Effect of Seasons on Reproductive Hormonal Profiles In Yankasa Sheep (Short communication)

Ayoola J. Shoyombo[1] , Ake A. Moses[1], Mustapha A. Popoola[2], Comfort I. Ukim[2], Hosea Yakubu[3], Muslim K. Ewuola[3], Jubril A. Egbeyan[3], Jacob Kuusu[1], Oluronke A. Bolatito[4], Abiodun A. Idowu[1]

[1]College of Agricultural sciences, Department of Animal Science, Landmark University, Omu-aran, Kwara state, Nigeria, [2]Tertiary Education Trust Fund, Abuja, Nigeria, [3]Faculty of Agriculture, Department of Animal Science, University of Abuja, Nigeria, [4]Federal College of Animal Health and Production Technology Moor Plantation, Ibadan Oyo state.

Abstract

Aside nutrition, disease infestations and external factors, seasonal change is another factor that influences the performance of sheep. For a better understanding of the effects of seasonal changes on sheep Six (6) Rams and Six (6) Ewes of Yankassa breed of sheep were sampled at Landmark University Teaching and Research farms during the rainy season and then the same animals were utilized for the experiment during the dry season. For the rams, findings showed that there was no any significant difference between seasons for the hormones understudied, i.e. no difference between seasons ($P > 0.05$). In contrary, for yankassa ewes, the values obtained for the follicle-stimulating hormone or FSH (0.823 ± 0.56) during the dry season differed from that of the wet season FSH (0.182 ± 0.08). However, there was no any significant difference between the seasons for testosterone, progesterone, estradiol and leutinizing hormone understudied, that is, $p > 0.05$.

Keywords: seasonal change, testosterone, wet season, progesterone, Yankassa

INTRODUCTION:

The body of an animal is made up of different cells, tissues, organs and systems all of which must work together harmoniously to exhibit vital life processes needed for their survival. Also, for these life processes to occur with ease, for instance, animal fertility, there is a need to involve chemical messengers known as hormones (Pfeifer and Allen, 2021).

However, the effects of climate on the efficiency and functions of these vital chemical messengers (hormones) cannot be overemphasized. When temperature exceeds the normal range, the functioning of the neuroendocrine system and the natural bodily homeostatic balance become abridged (Beckford *et al.*, 2020; Van der Klein, *et al.*, 2020; Okon *et al.*, 2021). Even though, sheep that are domesticated in the temperate can be made to easily adapt to their local climatic conditions (Arowolo *et al.*, 2019). Yet, sheep naturally are seasonal breeders and in order to satisfy the current hunger for mutton, we must understand how their hormonal profile is structured and/or may be supplemented for all year-round production.

Aside from this, sheep that are kept in tropical climatic regions are often producing different outputs and yield because of the heat stress borne out of the combined effect of humidity and ambient temperature values (Ayo *et al.*, 2011; Ayo and Ogbuagu, 2021). The normal functioning of the reproductive hormones in livestock can be suppressed when the heat is excessive (Koubkova *et al.*, 2002). Light as another attribute of seasons is a key player in this subject. The duration and availability of light play a major role in animal behaviour, reproduction and output products such as mutton, eggs and the likes (Sarma *et al.*, 2019).

There is a relationship between the duration of the light and fertilization. The level of warmth or coldness of an animal affects the testicular functioning and spermatozoa formation (McDaniel *et al.*, 2004; Igbokwe, 2018). For sheep, temperature within and without also affects sperm cell manufacturing and the release of testosterone (Igbokwe, 2018)

In the quest for efficient research and food production so as to enhance food security especially the availability of animal

proteins, it is important to understand that there is a link between the performance of sheep and the period or seasons when they are reproduced (El Kadili S.*et al.*, 2019).

1.2 Seasons and their Impact on Sheep Production;

Livestock farming is sensitive to the minute change in weather and several authors have studied the effects of climate on sheep production as well as other small ruminants **(**Sarmal *et al.*, 2019; Vandana *et al.*, 2021). Even though the use of meteorological tools has made weather forecasting possible as a guide for sheep breeding (Loboguerrero *et al.*, 2018), we must not downplay the impact of stress caused by heat (Igbokwe, 2018; Wasti *et al.*, 2020). Heat stress also makes the animal uneasy (Ranjan *et al.*, 2019). Seasonal change had a limiting effect on the rate of follicular development in ewes which is a prerequisite for sexual maturity (Hidayat, 2020).

From previous researches, another reason why we must pay attention to the study of seasons and climate change in relation to their effect on the efficiency of sheep is that when the elements of climate become unsuitable for survival, sheep tend to have their reproductive endeavors and productivity suppressed (Ozawa *et al.*, 2005). Even though, this seasonal or climate changes vary from one geographical area to another where these sheep are under husbandry, yet, aside from nutrition and other factors, climate is a strong determinant of their output in terms of productivity and (prolificacy) or reproduction (Oliveira *et al.*, 2013).

Therefore, the aim of this study is to understand the effects of seasonal changes (Climate) not only on the hormonal profiles of sheep (ram and ewes), but to also arrive at a logical conclusion which can be a good basis for future research and recommendation

1.3Wet Season as a Case Study:

Sheep perform maximally under cool temperatures in the wet season (Khan *et al.*, 2011). Notable authors have concluded in their work that other elements of weather such as the relative humidity and ambient temperature can compromise the welfare of sheep when in extremity (Habeeb *et al.*, 2018).

1.4 Dry Season as a Case Study:

During the harmattan period, Nigerian sheep are faced with respiratory difficulty coming from dust prevalence caused by the wind, water shortage due to dryness at noon period, and general unconducive environment which would also affect reproductive activities and the associated hormones (Akagha and Nwagbara, 2021). In places where the heat is not effectively managed, sheep under husbandry are often victims of heat stress which could result in reduced reproductive activities and death (lethal effect) in some cases (Egbuniwe *et al.*, 2018; Kang *et al.*, 2020).

1.5 Reproductive hormones and Ovulation

The follicle-stimulating hormone and the luteinizing hormones are usually erratic in cases when the environmental temperature is beyond the normal range for sheep (Rozenboim *et al.*, 2004).

1.6 Progesterone :

One of the ways in which there is a transference of valuable traits that are hereditary from one generation to the next is through pregnancy and progesterone (blood progesterone) which is the pregnancy hormone, actually configure the uterus for the purpose of foetal implantation and maintenance (Rahman, 2006).

To care for the pregnant ewe maximally, it is important to know the number of fetuses inside the uterus through ultrasonography (Medan *et al.*, 2004)

1.7Effect of Nutrition:

Although the testosterone is a hormone that greatly influences the reproductive acumen of rams, the quality of the feed materials that the animal consumes also influence spermatogenesis and its sexual features (El Kadili S. *et al.*, 2019)

Aside the effects of these weather elements on the configuration of sheep hormonal profile, seasons also influence the outbreak of diseases and not just in rams, other livestock such cattle have been proven by (Tran L.V. *et al.*, 2016) that nutrition actually affect the rate of sexual activities .

2.0MATERIAL AND METHOD

2.1Experimental site

This study was conducted at the Teachings and Research farm of Landmark University, Kwara State, located between Latitude 8 0 05" and 10 0 05" North and Longitude 20 50' and 60 05' East of Greenwich Meridian. Experimental animals were sampled from the farm and subjected to an adjustment period of one week before the start of the experiment. Animals were housed in a closed shed with sufficient ventilation to allow heat and moisture to escape in a completely randomized design. Appropriate feeding, medication and watering facilities were provided within the housing system for the duration of the research.

2.2Ethical statement

Landmark University Ethics Committee, Landmark University, Omu-Aran, Kwara State, Nigeria, approved the current study. This research followed every laid down ethical principle and standard necessary for animal care and use.

2.3Experimental animals and sample collection

The experiment was carried out with **t**welve (12) Yankassa sheep breed with an equal number of healthy rams and ewes of about 3-5 years old, and **the samples were taken when the ewes were not cycling . Aside from the rams and ewes being housed individually in a closed shed with sufficient ventilation, they were also placed on the same plan of nutrition throughout the experimental period. Although day length was monitored to be the same for both periods under study, the observations for their hormonal changes were recorded for the rams and ewes during the dry season, . This was also repeated for the wet season**. The animals were also maintained without replacement for the duration of the research. Whole blood (5ml) was collected via jugular venipuncture from the sheep into heparin tubes at 6 hours intervals throughout the day using a needle and syringe. Blood collection was done by restricting the animal in a way that to and fro movement would be disallowed. Samples were collected at the peak of the rainy and dry seasons, respectively. After the blood sample was collected, the blood sample was allowed to rest for 24 hours. After 24 hours, the blood sample was centrifuged at 1000RPM using a centrifuge machine.

The supernatant (serum) was decanted with a micropipette and deposited in another plain bottle. Plain bottles containing serum were stored in freezers until further laboratory procedures where Follicle Stimulating Hormone (FSH), Luteinizing Hormone (LH), Testosterone, Estradiol and Progesterone were analyzed from the collected serum with enzyme-linked immunosorbent assay kits (Monobind Inc. Lake Forest, CA 92630, USA). These hormones were estimated using a 96-well transparent polypropylene microplate using an Alere Microplate Reader (Alere Medical Pvt Ltd, India, AM 2100).

STATISTICAL ANALYSIS

The means of the samples were compared using a t-test, with the level of significant difference set at ($p<0.05$). The SAS program was used to conduct this analysis (version 9.4)

3.RESULTS AND DISCUSSION

Upon completion of this research work, the results obtained for the influence of wet and dry seasons on the hormonal profiles of sheep were analysed and documented.

In Yankassa Ram, except for numerical differences recorded for both seasons, there was no significant difference ($P>0.05$) across the hormonal profile understudied during the period of wet and dry seasons.

Although hormones such as FSH, Testosterone, Estradiol and Progesterone were higher during the wet season than the result obtained for the dry season, the reverse was the case for Leutinizing hormone because it was higher (2.488 ± 0.75) during the dry season than wet season (1.937 ± 0.84). Testosterone in ram was higher during the wet season than in the dry season. The reason could be because of the relevance of this hormone to create pheromones so as to attract the ewes for sexual reproduction (Fan *et al.*, 2018; Trova *et al.*, 2021) . Even though, it is suggested that this research should not just be replicated but also given utmost priority in different geographical areas, the sperm volume of rams as well as the fertility are not usually affected by seasonal changes (D'Alessandro A. 2003). In addition, temperate regions gave the same result as recorded by (Avdi M. *et al.*, 2004). Despite the fact that the size of the scrota sac in rams play a role in the quantity of the semen being produced (El Kadili S. *et al.*, 2019), rams are animals that reproduce seasonally and so, during the times when there is no breeding (non

- breeding season), there is a reduction in the number of reproductive activities. From the reports of Al-Anazi *et al.*,2017 the degree of acidic or alkalinity of the semen of sheep is sensitive to season. The fact that seasonal changes usually exert some influence on FSH, LH and testosterone was further verified by (Dardente H. *et al.*, 2016). From this study, the rams were more active sexually during the wet season than dry season . A good reason for this could be because of the increase in testosterone. Seasons according to (Benmoula A. *et al.*, 2017; Ntemka A. *et al.*, 2019; Ngcobo J.N. *et al* 2020) most times, never affect the reproductive activities and functions of ram.

PARAMETERS	MEAN ± SE (DRY SEASON)	MEAN ± SE (WET SEASON)	P – VALUE
FSH (mIU/ml)	0.823 ± 0.56	0.182 ± 0.08	0.0005
TESTOSTERONE (ng/ml)	1.198 ± 0.32	0.632 ± 0.24	0.1865
ESTRADIOL (pg/ml)	152.7 ± 9.29	153.5 ± 8.18	0.7877
PROGESTERONE (ng/ml)	7.278 ± 1.37	6.693 ± 2.16	0.3439
LH (mIU/ml)	2.618 ± 0.86	3.155 ± 0.75	0.6508

Hence, we can therefore conclude that the sheep exhibited increased sexual activities, as well as normal sperm cells production during wet seasons.

Similarly, the changes brought about by seasonal differences on the hormonal performance of Yankassa ewes were documented. For the ewes, there was no any major significant difference (p>0.05) in the values for Leutinizing hormone, Testosterone, Estradiol and progesterone after the end of both wet and dry seasons. The result for the leutinizing hormone in Yankassa ewes showed that more of the hormone was released during the wet season (3.155 ± 0.75) than the dry season (2.618 ± 0.86). Previous studies by some scholars (Benmoula A. *et al.* 2017; Ntemka A. *et al.* 2019) ascertained the fact that some breeds of Sheep never displayed any behavioral or reproductive changes despite different seasons . (Ngcobo J.N. *et al.* 2020) also did some research work on this and discovered that no change was recorded despite seasonal changes. This also coinceded with the findings of this research because at the end of the experiment, there was no significant difference (P>0.05) in the reproductive hormones of sheep except the numerical differences that was recorded across the two seasons.

In contrast, where the LH level was higher during the dry season (2.488 ± 0.75) for Yankassa rams, the value obtained for ewes was higher during the wet season (3.155 ± 0.75). Estradiol was also greater during the wet season for ewes than that of the ram. In ewes, except for the numerical differences observed across the seasons, testosterone had no significant change (P>0.05) for both dry and wet seasons. A similar result was recorded for the rams, hence; this further indicated that seasons did not exert any major effect on testosterone level in Yankassa Sheep. In the same vein and as derived from this study, seasons had no significant effect on FSH in Yankassa rams. Aside from the numerical differences between the dry and wet seasons, the value obtained for FSH during wet season (0.608 ± 0.14) was greater than that of the dry season (0.476 ± 0.11). Whereas in male sheep a greater concentration of FSH was at Sertoli cells of the testes, more of this hormone is directed in the ovary at granulosa cells (Creasy and Chapin, 2013; Wang *et al.*, 2021).

Table 1 Seasonal effect of the Wet and Dry on the hormonal profile in Yankassa Ewes

Means within rows with P < 0.05 are significantly different

Table 2 Effect of the Wet and Dry Seasons on Hormonal Profiles of Yankasa Rams

PARAMETERS	MEAN ± SE (DRY SEASON)	MEAN ± SE (WET SEASON)	P – VALUE
FSH (mIU/ml)	0.476 ± 0.11	0.608 ± 0.14	0.4664
TESTOSTERONE (ng/ml)	4.160 ± 1.53	5.873 ± 1.88	0.4963
ESTRADIOL (pg/ml)	76.167 ± 9.05	80.833 ± 13.91	0.3674
PROGESTERONE (ng/ml)	1.333 ± 0.38	1.590 ± 0.38	0.6476
LH (mIU/ml)	2.488 ± 0.75	1.937 ± 0.84	0.6356

Means within rows with P < 0.05 are significantly different

Considering the result for the Leutinizing hormone for Yankassa ewes, the dry and wet seasons did not exert any significant difference (P>0.05) but there was a numerical difference for both seasons. Whereas the value for Leutinizing hormone was higher during the wet season (3.155 ± 0.75) as against (2.618 ± 0.86) for the dry season for ewes under study, this same hormone was higher in the dry season (2.488 ± 0.75) than that of the wet season (1.937 ± 0.84) for Yankassa rams under study. Categorically, the LH enhances the production of testosterone in males **(**Cardoso and Padmanabhan, 2019 **)** but the discrepancy in the values of LH for the ram and ewes during both seasons could be attributed to different weather conditions. A similar finding was recorded by **(**Salles *et al.*, 2020). Progesterone secretion was recorded to be higher during the wet season for ewes **(**Stephens and Johnson, 2020**)** but the findings from this experimental study showed that Progesterone was higher during the dry season (7.278 ± 1.37) than during the wet season (6.693 ± 2.16) this may be due to the fact that progesterone prepares the uterus to be able to accommodate the incoming oocytes for pregnancy **(**Inoue *et al.*, 2019).

4 Conclusion

Both dry and wet seasons play a major role regarding the reproductive and productive activities of the sheep. Naturally, there are more available water and feeding resources during wet seasons than that obtainable from dry seasons. Yet the effects of changes in seasons must not be down played with regards to sheep reproduction. Furthermore, the report of this study presented some numeric variances in the means of the hormones understudied, yet, it can be inferred that seasonal changes did not exert any significant difference on the hormonal profile of Yankassa sheep.

Funding

This particular research was not granted any funds or support by public agencies, commercial or not-for-profit sectors.

Acknowledgement:

My sincere appreciation goes to members of faculty of Landmark University, for their support and commitment to this research, as well as ensuring that this manuscript is nothing short of quality. Last but not the least, I acknowledge the students and staff of Landmark University Teaching and Research farms for being there during the research.

Author's contribution

Ayoola J. Shoyombo[1] , Conceptualization, Data Curation, Writing, Formal analysis, Project Administration; **Ake A. Moses[1],** Funding acquisition, Investigation**; Mustapha A. Popoola[2],** Methodology, Resources, Data Curation ; **Comfort I. Ukim[2],** Software, Supervision; **Hosea Yakubu[3],** Validation, Visualization; **Muslim K. Ewuola[3],** Writing, Original draft; **Jubril A. Egbeyan[3],** Supervision, Visualization; **Jacob Kuusu[1],** Project Administration, Resources; **Oluronke A. Bolatito[4],** Data Curation, Funding acquisition; **Abiodun A. Idowu[1],** Review, Writing .

All the respective authors did read through the manuscript and then agreed that it should be published

REFERENCES

1. Akagha, N., & Nwagbara, M. (2021). Effects of Season on Disease Frequency and Mortality of Sheep in Owerri Urban South-Eastern Nigeria. International Journal of Environment, Agriculture and Biotechnology, 6, 3.
2. Al-Anazi Y., Al-Mutary M.G., Al-Ghadi M., Alfuraiji M.M., Al-himaidi A.R., Ammari A. Seasonal Variations in Scrotal Circumference and Semen Characteristics of Naimi and Najdi Rams in Saudi Arabia. *S. Afr. J. Anim. Sci.* 2017;47:454. doi: 10.4314/sajas.v47i4.4. [CrossRef] [Google Scholar]
3. Arowolo, M. A., He, J. H., He, S. P., & Adebowale, T. O. (2019). The implication of lighting programmes in intensive broiler production system. World's Sheep Science Journal, 75(1), 17-28.
4. Avdi M., Banos G., Stefos K., Chemineau P. Seasonal Variation in Testicular Volume and Sexual Behavior of Chios and Serres Rams. *Theriogenology*. 2004;62:275–282. doi: 10.1016/j.theriogenology.2003.10.004. [PubMed] [CrossRef] [Google Scholar]
5. Ayo, J. O., & Ogbuagu, N. E. (2021). Heat stress, haematology and small intestinal morphology in broiler chickens: insight into impact and antioxidant-induced amelioration. World's Sheep Science Journal, 77(4), 949-968.
6. Ayo, J. O., Obidi, J. A., & Rekwot, P. I. (2011). Effects of heat stress on the well-being, fertility, and hatchability of chickens in the northern Guinea savannah zone of Nigeria: a review. International Scholarly Research Notices, 2011.
7. Beckford, R. C., Ellestad, L. E., Proszkowiec-Weglarz, M., Farley, L., Brady, K., Angel, R., ... & Porter, T. E. (2020). Effects of heat stress on performance, blood chemistry, and hypothalamic and pituitary mRNA expression in broiler chickens. Sheep Science, 99(12), 6317-6325.
8. Benmoula A., Badi A., El Fadili M., EL Khalil K., Allai L., El Hilali A., El Amiri B. Effect of Season on Scrotal Circumference, Semen Characteristics, Seminal Plasma Composition and Spermatozoa Motility during Liquid Storage in INRA180 Rams. *Anim. Reprod. Sci.* 2017;180:17–22. doi: 10.1016/j.anireprosci.2017.02.008. [PubMed] [CrossRef] [Google Scholar]
9. Cardoso, R. C., & Padmanabhan, V. (2019). Developmental programming of PCOS traits: insights from the sheep. Medical sciences, 7(7), 79.
10. Creasy, D. M., & Chapin, R. E. (2013). Male reproductive system. Haschek and Rousseaux's handbook of Toxicologic Pathology, 2493-2598.
11. D'Alessandro A. Evaluation of Seasonal Variations of Semen Freezability in Leccese Ram. *Anim. Reprod. Sci.* 2003;79:93–102. doi: 10.1016/S0378-4320(03)00113-1. [PubMed] [CrossRef] [Google Scholar]
12. Dardente H., Lomet D., Robert V., Decourt C., Beltramo M., Pellicer-Rubio M.-T. Seasonal Breeding in Mammals: From Basic Science to Applications and back. *Theriogenology.* 2016;86:324–332.
13. Egbuniwe, I. C., Ayo, J. O., & Ocheja, O. B. (2018). Betaine and ascorbic acid modulate indoor behavior and some performance indicators of broiler chickens in response to hot-dry season. Journal of thermal biology, 76, 38-44.
14. El Kadili S., Raes M., Bister J.-L., Archa B., Chentouf M., Kirschvink N. Effect of Season on Sexual Behavior, Testicular Measurements and Seminal Characteristics in "Beni Arouss" North Moroccan Bucks. *Anim. Reprod. Sci.* 2019;201:41–54. doi: 10.1016/j.anireprosci.2018.12.007. [PubMed] [CrossRef] [Google Scholar]
15. Fan, M., Zhang, M., Shi, M., Zhang, T., Qi, L., Yu, J., ... & Liu, S. (2018). Sex hormones play roles in determining musk composition during the early stages of musk secretion by musk deer (Moschus berezovskii). Endocrine journal, 65(11), 1111-1120.
16. Habeeb, A. A., Gad, A. E., & Atta, M. A. (2018). Temperature-humidity indices as indicators to heat stress of climatic conditions with relation to production and reproduction of farm animals. Int J Biotechnol Recent Adv, 1(1), 35-50.
17. Hidayat, C. (2020, March). Reducing Negative Effect of Heat Stress In Broiler Through Nutritional And Feeding Strategy. In IOP Conference Series: Earth and Environmental

Science (Vol. 465, No. 1, p. 012034). IOP Publishing. https://www.researchgate.net/publication/259865707/download

18. Igbokwe, N. A. (2018). Effects of environmental heat stress on reproduction and its management in sheep. Nigerian Veterinary Journal, 39(2), 101. https://doi.org/10.4314/nvj.v39i2.2
19. Inoue, S., Yang, R., Tantry, A., Davis, C. H., Yang, T., Knoedler, J. R., ... & Shah, N. M. (2019). Periodic remodeling in a neural circuit governs timing of female sexual behavior. Cell, 179(6), 1393-1408.
20. Kang, S., Kim, D. H., Lee, S., Lee, T., Lee, K. W., Chang, H. H., ... & Choi, Y. H. (2020). An acute, rather than progressive, increase in temperature-humidity index has severe effects on mortality in laying hens. Frontiers in Veterinary Science, 7, 853.
21. Khan, R. U., Naz, S., Nikousefat, Z., Tufarelli, V., Javdani, M., Rana, N., & Laudadio, V. (2011). Effect of vitamin E in heat-stressed sheep. World's sheep science journal, 67(3), 469-478.
22. Koubkova M, Haertlova H, Knizkova I, Kunc P, Flusser J, Dolezal O. Influence of high environmental temperatures and evaporative cooling on some physiological, hematological and biochemical parameters in high yielding dairy cows. Czech Journal of Animal Science-UZPI (Czech Republic) 2002:309-318.
23. Loboguerrero, A. M., Boshell, F., León, G., Martinez-Baron, D., Giraldo, D., Mejía, L. R., ... & Cock, J. (2018). Bridging the gap between climate science and farmers in Colombia. Climate Risk Management, 22, 67-81.
24. McDaniel, C. D., Hood, J. E., & Parker, H. M. (2004). An attempt at alleviating heat stress infertility in male broiler breeder chickens with dietary ascorbic acid. Int. J. Poult. Sci, 3(9), 593-602.
25. Medan M, Watanabe G, Absy G, Sasaki K, Sharawy S, Taya K(2004). Early pregnancy diagnosis by means of ultrasonography as a method of improving reproductive efficiency in goats. J. Reprod. Dev. 50(4): 391-397.
26. Ngcobo J.N., Nephawe K.A., Maqhashu A., Nedambale T.L. Seasonal Variations in Semen Parameters of Zulu Rams Preserved at 10 °C for 72 H During Breeding and Non-Breeding Season. *Am. J. Anim. Vet. Sci.* 2020;15:226–239. doi: 10.3844/ajavsp.2020.226.239. [CrossRef] [Google Scholar]
27. Ntemka A., Kiossis E., Boscos C., Theodoridis A., Kourousekos G., Tsakmakidis I. Impact of Old Age and Season on Chios Ram Semen Quality. *Small Rumin. Res.* 2019;178:15–17. doi: 10.1016/j.smallrumres.2019.07.004. [CrossRef] [Google Scholar]
28. Okon, E. M., Falana, B. M., Solaja, S. O., Yakubu, S. O., Alabi, O. O., Okikiola, B. T., ... & Edeme, A. B. (2021). Systematic review of climate change impact research in Nigeria: implication for sustainable development. Heliyon, 7(9), e07941.
29. Oliveira MEF, Sousa HLL, Moura ACB, Vicente WRR, Rodrigues LFS, Araújo AA. The effects of parturition season and suckling mode on the puerperium of Santa Ines ewes and on the weight gain of lambs. *Arq Bras Med Vet Zootec*. 2013;65:857–864. doi: 10.1590/S0102-09352013000300035. [CrossRef] [Google Scholar]
30. Ozawa M, Tabayashi D, Latief TA, Shimizu T, Oshima I, Kanai Y. Alterations in follicular dynamics and steroidogenic abilities induced by heat stress during follicular recruitment in goats. *Reprod.* 2005;129:621–630. doi: 10.1530/rep.1.00456. [PubMed] [CrossRef] [Google Scholar]
31. Pfeifer, J. H., and Allen, N. B. (2021) Puberty initiates cascading relationships between neurodevelopmental, social, and internalizing processes across adolescence. Biological Psychiatry, 89(2), 99-108.
32. Rahman ANMA (2006). Hormonal changes in the uterus during pregnancy- lessons from the ewe: A review. J. Agric. Rural Dev. 4(1): 1-7.
33. Ranjan, A., Sinha, R., Devi, I., Rahim, A., & Tiwari, S. (2019). Effect of heat stress on sheep production and their managemental approaches. Int. J. Curr. Microbiol. Appl. Sci, 8, 1548-1555.
34. Robinson JJ, Ashworth CJ, Rooke JA, Mitchell LM, McEvoy TG (2006). Nutrition and fertility in ruminant livestock. Anim. Feed Sci. Technol. 126(3-4): 259-276.

35. Rozenboim, I., Mobarky, N., Heiblum, R., Chaiseha, Y., Kang, S. W., Biran, I., ... & El Halawani, M. E. (2004). The role of prolactin in reproductive failure associated with heat stress in the domestic turkey. Biology of reproduction, 71(4), 1208-1213.
36. Salles, M. G., Viana Neto, A. M., Vieira Neto, M. F., Rodrigues, I., da Rocha, D. R., de Souza Carneiro, P. T., & de Araújo, A. A. (2020). Tropical climate induces seasonal changes in the reproductive parameters and hormonal profile of Saanen bucks. Veterinarski arhiv, 90(3), 235-242.
37. Sarma, M., Borah, M. K., Kalita, K. P., Mahanta, J. D., Kalita, N., Talukdar, J. K., ... & Islam, R. (2019). Effect of Season on Performance of Broiler Chicken under Deep Litter System of Management in Assam. Int. J. Livestock Res, 9(7), 246-253.
38. Stephens, C. S., & Johnson, P. A. (2020). Reproductive physiology of sheep. In Animal Agriculture (pp. 331-347). Academic Press.
39. Tran L.V., Malla B.A., Kumar S., Tyagi A.K. Polyunsaturated Fatty Acids in Male Ruminant Reproduction—A Review. *Asian-Australas. J. Anim. Sci.* 2016;30:622–637. doi: 10.5713/ajas.15.1034. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
40. Trova, S., Bovetti, S., Bonzano, S., De Marchis, S., & Peretto, P. (2021). Sex Steroids and the Shaping of the Peripubertal Brain: The Sexual-Dimorphic Set-Up of Adult Neurogenesis. International Journal of Molecular Sciences, 22(15), 7984.
41. Van der Klein, S. A., Zuidhof, M. J., & Bédécarrats, G. Y. (2020). Diurnal and seasonal dynamics affecting egg production in meat chickens: A review of mechanisms associated with reproductive dysregulation. Animal reproduction science, 213, 106257.
42. Vandana, G. D., Sejan, V., Lees, A. M., Pragna, P., Silpa, M. V., & Maloney, S. K. (2021). Heat stress and sheep production: impact and amelioration. International Journal of Biometeorology, 65(2), 163-179.
43. Wang, H. Q., Zhang, W. D., Yuan, B., & Zhang, J. B. (2021). Advances in the regulation of mammalian follicle-stimulating hormone secretion. Animals, 11(4), 1134.
44. Wasti, S., Sah, N., & Mishra, B. (2020). Impact of heat stress on sheep health and performances, and potential mitigation strategies. Animals, 10(8), 1266.

Authors:

First Author - Ayoola J. Shoyombo, Dept. osf Animal Science, Landmark University, P.M.B. 1001, Omu Aran, Kwara State, Nigeria.

Second Author - Abiodun A. Idowu

Third Author - Ake A. Moses

Fourth Author - Mustapha A. Popoola

Fifth Author - Comfort I. Ukim

Sixth Author - Hosea Yakubu

Seventh Author – Muslim K. Ewuola

Eight Author– Jubril A. Egbeyan

Ninth Author– Jacob Kuusu

Tenth Author – Oluronke A. Bolatito

Correspondence Author – Abiodun Adebayo Idowu

Department of Animal Science, Landmark University, Omu-aran, Nigeria,