CGIAR RESEARCH PROGRAM ON Livestock

More meat milk and eggs by and for the poor

POLICY BRIEF

Heat stress on dairy productivity: Policy recommendations for the dairy value chain in Zambia

Key messages

- Heat stress has an impact on lactation, reproduction, gestation length, and dry matter consumption, all of which have an impact on milk yield in dairy cattle.
- Exotic breeds, old aged, free-range, high body-score, pregnant, and lactating dairy cattle are all at risk of heat stress.
- Most regions are already experiencing an increasing trend of severe heat stress historically and the trend is likely to continue in the future.
- Dairy farmers' livelihoods are in danger, as is the sector's long-term viability.
- Stakeholders in the dairy value chain must take action to combat the impending effects of heat stress on the industry.

Policy options

- Heat stress in dairy cattle should be well acknowledged, and information regarding the best ways for coping, adapting, and minimizing it at the farm level, should be widely shared.
- More specialization along the dairy processing chain could help Zambia's dairy sector become more competitive.
- Close research-policy cooperation and information sharing with stakeholders from the public and private sectors, as well as researchers, academics, and farmers.
- Coordination of policymaking for heat stress at the national and local levels and incorporation into development strategies and action plans.

EXECUTIVE SUMMARY

The dairy industry is a significant contributor to Zambia's economy. In 2019, the country had over 3.6 million cattle, with a total milk output of 453 million litres and smallholder dairy producers accounting for over 72% of this. Zambian milk production is inadequate to satisfy the country's expanding demand for dairy products. Climate-related heat stress is expected to exacerbate the problem. A recent study identified hotspot areas in Zambia where heat stress could have a negative impact on dairy productivity. Most of the country is having moderate heat stress conditions already and predictions point to the possibility of severe conditions in the future. When an animal's heat burden exceeds its ability to shed heat, it suffers from heat stress. Heat-stressed dairy cows eat less dry matter, have a lower conception rate, are more susceptible to diseases, produce less milk, and have a higher mortality rate. As a result, the farmer's income is reduced. In recent years, smallholder dairy production systems, which account for most dairy production in Zambia, are shifting to market-oriented systems. Adapting these systems to heat stress should, however, be a priority if they are to remain viable. This policy brief summarizes research findings on heat stress in Zambian dairy cattle, analyzes effective interventions, and culminates with evidence-based policy recommendations. Recommended policy option including promoting coping and adaptation measures at farm level, more specialization along the dairy processing chain, close research-policy cooperation and information sharing with stakeholders and coordination of policymaking for heat stress at all levels i.e., national, and local levels as well as incorporation into development strategies and action plans. If the government and commercial players are to achieve the development goal of sustainably empowering farmers and increasing their earnings, all stakeholders must rally behind the implementation of coping and adapting strategies.

Stakeholder group discussions at the same meeting. ©Photo ILRI

BACKGROUND

Dairy production is an important economic activity in Zambia. As of 2019, Zambia had approximately 3.6 million cattle (FAO, 2019). However relative to its vast grazing land, Zambia has a comparatively small cattle population. Zambia's total milk output in 2019 was around 453 million litres (FAO, 2019), with smallholder dairy producers accounting for approximately 72 percent of that. Even though the recommended level of milk consumption is 200 litres per year, per capita milk consumption in Zambia is 24 litres per year. The southern province of Zambia is the country's traditional cattle-raising region, with vast herds of indigenous breeds and portions of herds with improved genetics retained for dairy purposes.

Heat stress occurs when external temperatures rise and animals are unable to regulate their body temperatures or even maintain their regular body temperatures (Hahn et al., 1997). Heat stress is caused by a combination of heat and humidity, which has a negative impact on animal performance. As a result, we must guarantee that dairy cattle are kept within temperatures and relative humidity that are suitable for them — the degree of heat stress is quantified using a temperature-humidity index (THI).

The climate in Zambia is changing, with seasonal mean temperatures rising over the previous 50 years. Based on Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 scenarios, temperature is anticipated to rise by 1.5 to 3.5°C by 2100, and relative humidity would rise by 4 to 7%. These climatic changes are expected to alter the THI, increasing the risk of heat stress in dairy cattle.

Heat stress has a variety of negative impacts on dairy cattle, including lactation and reproductive function (Lemerle & Goddard, 1986). Heat stress extends the gestation duration of dairy cows when compared to cooler conditions (Tao et al., 2012), this is due to changes in feed consumption patterns caused by heat stress. When dairy cows are exposed to moderate heat stress for more than four days, their dry matter intake and milk yield decrease by 48 and 53 percent, respectively (Garner et al., 2017) However, there is a lack of quantitative data on the impact of heat stress on productivity and economic losses in Zambia. For comparison, heat stress costs the U.S. dairy industry approximately $1000 million/year in revenue.

Zambia has outlined a strategy for climate change adaptation. The National Climate Change Policy, which took effect in 2017, established a well-structured and coordinated national policy to effectively tackle climate change's negative repercussions. Vulnerable groups, such as poor rural women, children, and youth, are also given special attention. In addition, a Climate Change Gender Action Plan was implemented in 2017 to ensure women's leadership in the face of climate change. Zambia signed the Nationally Determined Contributions (NDCs) Partnership Plan in 2016. The document was revised in 2020 to emphasize adaptation on strategic productive systems such as agriculture, wildlife, and water, as well as strategic infrastructure, health, capacity building, research, technology transfer, and funding for adaptation. The National Adaptation Plan of Action (NAPA, 2007) was created with the goal of identifying priority tasks for rapid adaptation efforts. Agriculture and food security (livestock, fisheries, and crops), energy and water, human health, natural resources, and wildlife were among the sectors mentioned. Heat stress adaptation is consistent with the NAPA's nine priority intervention areas. The Dairy Industry Development Act of 2010 regulates the dairy sector to create an efficient and self-sustaining industry that contributes to poverty reduction, household food security, and job development. The Dairy Industry Development Board was established to promote milk production and facilitate growth among value chain actors.

Priority should be given to updating development policies to include heat stress risk in dairy cattle. Resources should be allocated for action plans to catalyse climate smart innovations towards a resilient dairy value chain. To implement the policies and initiatives indicated above, all players in the livestock and climate change adaptation fields should be involved in implementation. The following shortcomings become apparent: (i) the Dairy Industry Development Act of 2010 is not explicitly integrated into climate change adaptation measures, ii) although there is a Climate Change Gender Action Plan in place, the involvement of women and youth is low in all stages of the value chain, (iii) where stakeholders have made progress in developing associated policies, strategies, and plans together, a gap in execution still exists.

RESEARCH INSIGHTS

Heat stress risk mapping

In a recent study, Rahimi et al. (2021)but the extent to which heat stress negatively affects livestock production in this region is poorly understood. Here we use ERA-Interim reanalysis data to show that the frequency of 'Severe/Danger' heat events for dairy cattle, beef cattle, sheep, goats, swine and poultry significantly increased from 1981 to 2010. Using a multi-model ensemble of climate change projections for 2021–2050 and 2071–2100 (under representative concentration pathway (RCP identified hotspot areas in Zambia where heat stress could have a negative impact on dairy productivity. Most of the country is having moderate conditions. The average severe frequency varies from 2.5 percent (ten days per year) in the south to 10% (37 days per year) in the southeast. However, predictions hint to the possibility of severe conditions in the future. More areas will be vulnerable to heat stress because of climate change, according to model projections, which predict severe heat stress conditions by 2100. According to RCP 8.5, the length of severe heat stress conditions in the southwestern and eastern parts of the country is anticipated to increase by more than 60 days by 2100, up from less than 5 days in the historical period.

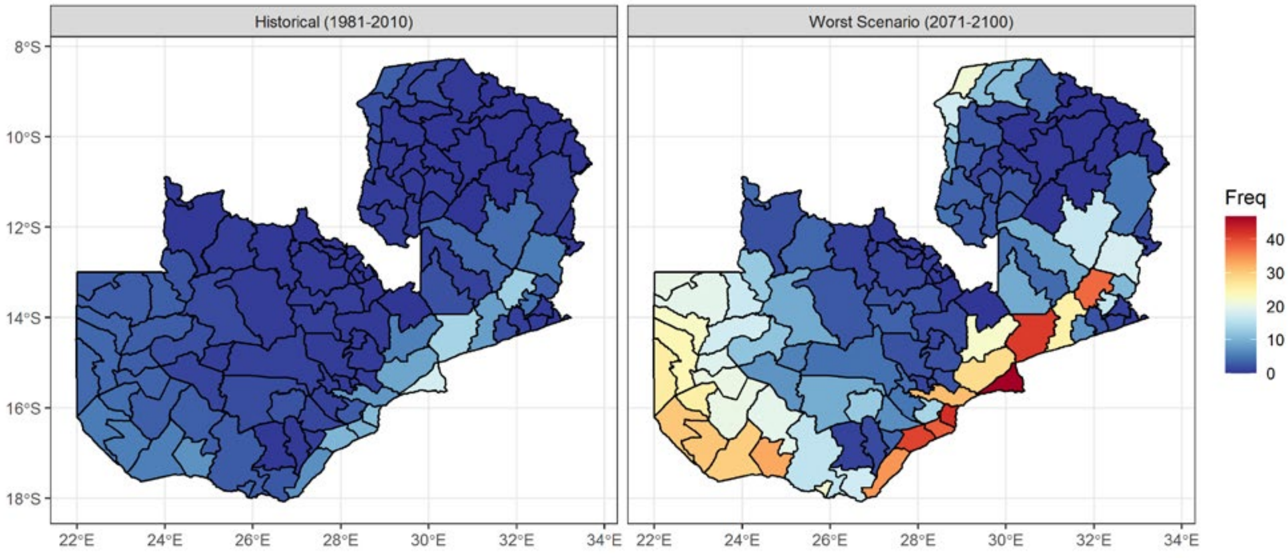


Figure 1: Frequency of severe heat stress conditions during the historical (1981-2010) and future (2071-2100) periods for dairy cattle in Zambia.

Factors that increase the risk of heat stress

Understanding the factors that contribute to heat stress in dairy cattle is necessary for heat stress management. Environment, management, and animal characteristics are the three variables that contribute to heat stress. Air temperature and humidity, which are used to compute THI, are the two environmental factors that contribute to heat stress in dairy cattle. Housing conditions (well ventilated versus poorly vented) and grazing circumstances (shaded versus non-shaded) are two management aspects that can help prevent heat stress. Furthermore, the duration of exposure determines the severity of heat stress. Dairy cattle that are at greater risk of heat stress include the exotic breeds e.g., high milk producing breeds like Holstein-Friesian (Kishore et al., 2014), older (Wang et al., 2020), lactating (Bohmanova et al., 2007), high body condition score, active and free range animals. Therefore, farmers should pay special attention during periods of high THI, as well as to dairy animals that are particularly vulnerable.

©Photo Georgina Smith/ Alliance of Bioversity International and CIAT

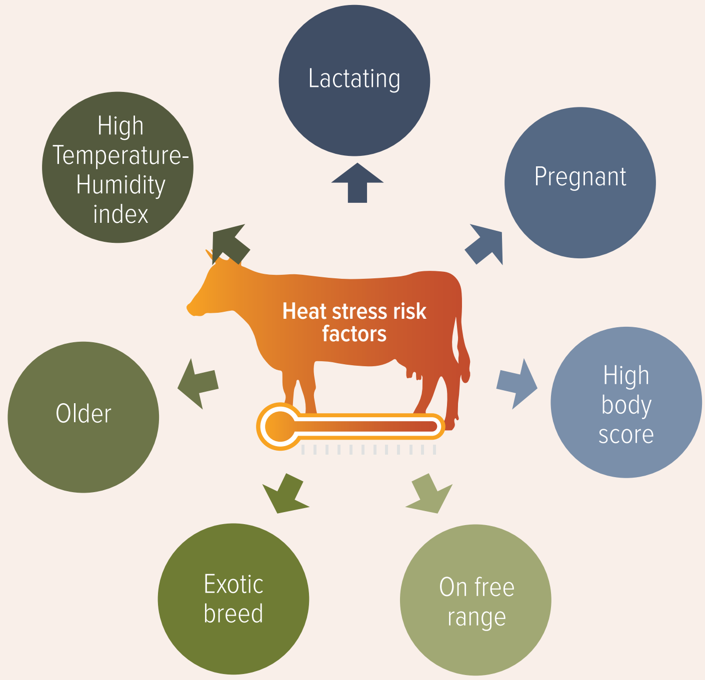


Figure 2: Factors that increase heat stress risk in dairy cattle

Effects of heat stress

Heat stress has a range of effects on the dairy value chain, ranging from mild to severe. They affect both men and women at all stages of the value chain and have an impact on all value chain players (see Table 1).

Table 1: Effects of heat stress in the dairy value chain activities in Zambia

Stage	Consequence	Severity*	Who is impacted
Input supply	Poor body score, Low conception rate, Storage for semen straws is affected	Major	
	Affects the quality and price of feed	Major	
	Increases the cost of health/ disease prevention activities	Severe	
On-farm production	Reduces the immunity of the animals hence increasing their susceptibility to diseases	Severe	
	Low feed intake leading to low milk production	Major	
	High bacteria count disrupting the cold chain	Major	
Post-harvest	Negatively affects the milk quality (Spoilage is high)	Severe	
	Affects the quality of the processed products	Severe	
	More energy is used, Wear and tear of cooling machines	Severe	
Output market	Reduced volume of milk increasing cost of product	Severe	
	Affects quality of milk hence low shelf life	Moderate	
	Packaging will become more expensive to increase shelf life	Moderate	

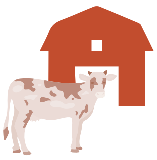
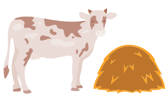
* Severity levels, severe being the worst.

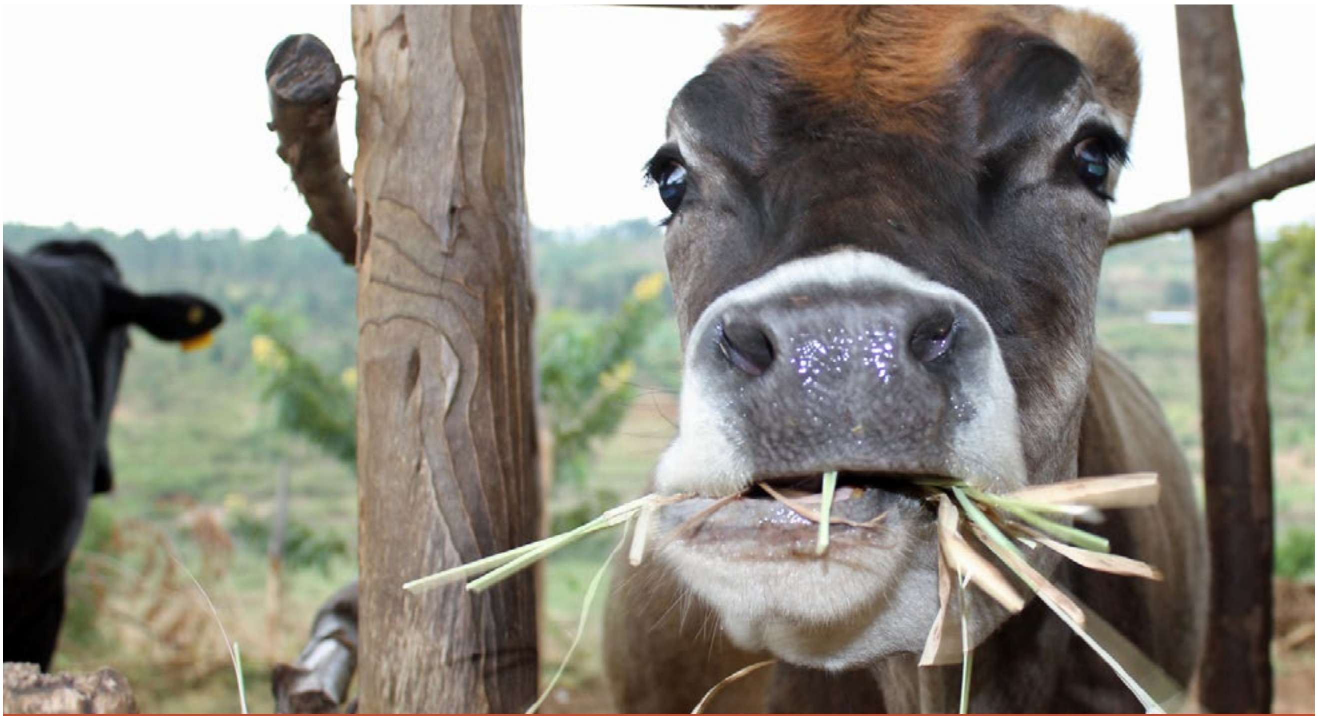
Severe Major Moderate

How to cope and adapt

Physical changes to the environment and feed management are adaptable, easy to promote and modify in accordance with local conditions and may be implemented quickly. Other measures, such as the genetic development of heat-tolerant breeds, can help mitigate heat stress over longer timeframes, but they require a collaborative effort from all parties.

Table 2: Ongoing and potential adaptation to heat stress in the dairy value chain in Zambia

Stage	Ongoing	Potential
Input supply	Continuous AI training and practice	Adding new AI centers to areas where none already exist
	Proper feed formulation and storage	Training and introduction of farmers to best forage, commercialization of fodder by co-operatives to provide the feed to their members at an affordable price.
	Provision of general extension services	Recruitment of more specialized extension staff who, among other skills, are privy to issues relating to heat stress and how to cope with it
On-farm production	Sensitization of farmers on outbreaks of diseases, spraying and dipping of animals	Private sector participation in providing herd health facilities to farmers, compulsory dipping, and herd health schedules
	Training on feed formulation, mixing and feeding	More capacity building on feed formulation, mixing and feeding
	Grazing in the flood plains to supplement poor upland feed availability during the dry season	Training more farmers on forage conservation and utilization, rangeland improvement interventions, controlled grazing, promote drought tolerant forages.
	Training on housing/ infrastructure construction	Construct improved structures with the help of Ministry of Agriculture, Technical Service Branch.
Post-harvest	Milk testing at the Milk collection centres (MCCs)	Provision of support to MCCs to do all the milk quality tests and not rely on off-takers
	Capacity building in hygiene and storage	Farmers to be encouraged to acquire milk cans and metal milking buckets
	Maintaining the freshness of milk through cooling, use of generators, solar coolers etc.	Provision of efficient cooling storage equipment support to farmers, solar milk cooling tanks
Output market	Increased establishment of dairy product associations, farmers to join associations	More awareness of common product association, increased information/ knowledge exchange within farmers
	Continued advertising of milk products	Improve on good advertisement, milk consumption campaigns and promotions
	Small scale product processing, increased number of stores/shops	More research and technological innovation to improve milk products



Climate Smart Bracharia. ©Photo StephanieMalyon/CIAT

POLICY RECOMMENDATIONS

1. Farm-level coping and adaptation measures
   i. Better availability and affordability of breeding and feeding inputs could reduce production costs and improve productivity.
   ii. Heat-stress in dairy cattle should be made more widely known, and information about best strategies for coping, adapting, and minimizing it should be shared so that people can respond appropriately.
   iii. Existing extension institutions should teach farmers how to identify heat-stressed dairy animals quickly and easily for heat stress management and mitigation.
   iv. Strengthen community-based initiatives, women's organizations, to develop support programs and information regarding low-cost coping and adaptation approaches and technology.
   v. Encourage the planting and maintenance of trees on farms to generate an appropriate microclimate for dairy cattle heat stress mitigation.
   vi. Promote the establishment of suitable fodder varieties that can withstand drier climates.
   vii. Support pasture growers to promote viable business models to make fodder production a viable business venture that can supply dairy farmers all-year-round fodder.
2. Action along the value chain
   i. More specialization to ensure efficiency i.e., better collection systems, processing facilities at the local level along the dairy processing chain could help Zambia's dairy sector become more competitive.
   ii. Traditional farmers could be able to participate in more markets and generate more revenue if market access is improved such as establishment of more Milk Collection Centers.
   iii. Need to invest in technologies that can reduce the cost for maintaining the cold chain for improved milk quality.
3. Close research-policy cooperation and information sharing
   i. Stakeholders from the public and private sectors, as well as researchers, academics, and farmers, should interact and participate in multidisciplinary participatory research, as well as data and information sharing.
   ii. Establishment of heat-stress surveillance systems to track current and future heat-stress events, effects, and implications.
4. Coordination of policymaking at the national and local levels
   i. Heat stress risk should be incorporated into development strategies and action plans for individual departments' resource allocation and activities.

ii. Easier access to and reduced cost of financing, as well as an improved regulatory environment, could promote increased investment and expansion in the dairy sector.

iii. Gender mainstreaming in heat stress adaptation should be a part of climate policies and practices, and adaption measures should be guided by the differences in tasks and contributions of men, youth, and women along the value chain.

5. Heat stress management necessitates informed and expanded public and private sector investment to stimulate innovations aimed at anchoring resilience in present dairy production systems

Dairy farmers must adapt to heat stress due to climate change. Policymakers can take advantage of existing and novel ways for coping with and adapting to heat stress. All stakeholders must rally behind the adoption of coping and adaptation measures if the government and private players are to achieve the development aim of sustainably empowering farmers and increasing their revenue.

The participants of the heat stress assessment stakeholders consultative meeting (7th-8th June, 2021, Choma, Zambia). ©Photo xxx

AUTHORS

John Mutua is a senior research associate at the Alliance of Bioversity International and CIAT based in Nairobi, Kenya. j.y.mutua@cgiar.org

Noah Sikaceya is a senior research associate at the Alliance of Bioversity International and CIAT based in Choma, Zambia. n.ngoma@cgiar.org

Solomon Mwendia is an associate scientist at the Alliance of Bioversity International and CIAT based in Nairobi, Kenya. s.mwendia@cgiar.org

An Notenbaert is a senior scientist at the Alliance of Bioversity International and CIAT based in Nairobi, Kenya. She has a background in land use planning and coordinates the activities of the Tropical Forages Team in Africa. a.notenbaert@cgiar.org

ACKNOWLEDGEMENTS

This work was supported by the Alliance of Bioversity International and CIAT through the framework of the Environment Flagship of the CGIAR Research Program (CRP) on Livestock and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

Local livestock feed does not have the same nutritional value as improved varieties. Livestock farmers re finding ways of boosting their production and lowering their environmental impact by planting improved forages.. ©Photo GeorginaSmith/CIAT

REFERENCES

Bohmanova, J., Misztal, I., & Cole, J. B. (2007). Temperature-humidity indices as indicators of milk production losses due to heat stress. *Journal of Dairy Science*, *90*(4), 1947–1956. https://doi.org/10.3168/jds.2006-513

FAO. (2019). *Food and agriculture organization of the United Nations statistical databases.* Food and Agriculture Organization of the United Nations. http://faostat.fao.org

Garner, J. B., Douglas, M., Williams, S. R. O., Wales, W. J., Marett, L. C., DiGiacomo, K., Leury, B. J., & Hayes, B. J. (2017). Responses of dairy cows to short-term heat stress in controlled-climate chambers. *Animal Production Science, 57*(7), 1233. https://doi.org/10.1071/AN16472

Hahn, G. L., Parkhurst, A., & Gaughan, J. (1997). Cattle respiration rate as a function of ambient temperature. *Trans. ASAE, 40*(6), 97–121.

Kishore, A., Sodhi, M., Kumari, P., Mohanty, A. K., Sadana, D. K., Kapila, N., Khate, K., Shandilya, U., Kataria, R. S., & Mukesh, M. (2014). Peripheral blood mononuclear cells: A potential cellular system to understand differential heat shock response across native cattle (Bos indicus), exotic cattle (Bos taurus), and riverine buffaloes (Bubalus bubalis) of India. *Cell Stress and Chaperones, 19*(5), 613–621. https://doi.org/10.1007/s12192-013-0486-z

Lemerle, C., & Goddard, M. E. (1986). Assessment of heat stress in dairy cattle in papua new guinea. *Tropical Animal Health and Production, 18(*4), 232–242. https://doi.org/10.1007/BF02359540

Rahimi, J., Mutua, J. Y., Notenbaert, A. M. O., Marshall, K., & Butterbach-Bahl, K. (2021). Heat stress will detrimentally impact future livestock production in East Africa. *Nature Food*, *2*(2), 88–96. https://doi.org/10.1038/s43016-021-00226-8

Tao, S., Monteiro, A. P. A., Thompson, I. M., Hayen, M. J., & Dahl, G. E. (2012). Effect of late-gestation maternal heat stress on growth and immune function of dairy calves. *Journal of Dairy Science*, *95*(12), 7128–7136. https://doi.org/10.3168/jds.2012-5697

Wang, J., Li, J., Wang, F., Xiao, J., Wang, Y., Yang, H., Li, S., & Cao, Z. (2020). Heat stress on calves and heifers: A review. *Journal of Animal Science and Biotechnology*, *11*(1), 79. https://doi.org/10.1186/s40104-020-00485-8

CONTACT

An Notenbaert
Alliance of Bioversity International and CIAT, Kenya
a.notenbaert@cgiar.org

Noah Sikaceya
Alliance of Bioversity International and CIAT, Zambia
n.ngoma@cgiar.org

Ministry of Livestock and Fisheries

RESEARCH PROGRAM ON Livestock

This research was conducted as part of the CGIAR Research Program on Livestock and is supported by contributors to the CGIAR Trust Fund. CGIAR is a global research partnership for a food-secure future. Its science is carried out by 15 Research Centers in close collaboration with hundreds of partners across the globe. www.cgiar.org/funders