



ORIGINAL ARTICLE

Volume 1 · Issue 1 · 2026 | DOI: 10.67994/k81yfe85

Testicular Histomorphometry of the Helmeted Guinea Fowl (*Numida meleagris*) Exposed to Light-Dark Cycle and Melatonin

Gosomji, I.J.^{1*}, Baso, A.², Ahmad, N.A.³, Zubairu, M.² and Patrick, A.S.⁴

¹Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Jos, Nigeria

²Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Bayero University, Kano, Nigeria

³Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria

⁴Department of Bioresource Development, National Biotechnology Research and Development Agency, Abuja, Nigeria

* Corresponding author: Dr. Innocent J. Gosomji. Email: gosomjii@unijos.edu.ng

ABSTRACT

Information about reproductive activity stimulated by light-dark cycle and administered melatonin to manipulate reproduction in guinea fowls (*Numida meleagris*) is very limited. This study was aimed at exploring the effect of photomanipulation and melatonin (Mel) administered on testis of adult guinea fowls using histometric approach. Sixty adult male guinea fowls aged between 10-12 months were randomly allocated into six (6) groups ($n = 10$) based on the duration of the artificial light-dark (L:D) cycle and melatonin (1 mg/kg). These groups were short-day length with additional 1 mg/kg of melatonin (SDmel; [8L:16D]), short-day length only (SDmel), control with additional 1 mg/kg melatonin (CTLmel; [12L:12D]), control only (CTL), long-day length with additional 1 mg/kg melatonin (LDmel; [16L:8D]), and long-day length (LD). The experiment lasted for 8 weeks. Thereafter, the birds were euthanized, and their left testes were immediately removed and fixed in 10 % buffered formalin for hematoxylin and eosin stain processing. Histometric values such as seminiferous epithelial height (SEH), seminiferous luminal diameter (SLD), and seminiferous tubular diameter (STD) were determined using Motic Image Plus version 2.0. There was a significant interaction ($p < 0.05$) between L:D cycle and melatonin in SEH, SLD, and STD. The values increased in the LD groups. There was a significant difference ($p < 0.05$) when comparing melatonin and the L:D cycle in the SLD and STD. However, there was no significant difference ($p < 0.05$) in SEH. Across the six groups, there was a significant difference ($p < 0.05$) in SEH, SLD, and STD. However, the lowest value for STD was in the LD group. In conclusion, increased SEH and SLD with reduced STD in the LD is a structurally remodelled spermatogenesis that constantly depend on photoperiod-driven adaptive response rather than uniform tubular growth.

Keywords: Guinea fowl, Histomorphometry, Light-Dark cycle, Melatonin, Testis

ARTICLE INFORMATION

Article History

Received: 04 April 2026

Revised: 03 June 2026

Accepted: 30 June 2026

Published: 23 September 2026

How to Cite

Gosomji et al. (2026). Testicular Histomorphometry of the Helmeted Guinea Fowl (*Numida meleagris*) Exposed to Light-Dark Cycle and Melatonin. *African Journal of Veterinary Sciences*, 1(1), 17–23.

Copyright & Licence

© 2026 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Data Availability

Data supporting the findings are available from the corresponding author on reasonable request.

Introduction

The reproductive performance of the guinea fowls is strongly influenced by different environmental factors such as rainfall, temperature, and photoperiod (Hughes, 1986; Okyere et al., 2020; Gosomji et al., 2024). Among these factors, the most reliable predictor in the stimulation of reproductive activity in guinea fowls is the photoperiod, because it initiates reproductive performance in birds and possibly anticipates

environmental changes (Dawson et al., 2001; Hau et al., 2004; Bradshaw and Holzapfel, 2007; Dixit and Singh, 2012; Oke et al., 2015; Baso et al., 2022).

The duration of scotophase or photophase influences the development of testicular size (Banerjee and Chaturvedi, 2017). Short photoperiod decreases testicular size in the house sparrow (Anushi, 2006), pigeon (Yan et al., 2026), tree sparrow (Dixit and Singh, 2011), rose-ringed parakeet (Maitra and Dey, 1992), and quail (Juss, 1993).

Further histological study revealed varied sizes of germinal epithelial height, seminiferous luminal diameter, and tubular diameter. These transitional changes of the testis due to season could be attributed to the amount of endogenous melatonin in circulation (Munley *et al.*, 2020; Akar *et al.*, 2024).

The role of melatonin as an antioxidant and antiapoptotic agent cannot be overemphasized (Fischer *et al.*, 2013; Bejarano *et al.*, 2015; Salehi *et al.*, 2019). Its concentration and circulation in the body system is dependent on the duration of exposure to the light-dark cycle (Bhattacharya *et al.*, 2019). In addition, it provides photoperiodic signals that stimulate spermatogenesis by binding to specific receptors in the testis (Rossi *et al.*, 2014; Gonzalez-Arto *et al.*, 2016). Reduced sperm concentration, motility, and abnormal sperm morphology are related to low melatonin levels (Yie *et al.*, 1991; Awad *et al.*, 2006).

Previous investigations revealed that the interaction of the light-dark cycle with administered melatonin influences testicular morphophysiology of the guinea fowl. However, information on the interaction of the light-dark cycle and administered melatonin in the testicular histomorphometry of the guinea fowl is limited. Therefore, this study aimed to explore the interaction of the light-dark cycle and exogenous melatonin in the testicular histomorphometry of the male guinea fowl.

Materials and Methods

Animal Husbandry and Management

This study was conducted at the Department of Veterinary Anatomy facility (11°4'N, 7°42'E), Ahmadu Bello University, Zaria, Nigeria. Adult male (~1 year) guinea fowl (*Numida meleagris*), weighing 1.0-1.2 kg were utilised for this study. Before the commencement of the experiment, the male guinea fowls were selected using the position of the wattle as described by Umosen *et al.* (2008). The selected birds were managed in an intensive deep-litter system where feed (Vital Feed®, Grand Cereals, Jos, Nigeria) and drinking water were provided *ad libitum*.

The use of animals for this study was carried out in strict adherence to the Institutional Animal Use Ethical Committee of Ahmadu Bello University, Zaria (Approved number: ABUCAUC/2021/056).

Experimental Design

Sixty (60) apparently healthy adult male guinea fowls (*Numida meleagris*) were randomly allocated into six (6) groups (n = 10), as described by Gosomji *et al.* (2024; 2025), namely;

- Group I: Short day length and 1 mg/kg melatonin (SDmel; eight hours of light and sixteen hours of darkness [8L:16D]).
- Group II: Short day length (SD) only

- Group III: Control and 1 mg/kg melatonin (CTLmel; twelve hours of light and 12 hours of darkness [12L:12D])
- Group IV: Control and melatonin (CTL)
- Group V: Long day length and 1 mg/kg (LDMel; sixteen hours of light and eight hours of darkness [6L:8D]).
- Group VI: Long day length (LD) only

There was a daily administration of melatonin (1 mg/kg) via the intramuscular route in three (3) of the groups before the end of the light-dark cycle (Baso *et al.*, 2022; Gosomji *et al.*, 2024; 2025). The experiment was conducted in a pen that was demarcated for each group with dimensions of 200 x 110 x 100 cm. Artificial light was provided using white LED lights (12 W) to give an intensity of 350 lux to each group. The pen was maintained at a temperature of 27±2 °C using a black, tight chamber for 8 weeks of the experiment.

Sample Collection

At the end of the 8th week of the experiment, the birds were euthanized using a combined anaesthesia (35 mg/kg of ketamine and 5 mg/kg of xylazine) via the intramuscular route (Flecknell, 2015). Afterward, their thoraco-abdominal cavities were cut open using a scalpel blade to expose the testes and epididymides. The testes were carefully separated from the adjoining structures, which were then removed for subsequent study.

Tissue Processing

The testicular tissue processing was performed using a modified method by Bancroft and Gamble (2008), where the removed testes in each group were immediately fixed in 10% buffered formalin solution for 48 hrs. The fixed tissues were dehydrated using graded ethanol from 70% to 100 % overnight. The residue of ethanol was removed using xylene before embedding with paraffin wax (Kiernan, 2015). The embedded tissues were sectioned to 5 µm using a Leica RM2125 RT Rotatory Microtome (Leica Biosystems ussloch GmbH, Nussloch, Germany). Thereafter, the sections were stained with Hematoxylin and Eosin (H and E). The stained sections were individually examined to determine the histoarchitecture of the testis using a bright-field optical microscope (Leitz™, GmbH, Germany) attached to a digital camera equipped with imaging software, MII ImageView version 3.7.9229 (YSC Technologies, Fremont, CA, USA).

Histomorphometry

The measurement of the seminiferous epithelium was conducted using a modified method outlined by Omirinde *et al.* (2021). Twenty (20) round or oval profiles of seminiferous tubules (ST) obtained from digital photomicrograph (x 40 magnification) were selected for the evaluation of seminiferous epithelial

height (SEH), seminiferous luminal diameter (SLD) and seminiferous tubular diameter (STD). The SEH was measured from the basal lamina to the luminal edge of the seminiferous epithelium (Figure 1A). The SLD values were transverse measurements from one luminal edge to the other while STD measurements were taken from one end of the basal lamina of the seminiferous tubules to another in the opposite direction (Figure 1B – C). The histometric values were determined using the software, Motic Image Plus (MI plus) version 2.0.

Data Analysis

The generated data were analysed using the JMP® software, version 10 for Windows (2012). The statistical significance was assessed using a 3×2 factorial Analysis of Variance (Two-way ANOVA). Differences in the light-dark cycle and exogenous melatonin groups were analysed using Tukey's post hoc multiple comparison test. Statistical significance was set at $p < 0.05$.

Results

Histology

In this study, the histological results provide detail changes of the seminiferous tubules of the guinea fowls exposed to different L:D cycles and exogenous melatonin (Fig. 1A – F). In the SDmel groups, there was a complete sloughing of the germinal epithelium resulting in the decrease seminiferous epithelial height and accumulation of cellular debris in the lumen of the seminiferous tubules (Fig. 1A). In the SD group, there were vacuolations of the germinal epithelium with deposits of scanty cellular debris in the lumen of the seminiferous tubule (Fig. 1B). However, the germinal epithelium in CTLmel, CTL, LDmel and LD were normal and intact with no cellular debris in the lumen of the seminiferous tubule (Fig. 1C – F).

Histomorphometry

The histomorphometric analysis of the seminiferous tubules revealed marked differences in testicular histoarchitecture in the guinea fowl exposed to different L:D cycle and administered melatonin. There was a significant interaction ($p < 0.0001$) between the L:D cycle and administered melatonin in evaluating SEH (Table 1). The SEH was higher in LD than the CTL while the lowest is the SD group (Table 1). The SEH was not statistically significant ($p > 0.17$) in the L:D cycle only and melatonin only groups. Although the histometric values were slightly higher in the L:D cycle than in the melatonin group (Table 1). There was a significant difference ($p < 0.0001$) in SEH exposed to L:D cycles and administered melatonin. A significant increase was observed in the LDmel than the CTL while LD was slightly lower. In contrast, there was a significant decrease of the SEH in SDmel and SD than the control (Figure 2A).

There was a significant interaction ($p < 0.0001$) between L:D cycles and administered melatonin in

estimating SLD. In comparison with the control, there was a significant increase of SLD in the SD and LD groups. SLD was statistically significant ($p < 0.0001$) between the L:D cycle and melatonin groups. The SLD was higher in the melatonin group than the L:D groups. Across the L:D cycles and administered melatonin groups, there was a significant difference ($p < 0.0001$) in the SLD (Figure 2B). The significant increase was observed in the LDmel, SDmel, and LD groups compared with the control. However, the least SLD was the SD, lower than the control (Figure 2B). There was a significant interaction ($p < 0.001$) between L:D cycles and administered melatonin in determining the STD values. The STD significantly increased in LD and SD compared with the CTL (Figure 2C). There was a significant difference ($p < 0.03$) between the melatonin only and L:D cycle only in the STD. The STD was higher in melatonin groups than in the L:D cycle groups. Across the six groups, there was a significant difference ($p < 0.002$) in STD. It was observed significant increase in all the groups in comparison with the CTL (Figure 2C).

Table 1: Influence of light-dark cycles and administered melatonin in the seminiferous tubule of adult male helmeted guinea fowl (*Numida meleagris*)

Factor	SEH (μm)	SLD (μm)	STD (μm)
L:D Interaction with Mel			
8L:16D	5.35 ^b	85.74 ^b	191.18 ^a
12L:12D	49.69 ^a	81.50 ^b	178.64 ^b
16L:8D	51.07 ^a	100.86 ^a	190.93 ^a
SEM	0.81	2.16	2.68
<i>p</i> value	0.0001*	0.0001*	0.001*
L:D cycle & Mel			
Melanin only	34.74	97.44 ^a	190.48 ^a
L:D only	36.01	81.32 ^b	183.80 ^b
SEM	0.65	1.73	2.18
<i>p</i> value	0.17 ^{ns}	0.0001*	0.03*

L:D – Light-Dark cycle, Mel – Melatonin, SEH – Epithelial height, SLD – Luminal diameter, STD – Tubular diameter, SEM – Standard Error of Mean, Columns with alphabet superscript (a and b) are statistically significant

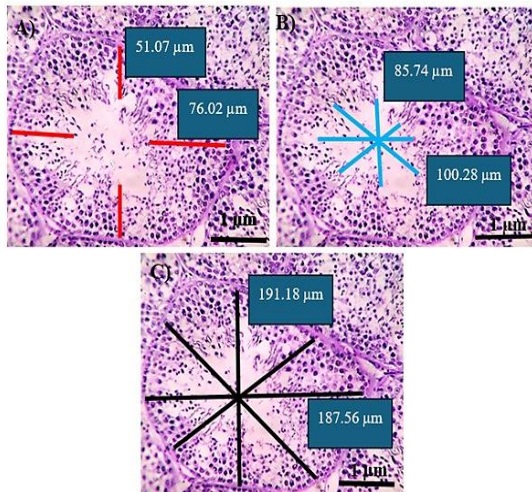


Figure 1: Photomicrograph demonstrating the measurement of histomorphometric values of the seminiferous tubules of guinea fowls exposed to light-dark cycle and exogenous melatonin (A) seminiferous epithelial height (B) seminiferous luminal diameter and (C) seminiferous tubular diameter. H & E stain. Scale bars: (A), (B) and (C) 1 µm

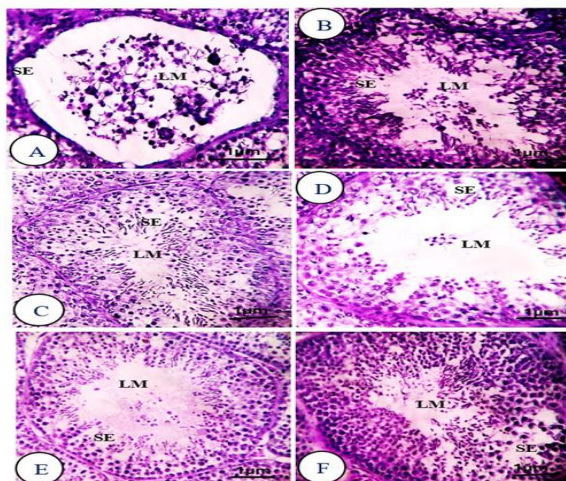


Figure 2. Light micrograph of guinea fowls (*Numida meleagris*) seminiferous tubule exposed to different L:D cycle and melatonin. (A) shows degenerated seminiferous epithelium (SE) and clumped cellular debris in the lumen (LM) of seminiferous tubule of the guinea fowl exposed to SDmel (short day + melatonin). (B) shows vacuolated seminiferous epithelium with scanty cellular debris in the lumen (LM) of seminiferous tubule of the guinea fowl exposed to SD (short day only). (C–F) shows normal seminiferous epithelium (SE) with evidence of scanty to empty lumen (LM) of the seminiferous tubule of the guinea fowls in CTMEL (control + melatonin), CTL (control only), LDMEL (long day + melatonin) and LD (long day only) respectively. H & E stain. Scale bars: (A–F) 1 µm

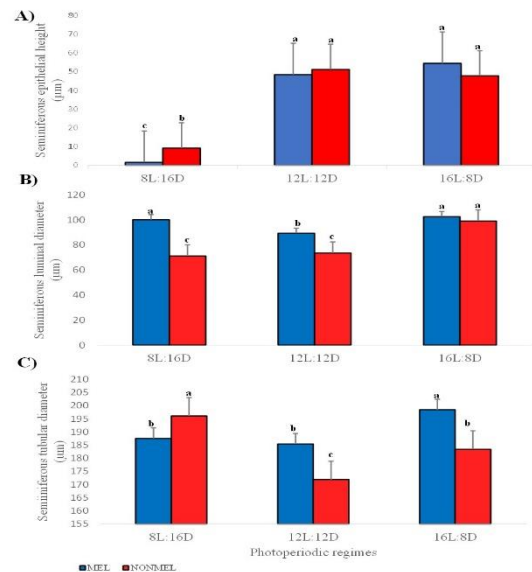


Figure 3: Charts illustrating testicular histomorphometry of helmeted guinea fowls exposed to light – dark cycles and exogenous melatonin. (A) Seminiferous epithelial height ($p < 0.05$) (B) Seminiferous luminal diameter ($p < 0.05$) (C) Seminiferous tubular diameter ($p < 0.05$). Bars with different alphabet superscripts (a – c) are significantly different

Discussion

This study demonstrates that artificial light regimes and melatonin significantly influence testicular histomorphometry and could modulates the reproductive activities of the guinea fowl (Gosomji et al., 2025). The densely or increased germinal epithelium as observed in the LD and LDMEL groups indicate increased spermatogenic activities. This is possible because LD photostimulates the hypothalamic-pituitary-gonadal axis resulting to increase reproductive activities. Contrary to the findings in LD, there was a decreased SEH in the SD and SDMEL groups. The drastic decrease in the SEH was as a result of physiological involution during the reproductive quiescent or resting phase of the reproductive cycle (Dixit and Singh, 2014; Shil et al., 2015; Dharani et al., 2017; Dharani et al., 2018). The variation of the luminal and tubular diameter (SLD and STD) in this study reflects the volume of sperm production (Sertoli, 2018; Islam et al., 2021). Increase in luminal and tubular diameters in the LD and LDMEL indicate that the guinea fowl testes are in active reproductive phase. This corroborates the findings in guinea fowl (Dhanari et al., 2018), quail (Shil et al., 2015) and jungle crow (Islam et al., 2010). The stimulatory effects of LD results in increased testicular size and hormonal activity demonstrating that photoperiod is a key

environmental regulator of male reproduction (Gosomji *et al.*, 2024).

The increase SEH reflects increased spermatogenic cells and increase SLD refers to increased tubular fluid secretion and sperm accumulation (Olawuyi *et al.*, 2019; Akhtar *et al.*, 2020). However, the partial reduction of STD in LD group indicates that the stimulation is not accompanied by proportional structural increase of the tubules (Caneguim *et al.*, 2009). Evidence shows that continuous light exposure can reduce seminiferous tubular diameter and alter testicular morphology alongside changes in reproductive hormone levels (Jiang *et al.*, 2022; Travacic *et al.*, 2025). The increase in STD in addition to the LDMel could be that melatonin ameliorates the scavenging effect of reactive oxygen species and as such enhances the activities of antioxidant enzymes associated with rapid growth or high-intensity lighting (Gosomji *et al.*, 2024; 2025). In conclusion, increased SEH and SLD with reduced STD in the long photoperiod group is a structurally remodeled spermatogenesis that constantly depend on photoperiod-driven adaptive response rather than uniform tubular growth. This study therefore confirms that long day length plays a key role in stimulating reproductive activity in guinea fowl by photoperiodic regulation of reproductive hormones. Consequently, adopting appropriate and consistent lighting management practices alongside proper nutrition and husbandry will improve production in poultry industry.

Conflict of Interest

There was no conflict of interest

Acknowledgement

Our deepest appreciation to Prof. M.B. Umar (Department of Veterinary Anatomy, Ahmadu Bello University, Zaria, Nigeria), Professor Tom A. Aire (St. George's University, True Blue, Grenada) and Prof. Augustine Arukwe (Norwegian University of Science and Technology, Norway) for their invaluable guidance and mentorship in the designing this experiment.

Authors Contribution

Innocent Jonah **Gosomji**: Conceptualization, Methodology, Investigation, Project administration, Validation, Data curation, Sample analysis, Resources, Writing – initial draft and revision; Abdullahi **Baso**: Methodology, Validation, Resources and Writing revision; Nura Aliyu **Ahmad**: Methodology, Validation, Resources and Writing revision; Mansur **Zubairu**: Sample analysis, Data curation, Data analysis and Validation; Alaphu Sarah **Patrick**: Validation, Data curation and Writing revision.

References

- Akar, M., Çevik M, Kocaman A, Kaya C, Esin B. & Björkman S. (2024). Melatonin Administration Enhances Testicular Volume, Testicular Blood Flow, Semen Parameters and Antioxidant Status during the Non-Breeding Season in Bafra Rams. *Animals* (Basel). 29;14(3): 442. doi: 10.3390/ani14030442.
- Akhtar, M. F., Ahmad, E., Mustafa, S., Chen, Z., Shi, Z., & Shi, F. (2020). Spermiogenesis, Stages of Seminiferous Epithelium and Variations in Seminiferous Tubules during Active States of Spermatogenesis in Yangzhou Goose Ganders. *Animals*, 10(4), 570. <https://doi.org/10.3390/ani10040570>
- Anushi, S.B. (2006). Effect of photoperiod length on body mass and testicular growth in the house sparrow (*Passer domesticus*) and brahminy myna (*Sturnus pagodarum*). *Reprod. Nutr. Dev.* 46, 69–76. doi: 10.1051/rnd:2005065.
- Awad, H., Halawa, F., Mostafa, T., & Atta, H. (2006). Melatonin hormone profile in infertile males. *international journal of andrology*, 29(3): 409-413. doi: 10.1111/j.1365-2605.2005.00624.x
- Bancroft, J. D. and Gamble, M. (2008). Theory and practice of histological techniques (6th edition). *Health Sciences*, USA, pp 53-161
- Banerjee, S. & Chaturvedi, C.M. (2017). Testicular atrophy and reproductive quiescence in photorefractory and scotosensitive quail: Involvement of hypothalamic deep brain photoreceptors and GnRH-GnIH system. *J Photochem Photobiol B Biol.* 175: 254-268. doi: 10.1016/j.jphotobiol.2017.09.005
- Baso, A., Umar, M. B., Sulaiman, M. H., Gosomji, I. J., Omirinde, J. O., Muazu, T. A., Zubairu, M. & Atabo, S. M. (2022). Photoperiodic-dependent morpho-biometric changes in the excurrent duct system of sexually-matured helmeted guinea fowl (*Numida meleagris*). *Sahel J. Vet. Sci.*, 19(3), 28-36. doi:10.54058/saheljvs.v19i3.320
- Bejarano, I., Monllor, F., Marchena, A.M., Ortiz, A., Lozano, G., Jim'enez, M.I., Gaspar, P., García, J.F., Pariente, J.A., Rodríguez, A.B. & Espino, J., (2015). Exogenous melatonin supplementation prevents oxidative stress-evoked DNA damage in human spermatozoa. *J. Pineal Res.* 57, 333–339. doi: 10.1111/jpi.12172.
- Bhattacharya, K., Sengupta, P. & Dutta, S. (2019). Role of melatonin in male reproduction. *Asian Pac. J. Reprod.* 8: 211–219. doi: 10.4103/2305-0500.268142
- Bradshaw, W. E. & Holzapfel, C. (2007). Evolution of animal photoperiodism. *Annu. Rev. Ecol. Evol. Syst.* 38:1-25. doi: 10.1146/annurev.ecolsys.37.091305.110115

- Caneguim, B.H., Cerri, P.S., Spolidório, L.C., Miraglia, S.M. & Sasso-Cerri, E. (2009). Structural alterations in the seminiferous tubules of rats treated with immunosuppressor tacrolimus. *Reprod Biol Endocrinol.* 25 (7):19. doi: 10.1186/1477-7827-7-19.
- Dawson, A., King, V. M., Bentley, G. E. & Ball, G. F. (2001). Photoperiodic control of seasonality in birds. *J. Biol. Rhythms*, 16(4): 365–380.
- Dharani, P., UshaKumary, S., Venkatesan, S., Joseph, C. & Ramesh, G. (2017). Morphometry and histology of the testicular capsule and peritubular tissue of testis of guinea fowl (*Numida meleagris*). *Indian J. Vet. Anat.*, 29 (1): 67-69.
- Dharani, P., UshaKumary, S., Venkatesan, S., Joseph, C. & Ramesh, G. (2018). Morphological Analysis of Testis of the Guinea Fowl (*Numida meleagris*) Under Tropical Savannah Climate of India. *Int. J. Morphol.*, 36(3): 909-914.
- Dixit, A.S. & Singh, N.S. (2011). Photoperiod as a proximate factor in control of seasonality in the subtropical male Tree Sparrow, *Passer montanus*. *Front. Zool.* 8: 1. doi: 10.1186/1742-9994-8-1.
- Dixit, A.S. & Singh, N.S. (2012). Seasonal variation in the sensitivity of the photoperiodic response system and the termination of photorefractoriness in the subtropical tree sparrow (*Passer montanus*). *J Exp Zool Part A.* 317(8): 488-498. doi: 10.1002/jez.1741
- Dixit, A. S., & Singh, N. S. (2014). Photoperiodic control of testicular growth, histomorphology and serum testosterone levels in the male Eurasian tree sparrow: Involvement of circadian rhythm. *Gen. Comp. Endocrinol.*, 208: 5-11. doi: 10.1016/j.ygcen.2014.09.003.
- Fischer, T.W., Kleszczyński, K., Hardkop, L.H., Kruse, N. & Zillikens, D. (2013). Melatonin enhances antioxidative enzyme gene expression (CAT, GPx, SOD), prevents their UVR-induced depletion, and protects against the formation of DNA damage (8-hydroxy-2'-deoxyguanosine) in ex vivo human skin. *J. Pineal Res.* 54: 303–312 doi: 10.1111/jpi.12018.
- Flecknell, P.A., 2015. *Laboratory Animal Anesthesia*. Fourth edn., Academic Press, London U.K, pp. 32–133.
- Gonzalez-Arto, M., Hamilton, T.R., Gallego, M., Gaspar-Torrubia, E., Aguilar, D., Serrano-Blesa, E., Abecia, J.A., Pérez-Pérez, R., Muñoz-Blanco, T. & Cebrián-Pérez, J.A. (2016). Evidence of melatonin synthesis in the ram reproductive tract. *Andrology* 4, 163–171. doi: 10.1111/andr.12117.
- Gosomji, I. J., Bello, U. M., Dzenda, T., Baso, A., Arukwe, A., & Aire, T. A. (2024). Influence of photoperiod and exogenous melatonin on testis morpho-physiology of sexually mature guinea fowl (*Numida meleagris*). *Anim Reprod Sci.*, 263, 107410. doi:10.1016/j.anireprosci.2024.107410
- Gosomji, I. J., Akinsola, O., Baso, A., Ahmed, N., Omirinde, J. O., Azeez, I. A., Plang, N.J., Koplamma, N.B. & Hena, S. A. (2025). Modulatory Effects of Melatonin and Artificial Light on Testicular Morphometry in Guinea Fowl (*Numida meleagris*). *Journal of Veterinary Physiology and Pathology*, 4(4), 64-68. doi: 10.58803/jvpp.v4i4.76
- Hau, M., Wikelski, M., Gwinner, H. & Gwinner, E. (2004). Timing of reproduction in a Darwin's finch: temporal opportunism under spatial constraints. *Oikos*, 106: 489-500. doi: 10.1111/j.0030-1299.2004.13206.x
- Hughes, B.L. (1986). Effects of temperature on reproduction in guinea fowl. *Poult Sci.* 65(1): 186-9. doi: 10.3382/ps.0650186.
- Islam, R., Sultana, N., Ayman, U., Akter, A., Afrose, M. & Haque, Z. (2021). Morphological and morphometric adaptations of testes in broilers induced by glucocorticoid. *Vet Med (Praha)*, 66 (12): 520–529. doi: 10.17221/38/2021-VETMED.
- Islam, M.N., Zhu, Z.B., Aoyama, M. and Sugita, S. (2010). Histological and morphometric analyses of seasonal testicular variations in the Jungle Crow (*Corvus macrorhynchos*). *Anatomical Science International*, 85(3): 121-9. doi:10.1007/s12565-009-0066-6
- Jiang, D.L., Xu, Y.L., Pan, J.Q., Fan, D., Shen, X., Li, W.Y., Ou-Yang, H.J., Xu, D.N., Tian, Y.B. & Huang, Y.M. (2022). Effects of melatonin on testicular function in adult male mice under different photoperiods. *Anim Reprod.* 26;19(3): e20220038. doi: 10.1590/1984-3143-AR2022-0038.
- Juss, T.S., Meddle, S.L., Servant, R.S. & King, V.M. (1993). Melatonin and photoperiodic time measurement in Japanese quail (*Coturnix coturnix japonica*). *Proc. R. Soc. Lond. B* 254, 21–28. doi: 10.1098/rspb.1993.0121.
- Kiernan, J.A. (2015). *Histological and Histochemical Methods: Theory and Practice*. 5th edition, Scion Publishing, p. 571. doi:10.5603/FHC.a2016.0007
- Maitra, S.K. & Dey, M. (1992). Importance of Photoperiods in Determining Temporal Pattern of Annual Testicular Events in Rose-Ringed Parakeet (*Psittacula krameri*). *Journal of Biological Rhythms*, 7(1): 13-25. doi: 10.1177/074873049200700102
- Munley, K.M., Deyoe, J.E., Ren, C.C. & Demas, G.E. (2020). Melatonin mediates seasonal transitions in aggressive behavior and

- circulating androgen profiles in male Siberian hamsters. *Horm Behav.* 117:104608. doi: 10.1016/j.yhbeh.2019.104608.
- Olawuyi, T.S., Ukwenya, V.O., Jimoh, A.G.A. & Akinola, K.B. (2019). Histomorphometric evaluation of seminiferous tubules and stereological assessment of germ cells in testes following administration of aqueous leaf-extract of *Lawsonia inermis* on aluminium-induced oxidative stress in adult Wistar rats. *JBRA Assist Reprod.* 23(1):24–32. doi: 10.5935/1518-0557.20180080
- Oke, O.E., Adejuyigbe, A.E., Idowu, O.P., Sogunle, O.M., Ladokun, A.O., Oso, A.O., Abioja, M. O., Abiona, J.A., Daramola, J. O., Whetto, M., Jacobs, E. B., Williams, T. J., & Njoku, C. P. (2015). Effects of housing systems on reproductive and physiological response of guinea fowl (*Numida meleagris*). *J Appl Anim Res.*, 88: 47-55. Available at: <https://www.cabidigitallibrary.org/doi/full/10.5555/20153192625>
- Okere, K., Kagya-Agyemang, J.K., Annor, S.Y., Asabere-Ameyaw, A. & Kyere, C.G. (2020). Influence of Season and Day Length on Production and Reproductive Traits and Egg Characteristics of the Guinea Fowl (*Numida meleagris*). *Asian J. Res. Zool.* 3(1): 26-34. doi: 10.9734/ajriz/2020/v3i130081.
- Omirinde, J.O., Olukole, S.G. & Oke, B.O. (2021). Age related changes in the testicular morphophysiology of the cane rat (*Thryonomys swinderianus*). *J. Microsc. Ultrastruct.* 9;10(3):118-126. doi: 10.4103/jmau.jmau_84_20.
- Rossi, S.P., Windschuetl, S., Matzkin, M.E., Terradas, C., Ponzio, R., Puigdomenech, E., Levalle, O., Calandra, R., Mayerhofer, A. & Frungieri, M.B. (2014). Melatonin in testes of infertile men: Evidence for anti-proliferative and anti-oxidant effects on local macrophage and mast cell populations. *Andrology* 2, 436–449. doi: 10.1111/j.2047-2927.2014.00207.x.
- Salehi, B., Sharopov, F., Fokou, P.V.T., Kobylinska, A., Jonge, L., Tadio, K., Sharifi-Rad, J., Posmyk, M.M., Martorell, M., Martins, N. & Iriti, M. (2019). Melatonin in medicinal and food plants: occurrence, bioavailability, and health potential for humans. *Cells* 8: 681. doi: 10.3390/cells8070681.
- Sertoli E. (2018). The structure of seminiferous tubules and the development of [spermatids] in rats. *Biol Reprod.* 1;99 (3):482-503. doi: 10.1093/biolre/ioy134.
- Shil, S.K., Abul Quasem, A. & Lutfur, M. (2015). Histological and Morphometric Analysis of Testes of Adult Quail (*Coturnix coturnix japonica*) of Bangladesh Rahma. *Int. J. Morphol.*, 33(1): 100-104.
- Travicic, D. Z., Miljkovic, D., Andric, S. A., & Kostic, T. S. (2025). Circadian disruption impairs Leydig cell maturation and reproductive development in male rats. *Reprod Biol Endocrinol* 23, 104 (2025). <https://doi.org/10.1186/s12958-025-01440-w>
- Umosen, A.D., Oneyeanusi, B.I., Salami, S.O., Nzalak, J.O., Imam, J. and Ibe, C.S. (2008) observation on the wattle of adult helmeted Guinea fowl (*Numida meleagris galeata*) *Int. J. Poult. Sci.*, 7(12):1204-1206. doi:10.3923/ijps.2008.1204.1206
- Yan, L., Feng, M., Feng, C., Chen, Z., Sun, X., Zhaorigetu, Guo, B. & Zhu, H. (2026). Photoperiodic schedules during rearing and laying stages modulate photoreceptors transcription and the hypothalamic-pituitary-testicular axis in male White King pigeons. *Poult. Sci.*, 105(3):106367. doi: 10.1016/j.psj.2025.106367.
- Yie, S.M., Daya, S., Brown, G.M., Deys, L. & YoungLai, E.V. (1991), Melatonin and aromatase stimulating activity of human seminal plasma. *Andrologia*, 23: 227-231. doi: 10.1111/j.1439-0272.1991.tb02543.x