LE STUDIUM
Loire Valley
Institute for Advanced Studies

LE STUDIUM Interdisciplinary Journal
ISSN 2669-7808
www.lestudium-ias.com

FELLOWSHIP FINAL REPORT

Balance between feed efficiency and bone health in free-range broilers reared under global warming conditions

François Djitie Kouatcho[1,3], Agnès Narcy[2], Sandrine Mignon[2]

[1] University of Ngaoundéré, Cameroon
[2] UMR BOA, Genetics, Nutrition and Systems (Genuts) research team, INRAE Centre Val de Loire, Nouzilly site
[3] LE STUDIUM Institute for Advanced Studies, 45000 Orléans, France

REPORT INFO

Fellow: **Professor François Djitie Kouatcho**
From: University of Ngaoundéré, Cameroon
Host laboratory in region Centre-Val de Loire: UMR BOA, Genetics, Nutrition and Systems (Genuts) research team, INRAE Centre Val de Loire, Nouzilly site
Host scientists: **Doctors Agnès Narcy and Sandrine Mignon**
Period of residence in region Centre-Val de Loire: Feb 2025 – Nov 2025

Keywords:
Poultry production, Bone health, Feed efficiency, Thermal stress, Slow-Growing broilers, Genetics

ABSTRACT

This study explores the interactions between bone health, feed efficiency, and environmental conditions in slow-growing broiler chickens reared under contrasting production systems, namely indoor housing and outdoor access. Emphasis is placed on summer production periods characterized by heat stress, a major challenge for poultry welfare and productivity under changing climatic conditions. Through an integrated approach combining morphometric, densitometric, mechanical, and genetic analyses, the research evaluates how rearing environment influences skeletal integrity and production performance. The results reveal significant relationships between bone quality traits, adaptive responses to environmental stressors, and feed efficiency, highlighting the complex biological mechanisms linking animal robustness and productive efficiency. By providing new insights into the effects of production systems and climatic stress on skeletal development, this work contributes to the advancement of sustainable and welfare-oriented poultry farming strategies, while supporting the development of climate-resilient livestock systems.

1- Introduction

Sustainable poultry production faces major challenges related to animal welfare, agroecological transition, and climate change. Feed efficiency has become a central issue in poultry systems, where production performance must be balanced with animal robustness and welfare. In parallel, alternative systems based on slower-growing genotypes and outdoor access are expanding in Europe and sub-Saharan Africa (Alders, 2005; De Jonge and van Trijp, 2013; Djitie et al., 2015). Free-range systems may improve skeletal development through increased activity (Moussa, 2007; Rodriguez-Navarro et al., 2018), but environmental conditions can also affect growth, nutrient utilization, and bone mineralization. Bone quality depends on mineral composition, structural organization, and several factors including genotype, nutrition, and rearing conditions (Boskey and Mendelsohn, 2005; Han et al., 2015; Mabelebele et al., 2017; Chaumont et al., 2025). Heat stress represents an additional challenge for poultry production, as high temperatures can reduce feed intake and negatively affect bone quality (Wiernusz and Teeter, 1996). Understanding the interactions between rearing systems, feed efficiency, and bone health is therefore important for developing sustainable and climate-resilient poultry farming strategies. The objective of this study was to investigate the relationships between feed efficiency and bone health in slow-growing broiler chickens

François Djitie Kouatcho, Sandrine Mignon, Agnès Narcy. Balance between feed efficiency and bone health in free-range broilers reared under global warming conditions, LE STUDIUM *Multidisciplinary Journal*, **2025**, 9, 129-133
https://doi.org/10.34846/le-studium.316.02.fr.11-2025

reared under contrasting systems (indoor housing versus outdoor access). Morphometric, densitometric, mechanical, and genetic approaches were used to evaluate how rearing conditions influence skeletal integrity and production performance.

This work was conducted during a scientific residency at the INRAE Centre Val de Loire within the Biology of Birds and Aviculture Unit (BOA), supported by Le Studium – Loire Valley Institute for Advanced Studies.

2- Experimental details

The primary objective of the stay was to study the relationship between feed efficiency and bone health in slow-growing broiler chickens (Label type) reared under two contrasting systems: indoor confinement and outdoor access. Attention was given to summer conditions, which may affect feed intake, skeletal development, and overall production performance. This work addresses key issues related to animal welfare, sustainable poultry production, and adaptation to climate variability.

Mobility disorders remain a major welfare concern in broiler production, as they are associated with pain, reduced growth, impaired feed efficiency, and increased mortality (Leterrier et al., 1998). In this context, understanding the links between skeletal quality and feed efficiency is particularly relevant under outdoor and warm environmental conditions.

The experiment was conducted during summer 2023 at the PEAT INRAE Poultry Experimental Facility. Six hundred one-day-old Label Rouge chickens were reared either in free-range or confinement systems. Feed intake, feeding behaviour, and body weight were continuously recorded using the electronic feeder system "Bird-E". At 84 days of age, tibia samples were collected and stored at −20°C for subsequent analyses.

The scientific activities carried out during the stay focused mainly on the analysis of the previously collected and frozen tibia samples. These analyses covered bone morphology, mineral content, and density (CT-scan and densitometry), mechanical properties (three-point bending tests using Instron systems), and physicochemical characterization of bone quality.

Statistical and genetic analyses included heritability estimation, genetic and phenotypic correlations, and principal component analyses (PCA). Additional activities involved participation in scientific discussions, data interpretation, and progress presentations within the Genuts team and the UMR BOA.

Materials and methods

The scientific activities carried out during the stay included:

• Bone morphometric evaluation;

• Structural and densitometric bone analyses using computed tomography (CT-scan) (Valable et al., 2020);

• Assessment of bone mechanical strength using Instron testing systems;

• Physicochemical analyses of chicken tibiae to assess bone mineralization.

Advanced statistical and genetic analyses, including estimation of heritability, genetic and phenotypic correlations, and principal component analyses (PCA).

3- Results and discussion

The work carried out during the stay led to the preparation of two scientific manuscripts currently under review prior to submission to international peer-reviewed journals. It also resulted in the submission and acceptance of two abstracts for oral presentation at the World's Poultry Congress, scheduled from July 13 to 17, 2026, in Toronto, Canada. These outputs are expected to contribute to the advancement of knowledge on poultry

production efficiency, animal welfare, and skeletal health.

During the stay, I actively participated in several scientific events, including three conferences in the Centre-Val de Loire region, two of which were organized by Le Studium, as well as the SPACE International Livestock Exhibition (SPACE 2025) in Rennes, where I was invited as a speaker during the AgriPanel session on "The future of livestock production in Francophone Africa". I also attended the 24th European Symposium on Poultry Nutrition in Maastricht and the FAO Livestock Week 2025 in Rome. Within this framework, I co-organized a side event entitled "Innovating for Inclusive and Resilient Livestock Systems" with international partners from Australia, Colombia, and the Democratic Republic of Congo, including Prof. Karol B. Barragán-Fonseca, a former Le Studium visiting researcher whom I met during the stay. This collaboration illustrates the lasting impact of the Le Studium program through the continuation of scientific relationships beyond the formal end of the visiting period.

The stay also significantly strengthened institutional cooperation through the reception of an official delegation from the University of Ngaoundéré (Cameroon), led by its Rector, Professor Mamoudou Abdoulmoumini, and composed of five heads of academic institutions. The delegation visited INRAE Centre Val de Loire, the Le Studium program, and the Centre for Molecular Biophysics in Orléans, with the aim of exploring future collaboration opportunities. In addition, I contributed to the Biotech Centre Magazine and participated in four webinars involving researchers and students from Cameroon, INRAE, and Le Studium, supporting knowledge exchange, mentoring, and the development of future collaborative initiatives.

4- Conclusion

This scientific stay significantly strengthened scientific and technical skills and expanded national and international research networks. It also laid a solid foundation for the continuation and formalization of sustainable collaborations between INRAE, Le Studium, the home institution, and other partner organizations.

5- Perspectives of future collaborations with the host laboratory

Based on this experience as a Le Studium Visiting Researcher, several recommendations are proposed to enhance engagement and long-term interaction among fellows and alumni. First, the creation of a dedicated Le Studium alumni platform would facilitate communication, networking, and sustained scientific exchange among current and former fellows. Second, a voluntary alumni coordination office could be established to organize limited activities under the supervision of Le Studium. Third, fellows and alumni could be involved in the vision, editorial development, and scientific animation of the multidisciplinary journal supported by Le Studium. Fourth, alumni who were unable to organize a scientific conference during their residency could be allowed to apply for such opportunities within two years after the end of their stay in the Centre-Val de Loire region.

6- Articles published in the framework of the fellowship

Two scientific manuscripts were prepared during the fellowship and are currently under review before submission to international peer-reviewed journals. Two scientific abstracts were also submitted and accepted for oral presentation during the World's Poultry Congress, Toronto 2026.

7- Acknowledgements

I would like to express my sincere gratitude to the Le Studium – Loire Valley Institute for Advanced Studies and its entire staff, namely Sophie Gabillet, Aurélien Montagu, Maurine Villiers, and Marie-Frédérique Pellerin, for the excellent scientific and administrative support

provided throughout my stay. I am equally grateful to INRAE Centre Val de Loire for hosting me under optimal research conditions. My special thanks go to Dr Agnès Narcy and Dr Sandrine Mignon for their scientific supervision, guidance, and continuous support. I also acknowledge all members of the Genuts team, the UMR BOA, as well as partners from SYSAAF and ITAVI, for the fruitful collaborations established. Finally, I wish to thank Dr Élisabeth Duval, Director of the UMR BOA, and Dr Cécile Berri, President of INRAE Centre Val de Loire, for their institutional support and commitment to international scientific cooperation.

8- References

- Alders R. 2005. L'aviculture : source de profit et de plaisir. FAO: Rome, 2005, 21 p.
- Boskey, A. L., & Mendelsohn, R. (2005). Infrared spectroscopic characterization of mineralized tissues. In Vibrational Spectroscopy (Vol. 38, pp. 107–114). https://doi.org/10.1016/j.vibspec.2005.02.015
- Chaumont, S., Mignon, S. V., Fagnoul, F., Collin, A., Berri, C., Guettier, E., & Le Bihan-Duval, E. (2025). Access to the outdoors during summer affects feed efficiency, carcass composition and meat quality in a slow-growing pure strain of chickens. Journal of Animal Science, 103, skaf157. https://doi.org/10.1093/jas/skaf157
- De Jong, J., & van Trijp, H. C. (2013). The impact of broiler production system practices on consumer perceptions of animal welfare. Poultry science, 92(12), 3080-3095. https://doi.org/10.3382/ps.2013-03334
- Djitie, F. K., Megueni, C., Teguia, A., & Bitom, D. L. (2015). Enquête socioéconomique et technique sur l'aviculture familiale dans la région de l'Adamaoua, Cameroun. Livestock Research for Rural Development, 27(2).
- Gourion-Arsiquaud, S., Faibish, D., Myers, E., Spevak, L., Compston, J., Hodsman, A., ... & Boskey, A. L. (2009). Use of FTIR spectroscopic imaging to identify parameters associated with fragility fracture. Journal of bone and mineral research, 24(9), 1565-1571.
- Han, J. C., Qu, H. X., Wang, J. G., Chen, G. H., Yan, Y. F., Zhang, J. L., … Cheng, Y. H. (2015). Comparison of the growth and mineralization of the Femur, Tibia, and Metatarsus of Broiler Chicks. Revista Brasileira de Ciencia Avicola / Brazilian Journal of Poultry Science, 17(3), 333–340. https://doi.org/10.1590/1516-635x1703333-340
- Mabelebele, M., Norris, D., Siwendu, N. A., Ng'Ambi, J. W., Alabi, O. J., & Mbajiorgu, C. A. (2017). Bone morphometric parameters of the tibia and femur of indigenous and broiler chickens reared intensively. Applied Ecology and Environmental Research, 15(4), 1387–1398. https://doi.org/10.15666/aeer/1504_13871398
- Moussa, M., Babilé, R., Fernandez, X., & Rémignon, H. (2007). Biochemical and biomechanical properties of tendons in two commercial types of chickens. Animal, 1(7), 983-988. https://doi.org/10.1017/S1751731107000183
- Rodriguez-Navarro, A. B., McCormack, H. M., Fleming, R. H., Alvarez-Lloret, P., Romero-Pastor, J., Dominguez-Gasca, N., ... & Dunn, I. C. (2018). Influence of physical activity on tibial bone material properties in laying hens. Journal of structural biology, 201(1), 36-45. https://doi.org/10.1016/j.jsb.2017.10.011

- Valable, A. S., Létourneau-Montminy, M. P., Klein, S., Lardic, L., Lecompte, F., Metayer-Coustard, S., ... & Narcy, A. (2020). Early-life conditioning strategies to reduce dietary phosphorus in broilers: underlying mechanisms. Journal of Nutritional Science, 9, e28. https://doi.org/10.1017/jns.2020.17
- Wiernusz, C. J., & Teeter, R. G. (1996). Acclimation effects on fed and fasted broiler thermobalance during thermoneutral and high ambient temperature exposure. British Poultry Science, 37(3), 677-687. https://doi.org/10.1080/00071669608417897