Climate change threatens farm animals: Italian researchers are using genomics to try to save them

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Researchers of Università Cattolica, Piacenza, are searching for genes to

make cattle and sheep breeds resistant to climate change, heat waves and drought: it is at risk the very survival of many local breeds, with huge economic losses for the production chain, while the arrival of new diseases can seriously affect cattle.

At the Faculty of Agricultural, Food and Forestry Sciences headed by Prof. Marco Trevisan, the Department of Animal, Nutrition and Food Sciences—DiANA, directed by Professor Francesco Masoero studies the genetics of adaptation. The geneticists, coordinated by Prof. Paolo Ajmone Marsan and involving Prof. Riccardo Negrini, Prof. Licia Colli and a large group of young doctoral students and postdoctoral fellows, recently published a review in the journal *Animals* about livestock adaptation to climate change.

Production loss due to climate change

"Production loss due to heat depends on environmental conditions, as assessed by the temperature/humidity index (THI)," explains Professor Ajmone Marsan. Several studies revealed worrying estimates of the order of millions of euros in direct costs (loss of production) and indirect costs (cost of veterinary interventions, fodder, etc.).

Prof. Trevisan points out that a paper, published this year in *The Lancet Planetary Health*, estimates the loss of global production from heat stress at something like $40 billion a year by the end of the century (ranging from a low of $34 to a high of $45), equivalent to about 10 percent of the 2005 value of meat and milk.

"Heat stress is deleterious to all animal species," Professor Negrini explains, "particularly for ruminants and high-producing dairy cattle, as well as our breeds. Unfortunately, climate projections indicate that summer weather in our country will be increasingly dry and hot. That will increase stress in animals, despite shading, ventilation, sprinkling of

water and possible conditioning."

Genomics to save livestock

Genomics can help save livestock from climate change, explains Professor Ajmone Marsan. For some years now, national breeding programs have changed the selection goals of livestock species, favoring animals that are more robust and functional and not just highly productive. Traditional selection produces excellent results but it requests at least 5 years. Genomics has almost tripled the speed of selection. With genomics, it is possible to identify and use the best variants of genes involved in whatever of interest for livestock well-being.

Through genomics, some genetic variants (mutations) that help animals to better adapt to hostile climates have already been identified. For example, in some local Caribbean cattle breeds (Senepol, Limoneiro and Carora), a "slick" mutation has been discovered that results in hair shortening and a series of physiological changes that make the animals extremely resistant to heat stress. The mutation has been introduced into the Friesian breed in Florida and it has also been shown to be effective in this breed, which is very important for milk production.

One goal could be to insert the gene into Italian herds and use it in selection programs.

The ongoing research projects in Italy and Europe

"Many ongoing research projects are looking for other favorable genetic variants associated with adaptation to the environment in other breeds and other species. We are actively involved in some of these projects," Prof. Colli says.

"We are studying the genetic basis of adaptation as part of national and international projects," he explains. "In particular, we are coordinating the project SCALA-MEDI that studies the genetics of adaptation in North African sheep and poultry. Five countries, Italy, France, Tunisia, Algeria and Morocco, 18 partners and more than 100 researchers are involved in the project. The main objective is to study and enhance the adaptive capacity to extreme climates of local North African breeds, particularly very hot and dry climates such as the Saharan ones. Understanding the genetic and epigenetic mechanisms of climate adaptation is important for planning genetic and genomic improvement programs that increase the production efficiency of local breeds without compromising their adaptive traits."

"Our aim is to demonstrate the economic value of the studied breeds as well," Professor Negrini says, "in order to contribute to their sustainable conservation. Adaptive genes are preserved in local breeds, but many of them are on the verge of extinction, replaced by improved breeds that are economically advantageous, while having poor adaptive capacity. There must be a balance between efficient production with industrial breeds, which allow the world to be fed sustainably, and conservation of livestock biodiversity as reservoir of useful genes."

"Genomics can increase the efficiency of local breeds, enhancing their sustainability, while studying their DNA to identify genes for adaptation useful for industrial breeds," Professor Ajmone Marsan points out.

"A second European project that has just ended is IMAGE (www.imageh2020.eu) coordinated by the French INRA. The primary objective of the project has been to characterize and exploit biobanks of DNA and animal semen and oocytes from livestock species," Professor Ajmone Marsan says. "Our group identified genes associated with climate adaptation in European sheep. We identified several genes and variants associated with environmental variables (such as temperature,

humidity, etc.) that are active in the immune system and metabolism, especially fat metabolism."

A final project is "A multi-species genomic approach to assess pre- and post-Columbian population dynamics in South America," which studies in parallel the genomes of human, bean and cattle on the South American continent.

"While its main objective is the reconstruction of human migration routes during the Paleolithic colonization of the continent, continental sampling of cattle will again allow us to study the genes of cattle adaptation along an extremely diverse climatic gradient, from Patagonia to the tropics; from sea level to the altitudes of the Peruvian mountains," Prof. Erminio Trevisi says.

"Genomics is a powerful tool and it will facilitate the selection of animals more resilient to climate change, but it is only one of the factors that can ensure animal welfare in extreme climates; it's crucial also to control farm structures, breeding management and precision feeding. The good news is that animals in production are increasingly closely monitored by cameras, sensors and intelligent data analysis systems, that alert farmers as soon as animals show the first signs of stress, allowing immediate implementation of mitigation measures."

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