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Poultry mortality due to heat stress: challenges and insurance solutions

Nadia Cherifi [1, (*)], Safia Zenia[2,3], Razika Boukert[1,4]

1.Institute of Veterinary Sciences,University Saad Dahleb- Blida1, Route de Soumâa, BP 270, 09000, Blida, Algeria,

2. SPA, Higher National Veterinary School of Algiers, Rue Issad Abbes, Oued Esmar, Algiers, Algérie

3. IFORCE, Faculty of Mathematics, University of Sciences and Technology, Houari Boumediene, B.P.32 Bab Ezzouar 16111 Algeria

4. Laboratory of Biotechnologies related to Animal Reproduction, Institute of Veterinary Sciences, Saad Dahleb University Blida 1, Algeria

***Corresponding author**: Nadia Cherifi

Postal address: Veterinary sciences institute, Saad Dahleb University Blida 1, 9000, Algeria.

Phone : (213) 551 71 69 75

E-mail: nadiach201382@yahoo.com

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Abstract

The study evaluates the feasibility of designing tailored insurance products to address poultry mortality risks due to thermal stress in northern Algeria. High temperatures create significant challenges, particularly for broiler chickens, which show greater heat sensitivity and higher mortality rates (19.95% ± 17.9%) compared to laying hens (13.07% ± 9.17%). Analysis by age reveals broiler chicks are initially heat-resistant, while laying hens have an 8.36 ± 7.01% mortality rate. Mid-cycle, broiler mortality increases to 12.16 ± 9.07%, and laying hens' mortality rises to 16.97 ± 9.11%. By cycle's end, broiler mortality peaks at 27.14 ± 21.18%, whereas laying hens' mortality is 11.66 ± 9.24%. Unequipped farms have higher mortality rates 25.78 ± 23.48% for broilers and 13.78 ± 9.75% for laying hens emphasizing the need for effective cooling and ventilation. Tailoring insurance premiums based on these factors and improving farming practices can mitigate risks and ensure financial viability for insurers.

Keywords: Age, Insurance premiums, Poultry mortality, Tailored insurance products, Thermal stress

Introduction

Regardless of the quality of the environment in which poultry develops, both in terms of vaccination and prevention, a significant percentage of mortality is still due to heat stress because poultry are sensitive to high temperatures (Mouss and al., 2020). In Algeria, the major constraint of poultry production is the high temperatures experienced during prolonged periods, often covering the entire production cycle, resulting in decreased chicken performance, with mortality rates reaching up to 60% (Boudouma, 2008). These challenges pose significant risks for poultry farmers in semi-arid climate regions, such as those in northern Algeria.

To protect against this risk, poultry farmers generally have two options: suspend their activities during the hottest period of the year (from June to September), thereby reducing their annual turnover and return on invested capital, or hedge against poultry mortality risk due to heat stress through specialized insurance. However, it is crucial to remind that a fundamental principle of insurance is not to cover risks that are too predictable, as if an event is certain to occur, it undermines the principle of risk mutualization (Rejda, 2018).

Therefore, insurance companies will only cover poultry mortality risk related to heatwaves if they can accurately assess its magnitude and cover it without suffering unacceptable losses.

The central question posed is: is it feasible for agricultural insurance companies to design tailored insurance products to cover poultry mortality due to heatwaves? Despite the predictability of this risk and its certain financial impact, this study explores the feasibility of its inclusion in insurance coverage. To do so, it proposes to analyze factors such as poultry age, available facilities and equipment, and the type of farming practiced, to determine the conditions under which such coverage could be feasible.

This study will examine detailed statistical data on poultry losses in different regions to better understand the frequency and severity of poultry mortality related to heatwaves. We will also evaluate the technical conditions surrounding this risk in poultry facilities, considering available equipment and farming practices. Additionally, we will examine how poultry age can influence heat sensitivity and the likelihood of death.

This research will enable agricultural insurance companies to explore the feasibility of developing specific insurance products that take into account these criteria to provide insurance coverage against poultry mortality due to heatwaves, while ensuring financial viability for insurers and offering effective protection for farmers.

Materials and Methods

Background and study area

Our study focuses on Northern Algeria, a region where summers are characterized by high temperatures and dry conditions. These summer conditions pose significant challenges for poultry farming due to the increased risk of thermal stress. Therefore, we are examining the need to develop tailored insurance products to cover these specific risks during the summer period. This study aims to analyze factors such as farming type, poultry age, available equipment in poultry farms, and farming practices to evaluate the conditions under which such coverage could be viable. Using collected data and results from statistical analysis, this study will formulate recommendations to develop more effective insurance policies tailored to the specific needs of poultry farms in a changing climate context.

The results of this study are based on a survey conducted in poultry farms located in 11 provinces of northern-central Algeria. In each province, a sample of 6 poultry farms experiencing exclusively heat stress-related mortalities was selected. Mortalities due to other diseases were not considered. The provinces included in this study are: Meftah, Tizi-Ouzou, Bejaia, Bouira, El Khemis, Médéa, Tlemcen, Remchi, Oran, Batna, and Annaba.It is important to note that we recorded mortalities while considering breeding cycles for broiler chickens and production cycles for laying hens.

- For broiler chickens, the total breeding cycle lasted 50 days, with different age phases corresponding to the start of the cycle for the starting period, mid-cycle for the growth period, and end of the cycle for the finishing period.

- As for laying hens, they begin laying at 18 weeks for a period of 11 months, with different age phases corresponding to the start of the cycle for the beginning of laying, mid-cycle for the peak laying period, and end of the cycle for the end of laying.

To collect these data, visits were made to poultry farms with the aim of utilizing data from veterinary reports monitoring the farms. Each broiler chicken house comprises 4,000 chickens, and each laying hen house comprises 2,000 to 3,000 laying hens. Mortalities are recorded as a percentage relative to the initial batches deployed.

Our survey relied on questionnaires distributed to supervising veterinarians at different farms. Information contained in these questionnaires includes the province name, location of the farm, start date of breeding, type of chickens (broiler chickens and laying hens), number of broiler chickens and laying hens deployed in the houses, mortalities recorded by age, farming type, and building type (equipped with cooling systems or not, presence or absence of fans and extractors).

Data Verification and Statistical Analysis

Data verification and statistical processing were performed using Excel, STATVIEW (stat view by Windows Abacus Concepts, Inc, copyright © 1992-1996 version 4.55), and STATISTICA 7 (copyright ©statsuft, Inc, 1984-2004). All data were entered into a standard computer database (Excel 2003). Results were processed using analysis of variance (ANOVA) model to compare mortality means across different studied variables and unpaired comparison tests (ANOVA, Fischer and Student). The aim was to analyze mortalities based on farming type (broiler chickens and laying hens), poultry age (start of cycle, mid-cycle, end of cycle), and building type (equipped or not equipped). Data were considered significant at $P < 0.05$.

Discussion of Results

1. *Analysis of Mortality Rates Based on Two Types of Poultry Farming (Broilers and Laying Hens)*

A general comparison of mortality rates reveals that broilers have a total mortality rate of 19.95% ± 17.9%, significantly higher than the 13.07% ± 9.17% mortality rate of laying hens ($p < 0.05$) (Table 1). This difference indicates a greater sensitivity of broilers to heat conditions compared to laying hens. In the hot climate of northern Algeria, broilers, which are exposed to prolonged high temperatures, seem to suffer more than laying hens. This observation aligns with the findings of several researchers regarding the heightened sensitivity of broilers (Allouche, 2021)

Given these differences in sensitivity, insurers could offer differentiated insurance premiums based on the type of poultry farming. Broiler farmers, facing a higher risk of heat-related mortality, could benefit from adjusted premiums to reflect this increased risk. Conversely, laying hen farmers, with lower mortality rates under the same climatic conditions, might be offered potentially lower premiums. This approach would allow insurers to adjust pricing according to the specific risks associated with each type of poultry farming.

This study, based on veterinary surveys, highlighted the issue of excessive overcrowding in poultry buildings, leading to inappropriate rearing conditions. The impact of overcrowding on the deterioration of the internal environment has been emphasized by (Rousset and al., 2016). Poultry density is crucial for the health and well-being of the animals, especially during hot periods (ITAVI, 2004). Adhering to density standards allows animals to move naturally, promoting efficient heat exchange and proper body temperature regulation. When poultry are too crowded, processes such as convection, conduction, and radiation are hindered, exacerbating the effects of heat. In this context, insurers can implement regulatory measures in their risk management, such as the application of deductibles, which represent a portion of losses not covered by insurance and borne by the insured (Richard and al, 2022). If density standards are not met, this deductible can be applied, encouraging farmers to adopt more sustainable rearing practices by adhering to technical conditions of poultry buildings and investing in appropriate ventilation equipment. These measures would certainly help reduce the risks of poultry mortality.

2. ***Analysis of Poultry Mortality Based on Age***

Given the different durations of poultry rearing (50 days for broilers and 11 months for laying hens), we estimated heat-induced mortality based on three phases: the beginning, middle, and end of the cycle for both types of poultry farming.

a) Analysis of Mortality at the Beginning of the Cycles

In this phase, the results pertain exclusively to laying hens. No heat-related mortality was recorded for broilers, indicating that chicks at this age found well-being despite high temperatures. This observation aligns with the research by Yalcin and al (2017), who noted that day-old chicks are not capable of regulating their body temperature and require an ideal temperature zone of 32°C, below which they become cold. Hill (2001) also stated, "Chicks with poor feathering need a high temperature upon arrival because they are poikilothermic in their first days of life." These observations justify the study's result (0% mortality), reflecting the resilience of broilers to heat at the beginning of this phase, or even the comfort that heat provides them during this early stage. These results could suggest the creation of a "specific prevention insurance" for farmers, including financial incentives or premium reductions for those who adopt proactive monitoring and prevention measures. According to Ehrlich and Becker (1972), prevention encompasses self-protection instruments (reducing the probability of an event) and self-insurance (mitigating the damage).

Conversely, the study's results show significant variations in mortality rates at the beginning of the production cycle, with 8.36% ± 7.01% compared to 16.97% ± 9.11% in the middle of the cycle (Table 2). These variations suggest adequate preparation of hens during the rearing period, likely mitigating the mortality rate at the beginning of this cycle despite the laying stress. Furthermore, observations show that in laying hens, thermal stress affects egg production more than mortality. Boudouma (2008) reported that all types of poultry respond to high temperatures (cyclic or constant) with a drop in production performance.

This dynamic of mortality and production could influence risk assessment by insurers when proposing tailored insurance policies. According to Ginder and Spaulding (2009), price is identified as the most determining factor for farmers when deciding to purchase insurance. Therefore, understanding the specific mortality rates at different phases of the production cycle would allow better adaptation of insurance policy costs to the actual risks faced by farmers.

b) Analysis of Mortality in the Middle of the Cycles

During this phase, the study revealed average mortality rates of 12.16% ± 9.07% for broilers. This indicates that, compared to the first phase during which no mortality was recorded, broilers show less resistance, and their initial comfort decreases. At this age, broilers are phenotypically feathered and possess excellent insulation, significantly reducing their heat loss. These observations confirm those of Aya Lydie N'Dri (2006) who noted that towards the end of the broiler rearing period, their resistance is lower because they are covered with feathers. To reduce these mortality risks in broilers during this phase, insurers could implement specific measures, such as partial coverage of costs if farmers do not enhance the thermal insulation of poultry houses using insulating materials. In this context, insurers could also encourage farmers to monitor and maintain optimal litter quality. High-quality litter plays a crucial role in reducing risks related to heat, excessive humidity, and harmful gas emissions, thereby improving animal comfort. This comprehensive understanding of environmental factors can motivate insurers to maintain full coverage of mortalities in case of incidents, promoting more responsible and animal welfare-focused farming practices.

The study also revealed that laying hens are less resistant to heat during this production phase, exhibiting a mortality rate twice that of the beginning of the production cycle, with an average of 16.97% ± 9.11% compared to 8.36% ± 7.01%. This may be due to the fact that they are in the most important production phase and, with the increase in body weight (heaviness), they have more difficulty dissipating heat. Indeed, Geraert and al (1993) suggested that lean animals might resist heat better than fatter ones. Thus, it would be pertinent to propose to insurers to integrate the concept of "Body Weight Management" into insurance clauses. They could encourage farmers to monitor and control the body weight of laying hens by establishing indemnity indices related to overweight. This approach would motivate poultry farmers to adopt feeding and management practices tailored to each age phase, thereby reducing the risk of mortality.

Furthermore, this result recorded during the second phase of their age can be explained by the decrease in their immune system during this hot period. Laying hens, whose vaccinations were followed during the rearing phase, escaping viral and environmental aggressions, find themselves weaker and more vulnerable during production. Thaxton and al (1969) observed a decrease in immune response in hens placed at 42°C for 30 minutes every 4 hours. Heller and al (1979) noted that high temperatures have a detrimental effect on the immune system by affecting antibody production, and Lin and Togashi (2002) reported a drop in immune response in laying hens exposed to a temperature of 31.5°C. In this context, the insurer could introduce clauses related to the Optimization of Poultry Immune Health into the insurance contract. They could promote preventive health programs that strengthen the immune system of laying hens during this age phase. This could include preventive strategies used appropriately in consultation with an animal health professional, such as veterinary experts.

c) Analysis of Mortality at the End of the Cycles

The results show significant variations. Broilers recorded an average mortality of 27.14% ± 21.18% at the end of the cycle compared to 12.16% ± 9.07% (Table 2) in the second phase, confirming their significant sensitivity to heat compared to the first two phases (Table 2). Geraert and al (1993) reported that broilers are particularly sensitive to thermal stress during the finishing phase. Additionally, these results confirm the observations of De Basilio and Picard (2002), who noted that "a heatwave during the last week of rearing causes hyperthermia and kills a significant number of broilers." In this context, insurers could collaborate with poultry farmers to assess the specific risks associated with heatwave conditions, particularly by analyzing local meteorological data to anticipate periods of intense heat at the end of the cycle when heat resistance diminishes in broilers. A specific coverage could be designed by insurers to protect against the increased mortality risks related to heat during this critical phase. This coverage could include special benefits or additional compensation to offset the losses associated with high mortality rates (Singerman and al, 2012., Delbridge and King, 2019).

Laying hens recorded an average mortality of 11.66% ± 9.24%. This result, recorded in this phase, remains lower than that recorded in the second phase (16.97% ± 9.11%) and is likely related to the end of their production cycle. The works of Yunis and Cahaner (1999) report that at the end of laying, hens exert less effort, and their metabolism quickly reduces to maintenance levels. Consequently, a decrease in their internal heat production allows them to better maintain homeostasis, resulting in better resistance compared to the mid-production phase and significantly better comfort compared to broilers during the same phase (27.14% ± 21.18%). Therefore, it would be advisable for insurers to adjust the insurance premiums for laying hens at the end of the cycle to reflect this lower mortality risk. These results highlight the importance of understanding the thermal responses of different poultry production phases to develop tailored insurance risk management strategies that address the specific needs of chicks and laying hens in the face of heatwave challenges throughout the three life cycles of poultry. Insurers thus offer farmers the possibility of obtaining compensations as the poultry life cycle progresses, without having to wait until the end of broiler rearing or the end of laying hen production. This allows farmers to regularly correct anomalies encountered in poultry houses, even if the compensations received are not very high. Coble and al (1996) demonstrated that farmers who anticipate smaller but more regular compensations are more inclined to ensure the security of their operations than those expecting less frequent but larger compensations. By integrating these approaches into the design of poultry insurance products, insurers can play a crucial role in financially protecting farmers against the risks associated with heatwaves, especially for broilers at the end of the production cycle. Customizing solutions and taking into account the specific risks at each stage of the rearing process allows for the proposal of more effective insurance solutions tailored to the realities of poultry farmers.

3. Analysis of Mortality Based on Building Conditions for Both Types of Farming

In non-equipped buildings, the study's results highlight an increased sensitivity of broiler chickens to unfavorable conditions, with mortality rates nearly doubled (25.78% ± 23.48%) compared to laying hens (13.78% ± 9.75%) (Table 3). This significant difference can be explained not only by their specific physiology but also by the absence of humidifiers, essential devices in regulating temperatures during periods of intense heat, thus promoting poultry thermal comfort. Ashish and al (2019) emphasizes the critical importance of cooling to mitigate the adverse effects of heat stress on chickens. The study has shown that although farmers recognize these essential environmental factors, they face budget constraints limiting their investments. They believe their resources would be better used in more productive farming practices. Given these findings, it is crucial to encourage farmers to invest in equipment such as humidifiers to reduce heat stress-related mortality risks. Kunreuther and Pauly (2005) argue that the absence of preventive measures is one of the anomalies present in the insurance market. Insurers can play a crucial role by offering financial incentives or premium reductions to farms that implement effective environmental risk management measures. The goal is to reduce losses related to poultry mortality while promoting the economic sustainability of farms.

In equipped poultry houses, although mortality averages are relatively lower compared to non-equipped buildings, they are still high, reaching 14.57% ± 8.36% for broiler chickens and 9.64% ± 4.6% for laying hens (Figure 1).

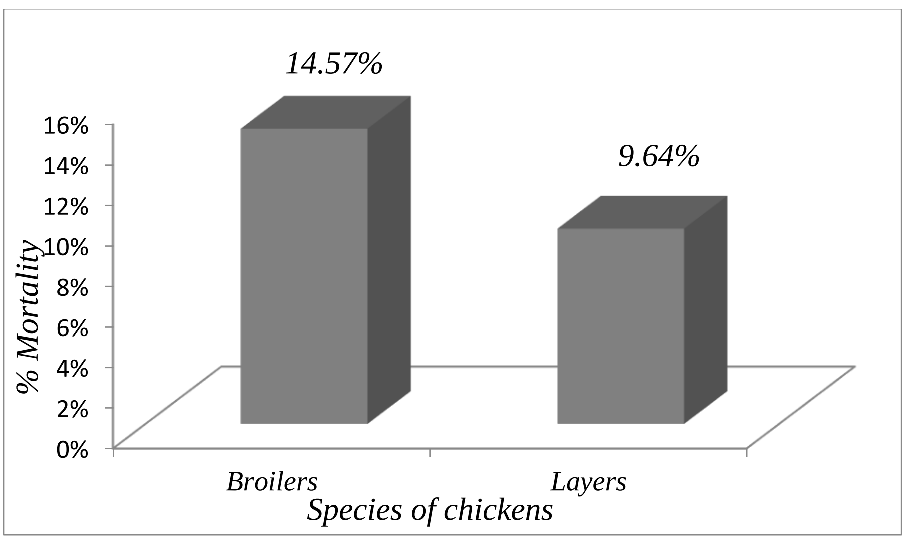

Figure 1. Mortalities in broiler chickens and laying hens in equipped buildings

Indeed, the study has shed light on a critical issue: internal equipment is not synchronized, compromising their effectiveness. Some equipment is non-functional or not correctly sized relative to building size, affecting their ability to ensure adequate ventilation. The importance of maintaining equipment in good condition before the hot season is emphasized in this study as they represent a strategic tool for the farmer during this particularly hot period. Chevalier and al

(2015) emphasize the importance of optimizing indoor environmental conditions, and Turnpenny and al (2001) stress their role in adapting buildings to climate change. Additionally, the study identified recurring issues in buildings equipped with pad cooling systems during heat periods due to insufficient water supply, with uncooled drinking water coming from external tanks. This study underscores the crucial importance of effective water management to maintain the proper functioning of these cooling systems. In a similar context, Robin and al (2005) highlighted the importance of evaporative cooling combined with effective ventilation to prevent mortality during hot periods. Their research underscores the effectiveness of these strategies in protecting chicken health during heatwaves, thus highlighting the importance of adopting appropriate cooling technologies to ensure comfortable and safe living conditions during extreme heat. Faced with these findings, insurers have a crucial role to play in raising awareness among farmers about the importance of maintaining and using poultry equipment correctly to ensure animal welfare and reduce heat-related mortality risks. By offering financial incentives or premium reductions to operators who maintain their equipment in good condition before the hot season, they will promote better management of this risk. This proactive approach contributes to strengthening good poultry farming practices and supporting the sustainability of the industry in the face of environmental challenges.

Conclusion

The results of this study, analyzing mortality based on farming types and production phases, reveal significant differences. Broiler chickens show increased sensitivity to high temperatures compared to laying hens, with higher mortality rates of 19.95% ± 17.90% for broilers and 13.07% ± 9.17% for laying hens. These findings suggest that insurers could offer differentiated premiums based on farming type, thereby adapting pricing to the specific risks associated with each type. Furthermore, the analysis of mortality across poultry life phases highlights critical periods, such as the end of the broiler production cycle, where heat sensitivity is highest, resulting in mortality rates of 27.14% ± 21.18%. These results underscore the importance of specific insurance coverage for these high-risk periods, incorporating preventive measures and incentives to improve farming practices.

Additionally, the study emphasizes the crucial impact of poultry house conditions on mortality. Mortality rates recorded for broilers and laying hens, respectively (25.78% ± 23.48%) and (13.78% ± 9.75%), demonstrate that inadequate or poorly maintained equipment increases risks related to heat stress. Insurers could play a key role in encouraging poultry farmers to invest in appropriate equipment and maintain optimal functioning before hot periods, offering financial incentives to enhance environmental risk management.

This research highlights tangible opportunities for agricultural insurance companies. By integrating the findings of this study into the design of poultry insurance products, insurers can offer personalized and effective solutions tailored to the specific needs of farmers facing heat stress challenges. These measures will not only promote the financial protection of poultry farmers but also the economic sustainability of farms, while mitigating the negative impacts of heat stress on poultry production in Algeria.

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Table 1. Mortalities by Chicken Type

Average mortality rates for laying hens and broilers	Mean ± Standard Deviation
Broilers	19.95±17.9[a]
Laying Hens	13.07±9.17[b]
***The values in a row marked with different letters are significantly different at P < 0.05.**	

Table 2. Average mortality rates according to age Chicken Age

Chicken Age (Cycles)	Broilers	Laying Hens
Début du cycle	Nothingness	8.36 ±7.01[a]
Milieu du cycle, Broilers	12.16 ±9.07[b]	16.97±9.11[b]
Fin du cycle, Laying Hens	27.14 ±21.18[c]	11.66 ±9.24[ba]
**The values in a row marked with different letters are significantly different at P < 0.05. Means ± Standard Deviation*		

Table3. Average mortality rates in unequipped buildings

Unequipped Buildings	Mean ± Standard Deviation
Broilers	25.78±23.48[a]
Laying Hens	13.78±9.75[b]
**The values in a row marked with different letters are significantly different at P < 0.05.*	