biology and life sciences forum

MDPI

Proceeding Paper

Reproduction Efficiency of Native and Imported Algerian Cattle Under Challenging Climatic Conditions †

Aziza Ferag [1,2,*], Djalel Eddine Gherissi [1,3,*], Tarek Khenenou [1,2], Amel Boughanem [4], Hafidha Hadj Moussa [4] and Amina Maamour [1]

[1] Departement of Veterinary Sciences, Institute of Agricultural and Veterinary Sciences, University of Souk-Ahras, Souk Ahras 41000, Algeria; khenenoutarek@gmail.com (T.K.)
[2] Laboratory of Science and Techniques for Living, University of Souk-Ahras, Souk Ahras 41000, Algeria
[3] Laboratory of Animal Production, Biotechnologies, and Health, University of Souk-Ahras, Souk Ahras 41000, Algeria
[4] National Center for Artificial Insemination and Genetic Improvement (CNIAAG), Birtouta 16045, Algeria
* Correspondence: ferag.aziza@gmail.com (A.F.); d.gherissi@univ-soukahras.dz (D.E.G.); Tel.: +213-662638204 (D.E.G.)
† Presented at the 9th International Seminar (MGIBR) Management and Genetic Improvement of Biological Ressources, Tlemcen, Algeria, 20–22 April 2024.

Abstract: This study examined the impact of climate change, specifically the Temperature–Humidity Index (THI), on local "Brune de l'Atlas" cows and imported dairy breeds (Prim'Holstein and Montbéliarde) in Algeria. Data from 24,773 artificial insemination records of 12,726 cows between 2016 and 2019 were analyzed for fertility traits such as conception rate at the first AI (CR1stAI), services per conception, and reproductive period (RP). The results indicated no significant impact of THI on CR1stAI for the local breed, though THI > 72 lowered CR1stAI in imported breeds. THI significantly increased the number of services per conception but did not affect the RP. Local breeds showed superior reproductive efficiency under high THI, likely due to genetic differences.

Keywords: Algeria; temperature–humidity index; fertility; local breeds; imported dairy breeds

Citation: Ferag, A.; Gherissi, D.E.; Khenenou, T.; Boughanem, A.; Moussa, H.H.; Maamour, A. Reproduction Efficiency of Native and Imported Algerian Cattle Under Challenging Climatic Conditions. *Biol. Life Sci. Forum* **2024**, *36*, 13. https://doi.org/10.3390/blsf2024036013

Academic Editors: Semir Bechir Suheil Gaouar, Rachid Azzi, Tarik Mohammed Chaouch, Mohammed Sidhoum, Ikram Mkedder, Mohammed Rida Mediouni, Sarra Selka, Amel Djaout, Hind Houssou and Hakim Tefiel

Published: 14 November 2024

1. Introduction

The imports of dairy products in Algeria accounted for 24% of the total African dairy imports by value [1]. To elevate local production, Algeria invested in importing high-genetic-potential pregnant cows. This presents a relatively complex challenge [2], where the rearing conditions in the southern Mediterranean region have a significant impact on dairy herd fertility and fecundity [3–5] as well as on the production of necessary forage [2], posing substantial challenges. Thermal stress induces physiological and metabolic disruptions, activating numerous adaptive mechanisms in affected animals [4,6,7]. Cows adapt to temperature stress through various behaviors, including altered feeding patterns, increased respiration rate, panting, sweating, and seeking shade [8,9]. Heat stress results in heightened health problems, reduced production, and a deterioration of welfare conditions [6,7,10,11]. Heat stress compromises reproduction. It disrupts the hormonal balance crucial for successful reproduction, notably reducing luteinizing hormone and progesterone levels, leading to issues such as poor follicle development, low-quality oocytes, silent estrus, abnormal or weak embryo development, and pregnancy loss; these factors collectively contribute to a decline in the reproduction rate and significant losses for the cattle industry [12]. Despite these challenges, indigenous breeds are well adapted to harsh local environmental conditions, exhibiting tolerance to heat stress, resistance to infectious diseases, and resilience against parasites [7,13].

Due to the limited information on the impact of heat stress on the reproductive performance of imported dairy cattle and the complete lack of data on its effects on local

cows, we conducted this study to thoroughly analyze the effects of heat stress on various reproductive parameters. These parameters include CR1stAI, SPC, and RP in both native "Brune de l'Atlas" and imported Algerian cattle" Prim'Holstein and Montbéliarde".

2. Materials and Methods

Breeding data sourced from individual cow registrations at the National Center for Artificial Insemination and Genetic Improvement (CNIAAG) were analyzed. This dataset comprised 24,773 artificial insemination records from 12,726 cows spanning the years 2016 to 2019 across 17 wilayas, in three distinct agroecological regions: littoral areas, semi-arid areas, and arid zones. Calculated parameters included the conception rate at the first artificial insemination (CR1stAI), the number of services per conception (SPC), and the reproductive period (RP), defined as the interval between the first and last insemination. Climatological data were obtained from the "Weather Underground" website, and the Temperature–Humidity Index (THI) was calculated for each artificial insemination day using the formula outlined by NOAA [14]. Logistic and linear regression analyses were conducted to explore the relationship between THI levels and CR1stAI, SPC, and RP using Spss v26.

3. Results

Table 1 shows the level of CR1stAI in three studied breeds where, under the influence of THI, there is a significant ($p < 0.001$) decrease of 31.6%, and 41.5% in Prim'Holstein, and Montbéliarde breeds. The local breeds (Brune de l'Atlas) show no significant effect of THI on CR1stAI, although a decrease of 22.4% is registered.

Table 1. Results of the conception rate at first artificial insemination with THI in Prim'Holstein, Montbéliarde, and Brune de l'Atlas breeds of dairy cattle.

		THI < 72	THI > 72	Overall	*p* Value	Odds Ratio
CR1st AI	Prim'Holstein	25.46% (730/2867)	19.55% (650/3324)	22.29% (1390/6191)	0.000	0.684
	Montbéliarde	25.58% (650/2541)	18.81% (515/2738)	22.07% (1165/5279)	0.000	0.585
	Brune de l'Atlas	27.59%	21.88%	24.41%	0.089	0.776

CR1st AI: the conception at the first artificial insemination.

Table 2 demonstrates the influence of THI on SPC, with a significant increase ($p < 0.01$) by 0.059, 0.093, and 0.008 for the Prim'Holstein, Montbéliarde, and Brune de l'Atlas breeds with each increase in the THI > 72.

Table 2. Regression results of the services per conception with THI in Prim'Holstein, Montbéliarde, and Brune de l'Atlas breeds of dairy cattle.

		Mean	B	SE	Sig	R^2	Sig (ANOVA)
Prim'Holstein	Constant THI	1.82 ± 0.828	1.57 0.059	0.044 0.027	0.000 0.032	0.001	0.032
Montbéliarde	Constant THI	1.79 ± 0.796	1.58 0.093	0.046 0.029	0.000 0.001	0.003	0.001
Brune de l'Atlas	Constant THI	1.74 ± 0.768	1.147 0.008	0.156 0.002	0.000 0.000	0.107	0.000

B: Coefficients, SE: Standard Error, Sig: Significance, R^2: R-square.

Table 3 shows the changes in RP with changes in THI. The Prim'Holstein and Montbéliarde breeds show an increase in the RP. For each increased point in the THI over 72, there is an increase in the RP by 0.618 and 2.178 days for both breeds, respectively. Inversely, the local breeds show a decrease by 0.007 days with each increase in THI on the RP.

Table 3. Regression results of the reproductive period (days) with THI in Prim'Holstein, Montbéliarde, and Brune de l'Atlas breeds of dairy cattle.

		Mean	B	SE	Sig	R^2	Sig (ANOVA)
Prim'Holstein	Constant THI	49.75 ± 62.088	48.802 0.618	2.770 1.720	0.000 0.719	0.000	0.719
Montbéliarde	Constant THI	47.40 ± 58.392	44.116 2.178	2.811 1.770	0.000 0.218	0.000	0.218
Brune de l'Atlas	Constant THI	41.29 ± 48.396	41.836 −0.007	8.147 0.108	0.000 0.946	0.000	0.946

B: Coefficients, SE: Standard Error, Sig: Significance, R^2: R-square.

4. Discussion

The results of the fertility showed issues in fertility in Algeria. The CR1stAI was lower than the results obtained in a previous study by Mouffouk et al. [15]. Conversely, the apparent FI was close, and the RP was greater than that obtained by Haou et al. [3].

The CR1stAI for the Prim'Holstein and Montbéliarde breeds showed a significant decrease with each increase in the THI surpassing 72, while the local breeds showed no significant effect. Furthermore, a higher effect of THI was registered on the Montbéliarde breeds. Furthermore, SPC increased significantly with each increase in THI > 72 for the three studied breeds. Recent studies showed a lower CR1stAI, a higher frequency of insemination, and decreased fertility under stressful THI levels in dairy cattle reared in the North African region [16,17]. The RP increased with each increase in the THI over 72, although the Brune de L'Atlas breeds showed a decrease in RP when THI increased. Specifically, a greater increase was noted in the Montbéliarde breeds, with an average elevation of 2.178 days. Additionally, the RP was found to be prolonged in correlation with THI [18,19]. These changes in fertility efficiency under heat stress were discussed in many previous studies and suggested that the ability of cows to withstand heat stress is attributed to their milk production performances [20–22], whereas cows with high milk production are more susceptible to climate change. Furthermore, coat color and hair characteristics impact the resistance to heat stress [21,23,24]. Interestingly, cows with shorter, smoother hair are better equipped to handle heat stress. A previous study showed that fertility varies mainly between breeds and was affected significantly by THI level, with a greater influence on Holstein cattle [15]. In our study, the local breeds (Brune de l'Atlas) were less sensitive to heat stress. Bayssa et al. [13] attributed the adaptability of indigenous breeds to high temperatures, and high solar radiation to their high skin pore density, enabling an effective regulation of body temperature.

5. Conclusions

In conclusion, the Algerian native cows showed better reproductive efficiency, even in conditions of elevated THI levels, as evidenced by the lack of the effect ($p > 0.005$) of THI on the CR1stAI and RP. These changes in the fertility efficiency between breeds may be due to genetic changes. This highlights the indigenous breed's capability to sustain reproductive performance under heat stress. Our results underscore the potential benefits of employing local breeds like the "Brune de l'Atlas" in areas with high THI levels, given their proven resilience and consistent reproductive efficiency under harsh environmental conditions. This emphasizes the critical need to conserve this essential genetic resource and advocate for its role in genetic enhancement strategies to address the significant climate challenges facing the North African region.

Author Contributions: Conceptualization, D.E.G. and T.K.; methodology, D.E.G. and A.F.; software, A.F. and D.E.G.; validation, A.F. and D.E.G.; formal analysis, A.F. and D.E.G.; investigation, A.B. and H.H.M.; data curation, A.F., A.M. and D.E.G.; writing—original draft preparation, A.F. and D.E.G.; writing—review and editing, A.F. and D.E.G.; supervision, D.E.G. and T.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data will be made available on request to the corresponding author.

Acknowledgments: The authors would like to express their deep gratitude to the hardworking staff of CNIAAG, as well as to veterinarians and breeders in the study region. The accomplishment of this research was greatly attributed to their active engagement and the essential details they contributed.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Chatellier, V. La planète laitière et la place de l'Afrique de l'Ouest dans la consommation, la production et les échanges de produits laitiers. In *3. Rencontres Internationales: "Le lait, Vecteur de Développement"*; Agreenium: Paris, France, 2019; 32p.
2. Mamine, F.; Fares, M.; Duteurtre, G.; Madani, T. Regulation of the dairy sector in Algeria between food security and development of local production: Review. *Rev. Élev. Méd. Vét. Pays Trop* **2021**, *74*, 73–81. [CrossRef]
3. Haou, A.; Miroud, K.; Gherissi, D.E. Impact des caractéristiques du troupeau et des pratiques d'élevage sur les performances de reproduction des vaches laitières dans le Nord-Est algérien. *Rev. Élev. Méd. Vét. Pays Trop* **2021**, *74*, 183–191. [CrossRef]
4. Chacha, F.; Gherissi, D.E.; Lamraoui, R.; Bouzebda-Afri, F.; Bouzebda, Z. Evaluation of body condition, daily milk production and some biochemical parameters during the postpartum period according to the calving season in Montbeliard dairy cows reared in the semi-arid region, Algeria. *Veter Stanica* **2022**, *53*, 677–687. [CrossRef]
5. Eulmi, H.; Deghnouche, K.; Gherissi, D.E. Dairy cattle breeding practices, production and constraints in arid and semi-arid Algerian bioclimatic environments. *Int. J. Environ. Sci.* **2023**, *81*, 1238–1255. [CrossRef]
6. Sejian, V.; Bhatta, R.; Gaughan, J.B.; Dunshea, F.R.; Lacetera, N. Adaptation of animals to heat stress. *Animal* **2018**, *12*, s431–s444. [CrossRef]
7. Kambal, S.; Tijjani, A.; Ibrahim, S.A.E.; Ahmed, M.A.; Mwacharo, J.M.; Hanotte, O. Candidate signatures of positive selection for environmental adaptation in indigenous African cattle: A review. *Anim. Genet.* **2023**, *54*, 689–708. [CrossRef]
8. Nanas, I.; Chouzouris, T.M.; Dovolou, E.; Dadouli, K.; Stamperna, K.; Kateri, I.; Barbagianni, M.; Amiridis, G.S. Early embryo losses, progesterone and pregnancy associated glycoproteins levels during summer heat stress in dairy cows. *J. Therm. Biol.* **2021**, *98*, 102951. [CrossRef]
9. Leliveld, L.M.; Lovarelli, D.; Finzi, A.; Riva, E.; Provolo, G. Effects of cow reproductive status, parity and lactation stage on behaviour and heavy breathing indications of a commercial accelerometer during hot weather conditions. *Int. J. Biometeorol.* **2023**, *67*, 1263–1272. [CrossRef]
10. Gherissi, D.E.; Chacha, F.; Lamraoui, R.; Messaadia, F.; Nouadri, S.E.; Bouzebda Afri, F.; Bouzebda, Z. Seasonal trends and milking-related factors influencing somatic cell counts in tank milks of dairy cattle in northeast Algeria. *Pak. J. Agric. Sci.* **2022**, *59*, 531–542. [CrossRef]
11. Kechroud, A.A.; Merdaci, L.; Miroud, K.; Gherissi, D.E. Herd-Level Risk Factors for Lameness, Leg Injuries, Thin Body Condition and Mastitis on Algerian Dairy Farms. *Folia Vet.* **2023**, *67*, 62–77. [CrossRef]
12. Khan, I.; Mesalam, A.; Heo, Y.S.; Lee, S.H.; Nabi, G.; Kong, I.K. Heat Stress as a Barrier to Successful Reproduction and Potential Alleviation Strategies in Cattle. *Animals* **2023**, *13*, 2359. [CrossRef] [PubMed]
13. Bayssa, M.; Yigrem, S.; Betsha, S.; Tolera, A. Production, reproduction and some adaptation characteristics of Boran cattle breed under changing climate: A systematic review and meta-analysis. *PLoS ONE* **2021**, *16*, e0244836. [CrossRef] [PubMed]
14. NOAA: National Oceanic and Atmospheric Administration. *Livestock Hot Weather Stress*; Operations Manual Letter C-31-76; Department of Commerce, NOAA: Silver Spring, MD, USA, 1976.
15. Mouffok, C.; Allouni, A.; Semara, L.; Belkasmi, F. Factors affecting the conception rate of artificial insemination in small cattle dairy farms in an Algerian semi-arid area. *Livest. Res. Rural Dev.* **2019**, *31*, 1–9.
16. Ouarfli, L.; Chehma, A. Index température-humidité et réussite de l'insémination artificielle de vaches laitières Holsteins et Montbéliardes en région saharienne. *Livest. Res. Rural. Dev.* **2018**, *30*, 2018.
17. Djelailia, H.; Bouraoui, R.; Jemmali, B.; Najar, T. Effects of heat stress on reproductive efficiency in Holstein dairy cattle in the North African arid region. *Reprod. Domest. Anim.* **2020**, *55*, 1250–1257. [CrossRef]
18. Sammad, A.; Umer, S.; Shi, R.; Zhu, H.; Zhao, X.; Wang, Y. Dairy cow reproduction under the influence of heat stress. *J. Anim. Physiol. Anim. Nutr.* **2020**, *104*, 978–986. [CrossRef]
19. Shi, R.; Brito, L.F.; Liu, A.; Luo, H.; Chen, Z.; Liu, L.; Guo, G.; Mulder, H.; Ducro, B.; Van Der Linden, A.; et al. Genotype-by-environment interaction in Holstein heifer fertility traits using single-step genomic reaction norm models. *BMC Genom.* **2021**, *22*, 193. [CrossRef]
20. Siatka, K.; Sawa, A.; Krężel-Czopek, S.; Piwczyński, D.; Bogucki, M. Effect of Some Factors on Number of Services per Conception in Dairy Cows. *J. Vet. Sci. Technol.* **2017**, *8*, 1–4. [CrossRef]

21. Purohit, P.; Gupta, J.; Chaudhri, J.; Bhatt, T.; Pawar, M.; Srivastava, A.; Patel, M. Effect of heat stress on production andreproduction potential of dairy animals Vis-À-Vis buffaloes. *Int. J. Livest. Res.* **2020**, *10*, 1–23. [CrossRef]
22. Sesay, A.R. Effect of heat stress on dairy cow production, reproduction, health, and potential mitigation strategies. *J. Appl. Adv. Res.* **2023**, *8*, 13–25. [CrossRef]
23. Nedjraoui, D. *Algeria Country Pasture/Forage Resource Profiles*; FAO: Rome, Italy, 2006; p. 10.
24. Lamari, S.; Madani, T.; Allouche, L. Hair characteristics and cortisol hair analysis as indicators of fertility in dairy cows. *Livest. Res. Rural Dev.* **2018**, *30*, 49.