.

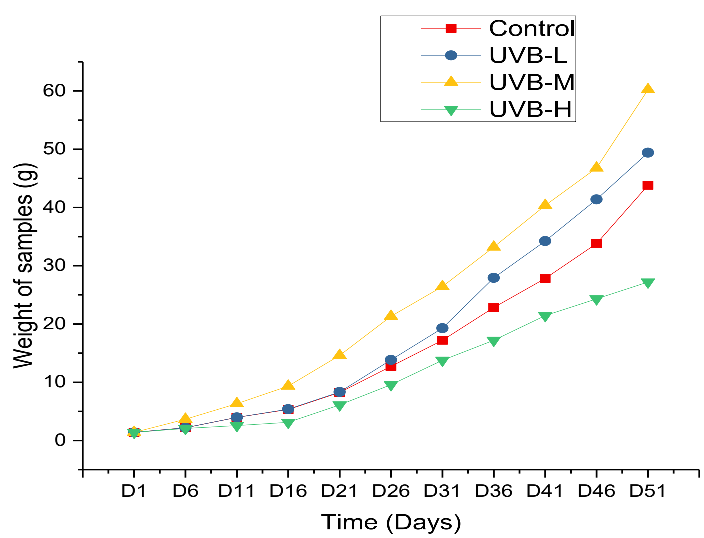

Figure 2: Weight of *Clarias gariepinus* samples in every 5 days
D1, D5, D11…D51 means day 1, day 6, day 11… day 51

Effects of UVB on weight (g) of *Clarias gariepinus*

Figure 2 show the effects of UVB on the weight (g) of the fingerling sample. A good observation of Figure 2 for short term exposure shows that UVB-M gained more weight (9.34 g) compared to that of the control sample (5.32), and UVB-L weighted slightly more than the control samples by 0.06 g, while a loss in weight (3.13 g) was observed in the UVB-H sample. Again, a careful observation of Figure 2 for long exposure (D51) also indicates that the UVB-M sample gained more weight (60.23 g), followed by the UVB-L sample (49.41 g), while a gross loss in weight (27.21 g) was observed in the UVB-H sample compared to the control sample.

A good observation of Figure 2 for short exposure shows that UVB-M gain more weight (9.34 g) compared to that of the control sample (5.32) and UVB-L weighted more than the control samples by 0.06 g while loss in weight (3.13 g) was observed in UVB-H sample. Again, a careful observation of Figure 2 for long exposure (D51) also indicates that UVB-M sample gain more weight (60.23 g), followed by UVB-L (49.41 g), while gross loss in weight (27.21 g) was observed in UVB-H compared to the control sample. The increase in weight observed in UVB-M and UVB-L samples could be a result of the moderate energy of vitamin D produced by UVB-M and UVB-L, which is vital for bone maintenance and weight regulation[40]. The result of this work is in line with the findings of Maricela et al. (2019) who reviewed the effects of ultraviolet in domestic animals and found that UV-B is capable of maintaining proper internal body temperature for metabolism in some homoeothermic animals and that vitamin D is very vital for bone maintenance and growth regulation in animals. However, the results of this work contradict the findings of Williamson, Hargreaves, Orr & Lovera (2019) who examined the beneficial and detrimental effects of UVR on aquatic organisms and observed that UV-B radiation is generally damaging.

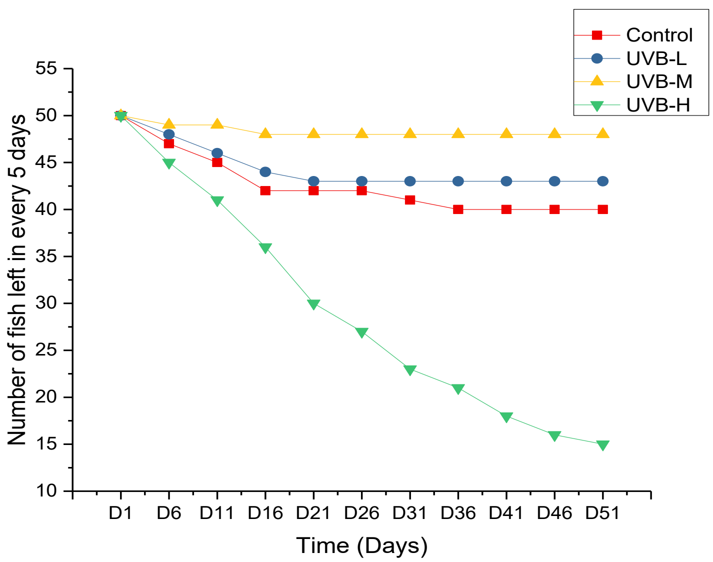

Figure 3: Mortality Rate of *Clarias gariepinus* in every 5 days
D1, D5, D11…D51 means day 1, day 6, day 11… day 51

Effects of UVB on mortality rate of *Clarias gariepinus*

Figure 3 illustrates the impact of UVB on Clarias gariepinus mortality. 50 specimens were maintained in each sample, as can be seen in Figure 3, and the number of samples left over every five days was noted. On the deep slopes between D1 and D16, the short-term exposure result shows a high death rate for the Control (8), UVB-L (6), and UVB-H (16) samples; on the gentle slope observed for UVB-M, the sample has a very low mortality rate (2). The mildly sloping curves for all samples except UVB-H show a decreasing death rate on later dates (long-term exposure D51); the deep slope of the UVB-H curve, on the other hand, suggests a high death rate. A good observation of figure 3 also shows the survival rates of samples to be 40, 43, 48, and 16 for the control, UVB-L, UVB-M, and UVB-H, respectively. The result indicates a high survival rate for UVB-L and UVB-M compared to the control sample. There was a total reduction in anti-protease and total peroxidase activities observed in samples exposed to UVB-H, as almost all specimens were observed to be hanging on the water surface. The high death rate observed from UVB-H may be attributed to stressors from UVB-H. This result agrees partially with that of Luke, Andrew, Betsy, Nick &Molly (2014) who studied the effects of Ultraviolet-B radiation on wound fin embryos and larvae and found that no embryos survived UV-B treatments.

Percentage growth, weight gain and survival rates of *Clarias gariepinus S*ample

Table 2 gives the percentage growth rate of *Clarias gariepinus samples* exposed to different UVB doses. The results of this study indicate that short- and long-term exposure increases the percentage growth rate of *Clarias gariepinus* fingerlings in UVB-L and UVB-M (60.87 and 89.32%, respectively) compared to that of the control sample (60.23%). While UVB-H indicates a reduction in the percentage growth rate (50.65) of *Clarias gariepinus* fingerling's.The observed reduction in growth for UVB-H was strongly dose-dependent, in agreement with similar findings obtained for three-spined stickleback and sea chub (Graus nigra) juveniles after 68 (6.5 kJ m^2 d1; absolute UVB doses for the experimental period of 442 kJ m^2) and (3.2 kJ m2 d1; absolute UVB doses for the experimental period of 22.4 kJ m^2) days of exposure to UVB, respectively. The reduction in growth due to UVB exposure was generally accompanied by poor nutritional status (Kazerouni, Franklin & Seebacher, 2016). High percentage weight gain and survival rates were observed in UVB-L and UV-M compared to the control sample, this result is in line with that of Ichaver *et al*., 2024 who observed that UVB was responsible for the growth of cat fish.

CONCLUSION

The work accessed the effects of different doses of artificial UVB radiation on growth, survival, and pigmentation of African Catfish (*Clarias gariepinus*) fingerlings. The results obtained indicate that UVB-H is responsible for taunted growth, loss in weight and change in skin colour ot African catfish (*Clarias gariepinus),* while UVB-L and UVB-M are responsible for decrease in mortality rate, increased body weight and skin healthy condition of the *catfish.*

The results obtained indicate that UVB-H is highly detrimental to *Clarias gariepinus* while UVB-L and UVB-M are beneficial to *Clarias gariepinus;* therefore, fish farmers are encouraged to employ the use of UVB-L and UVB-M on their fish farms in order to improve production and *healthy fish growth.* The work therefore suggests that more study should be carried out on other species of fish and aquatic life.

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