Observations and Projections of Heat Stress for Livestock in Sub-Saharan Africa

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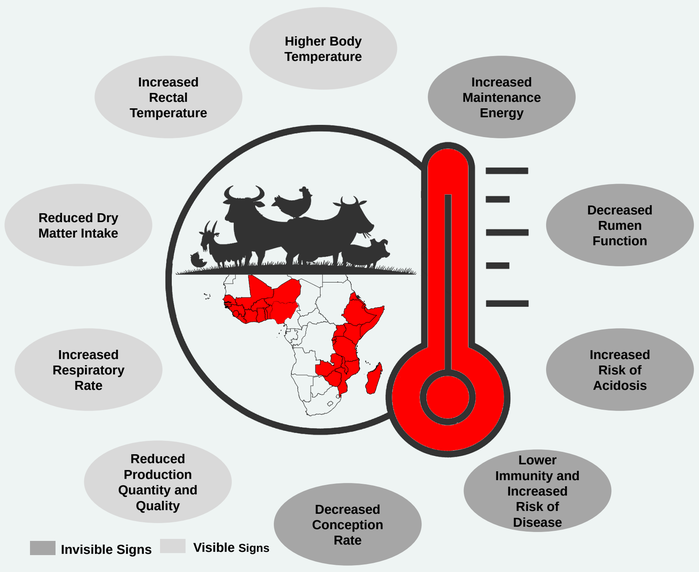
Introduction

Excessive heat load (EHL), or heat stress, describes the situation where livestock, primarily cattle, are not able to dissipate body heat effectively and their body temperature rises above normal.



Heat stress events for livestock species are expected to become more frequent due to climate change (Rahimi et al. 2020). In this investigation, we assess the frequency of heat stress as well as the changes in consecutive days with heat stress events for different livestock species (dairy cattle, beef cattle, sheep, goat, swine, and poultry) in Sub-Saharan Africa (SSA).

Data and Methods

Study Region The geographic focus of this study are East African (lies between 18°N-27°S and 22°-63°E; consists of 21 countries: Burundi, Comoros, Djibouti, Eritrea, Ethiopia, French Southern Territories, Kenya, Madagascar, Malawi, Mauritius, Mayotte, Mozambique, Reunion, Rwanda, Seychelles, Somalia, South Sudan, Tanzania, Uganda, Zambia, and Zimbabwe) and West African (lies between 15° E–16° W and 4° N–25° N; consists of 14 countries: Benin, Burkina Faso, Côte d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo) countries in SSA.

Data (I) Used ERA-Interim reanalysis data to map heat stress risk during the historical period. (II) Projections are based on a multi-model ensemble of GCMs (periods: 2021-2050 and 2071-2100; RCPs: 4.5 and 8.5) from CORDEX Africa.

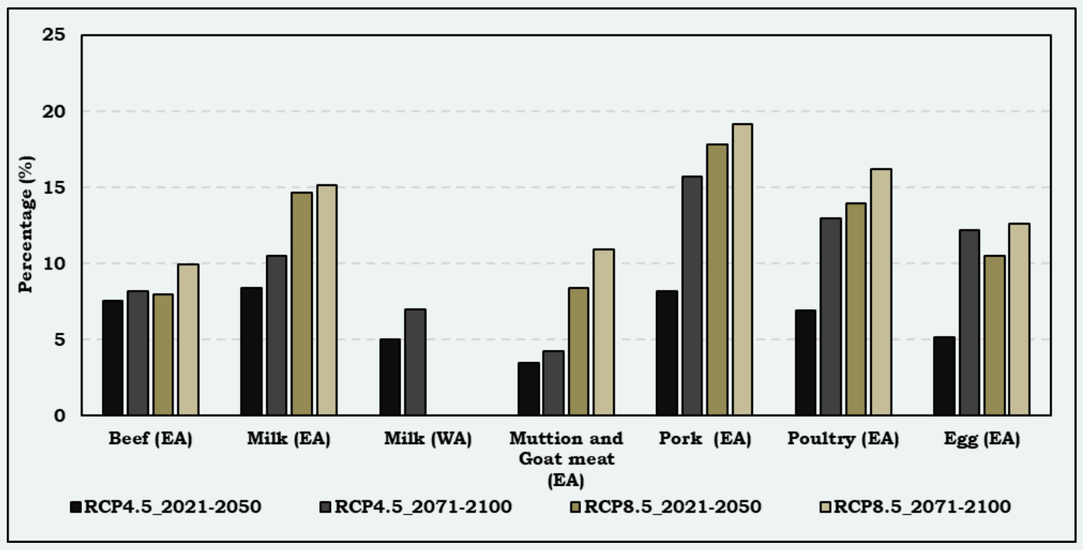
Method In this study we assessed the thermal heat-stress conditions using Temperature-Humidity Index (THI). For dairy and beef cattle, the THI was calculated using an equation developed by National Research Council (1971); For sheep and goat, the THI was calculated using the formula of Livestock and Poultry Heat Stress Indices (LPHSI 1990) modified by Marai et al. (2000); For poultry, the THI was estimated by the index of Zulovich and DeShazer (1990); For swine, the THI was calculated using the formula proposed by Roller & Goldman (1969).

Results

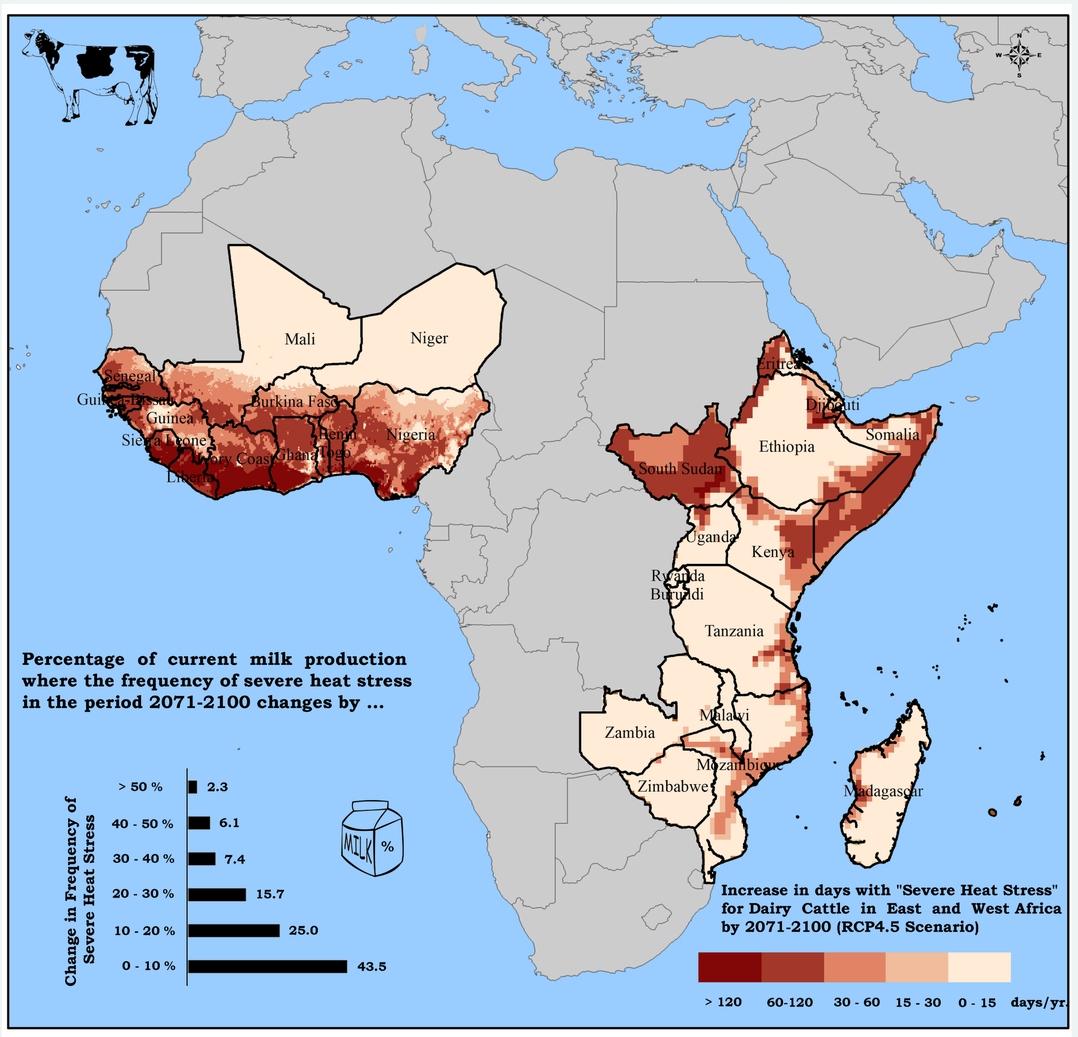
The obtained results indicated that in recent decades the frequency of Severe/Danger heat events, i.e. events that result in significant decreases in productive and reproductive performances, has already significantly increased (at 95% confidence level) in the region (e.g. for dairy cattle, it has increased in >1/5 of the study). We also found that by the end of the 21st century, under both RCP scenarios, the frequency of Severe/Danger heat stress conditions and the mean average length of consecutive days with heat stress events are likely to significantly increase for almost all livestock species.

Livestock Species	Average No. of days with heat stress	average length of consecutive days with Severe/ Danger heat stress	Historical Period	Future Periods			
				2021-2050	2071-2100	2021-2050	2071-2100
				RCP4.5	RCP4.5	RCP8.5	RCP8.5
Dairy Cattle (EA)	*None*		29	12	7	10	2
	Mild		77	66	50	62	28
	Moderate		215	241	250	242	250
	Severe/Danger		44	47	57	50	86
		Severe/Danger	2	3	10	5	20
Dairy Cattle (WA)	*None*		42	41	34	-	-
	Mild		134	105	95	-	-
	Moderate		171	184	183	-	-
	Severe/Danger		18	35	53	-	-
		Severe/Danger	3	4	7	-	-
Beef Cattle (EA)	*None*		47	25	16	22	6
	Mild		99	90	77	85	47
	Moderate		197	224	240	228	253
	Severe/Danger		22	26	32	30	59
		Severe/Danger	1	2	4	2	15
Sheep (EA)	*None*		102	82	68	77	57
	Mild		168	186	193	177	184
	Moderate		88	90	93	97	105
	Severe/Danger		7	6	11	14	19
		Severe/Danger	1	2	4	2	7
Goat (EA)	*None*		131	120	103	114	78
	Mild		168	177	188	176	180
	Moderate		62	63	69	71	93
	Severe/Danger		4	4	6	4	14
		Severe/Danger	1	1	3	2	3
Swine (EA)	*None*		55	28	24	23	11
	Mild		69	66	62	59	35
	Moderate		62	91	87	83	54
	Severe/Danger		179	179	192	200	265
		Severe/Danger	40	78	93	84	101
Poultry (EA)	*None*		212	194	187	167	135
	Mild		33	42	45	45	49
	Moderate		33	34	35	43	53
	Severe/Danger		88	96	99	110	128
		Severe/Danger	25	54	78	61	74

Such changes in frequency of dangerous heat stress condition, for instance, may affect on average ~15 % of our current livestock production (beef, milk, mutton, pork, poultry meat, and eggs) in EA countries by 2071-2100 climate period under RCP8.5.



Percentage of current livestock production in SSA which could be significantly challenged (p<0.05) due to the increase of the frequency of Moderate and Severe/Danger heat stress by 2021-2050 and 2071-2100 periods under RCP4.5 and RCP8.5 scenarios



Conclusions

Our analysis shows that severe and dangerous heat stress in animals caused by climate change looks set to hit milk and meat productivity for dairy cattle, beef cattle, sheep, goat, pigs and poultry across SSA countries. Our results highlight the hotspot regions where global climate change, in the absence of mitigation strategies, will significantly affect livestock productions in Sub-Saharan Africa in the future.

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