



# University of Jaffna

## Prof. Somasundaram Kandiah Memorial Lecture-2024 ( First Dean of the Faculty of Agriculture and Professor in Agronomy )

**“Improving Cattle Production in the Tropics”**

By  
**Dr. YASUHIRO MORITA,**  
Associate Professor,  
Kyushu University,  
Japan.

on  
**Wednesday, 4<sup>th</sup> September 2024**  
at 10.00 a.m

at  
**Main Auditorium, Faculty of Agriculture,  
University of Jaffna,  
Ariviyal Nagar, Kilinochchi.**



**Prof.Somasundaram Kandiah**  
**Memorial Lecture-2024**  
( First Dean of the Faculty of  
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Titled  
**“Improving Cattle Production in the Tropics”**

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**Prof.Somasundaram Kandiah**



# Message from the Vice-Chancellor

**Prof. S. Srisatkunarajah**  
**Vice-Chancellor**  
**University of Jaffna**  
**Sri Lanka**



It gives me great pleasure to honour the late Prof. Somasundaram Kandiah, who was appointed as the first Dean of the Faculty of Agriculture at the University of Jaffna in October 1990. Prof. S. Kandiah was born on September 9, 1936, in Ariyalai, which is located to the east of the Jaffna peninsula. He completed his secondary school at St. John's College in Jaffna before enrolling in the University of Colombo's Bachelor of Science program. Late Prof. S. Kandiah received his doctorate from the University of London after doing doctoral research on producing dwarf apple tree varieties through plant breeding. The late Prof. Kandiah later returned to the nation as a young PhD holder and worked as a research officer at at Tea Research Institute of Sri Lanka. Due to his outstanding research and academic qualifications, late Prof. S. Kandiah selected and started his academic career as Senior Lecturer in Botany at the Faculty of Science, University of Jaffna in 1978. At the Faculty of Science, he served as the Head of the Department of Botany and later promoted as associate Professor in Botany.

In 1990, late Prof. Kandiah has accepted to serve as a Professor in Agronomy for the newly established Faculty of Agriculture in Kilinochchi although many of the Tamil academics were leaving from the country as the civil war was worsening in the region. Thereafter, he was unanimously elected as the first Dean of the Faculty in October 1990. Many of his very first batch students of the Faculty of Agriculture remember him as humble, simple and noble academician as a dedicated teacher, outstanding researcher, committed administrator. He was very keen to understand and solve students' problems. He has supervised many research students on the areas of improvement of horticultural crops and initiated the dwarf palmyrah breeding program in the Northern, Sri Lanka.

During the Sri Lankan civil war, he used to go by bicycle from Kilinochchi to Jaffna along the Poonakary route with a few other faculty members. On March 23, 1991, Prof. Kandiah died of a heart collapse while riding back to Kilinochchi from a senate meeting at the University of Jaffna. The Faculty of Agriculture was concerned because it had unexpectedly lost a great academic while on duty. His passion and commitment to the Faculty of Agriculture will always be remembered by the University of Jaffna.

The Faculty of Agriculture consecutively hold the memorial lecture every year since 2022 to commemorate the services of its first dean late Prof. Somasundaram Kandiah and I am happy that it has been materialized successfully. This year, we are delighted to have Japanese eminent scientist Associate Professor MORITA Yasuhiro from Kyushu University University, Japan to deliver this 3<sup>rd</sup> memorial lecture of Late Prof. Somasundaram Kandiah under the title of "Improving cattle production in the tropics".

Dr. Yasuhiro MORITA is serving as Associate Professor at Graduate School of Bioresource and Environmental Sciences. Dr. Yasuhiro MORITA graduated as Clinical Veterinarian (Livestock) from the Yamaguchi University, Japan in 2010 and completed his PhD Studies on production of female embryos from immature oocytes in cow and pig at The United Graduate School of Veterinary Medicine, Yamaguchi University, Japan in 2016. He commenced his professional career as Clinical Veterinarian (Livestock) since 2010 and was then appointed as Assistant Professor in Asian Satellite Campuses Institute (ASCI), Nagoya University in 2017; then from 2022-2024 Obihiro University of Agriculture and Veterinary Medicine (OUAVM) as Associate Professor, since 2024 Dr. Yasuhiro MORITA moved to Graduate School of Bioresource and Environmental Studies (GSBE), Kyushu University, Japan as Associate Professor. He has been conducting a wide range of research in animal husbandry, reproduction, and genetics in Japan and Southeast Asian countries for improving cattle productivity under heat conditions. In recent years, Dr. Yasuhiro MORITA's researches has been focusing on physiological research for improving livestock production with ICT systems and research elucidating the relationship between the microbiome, including rumen, intestinal, genital microflora, and productivity and disease with the aim to generate novel livestock production that will last into the future. As a proven research scientist, to further strengthen his research, he is securing many research grants through competition.

Dr. Yasuhiro MORITA has published more than 30 research papers in high impact Q ranking Journals and presented in international

conferences. For the continuous contribution to the field of expertise, he has won prestigious award of the Annual Meeting of Tokai livestock Science 2022, Award of the Annual Meeting of Japanese Veterinary Medical Association Chugoku district 2016 and Economic director award of Japan Livestock Medical Technology and Research Meeting 2017. Moreover, Dr. Yasuhiro MORITA is decorating as member of American Dairy Science Association; Society for Reproduction and Development; Japanese Society of Animal Science; The Japanese Society of Veterinary Science and The Society of Farm Animal in Infectious Diseases.

University of Jaffna would extend its appreciation to Dr. Yasuhiro MORITA for agreeing to deliver the late Prof. S. Kandiah memorial lecture for the year 2024 from his expertise area of research. I hope his talk will add new knowledge in the field of Animal Science and open new regional agricultural research plan focusing to UN's SDG goal of zero-hunger in year 2030.

All Glories to Almighty

# "Improving Cattle Production in the Tropics"

## 1. Introduction

Heat stress in summer negatively impacts productive and reproductive performance in cattle (Fig.1) and decreases the income of dairy and beef farmers (Fabris et al., 2018; Brown-Brandl 2018). A previous study indicated that production losses from heat stress were estimated to be approximately \$40 billion per year by the end of the 21st century, or 9.8% of the value of meat and milk production from cattle in 2005, based on the greenhouse gas emissions (SSP5-8.5, IPCC) (Thornton et al., 2022). The present situation could last, and improving cattle management for productivity under heat conditions is an urgent global issue.

This lecture aims to provide an overview of the information on heat stress and its impact on cattle productivity from several aspects and to help improving cattle production in the tropics.

## 2. How to evaluate cattle heat stress

### *2.1 Physiological response under heat stress*

Previous studies showed that heat stress negatively impacted cattle, such as increased body temperature, respiratory rate, heart rate, salivation, panting, and sweating (Gwazdauskas et al., 1973; Roman-Ponce et al., 1978). Dairy cows must maintain a constant body temperature of around 37.8-38.6 °C to maintain their homeostasis. Environmental factor influences livestock production in many ways such as temperature and humidity, stall conditions, lighting, wind, ground conditions, and noise. In particular, environmental temperature and humidity conditions influence animal body

temperature and appetite causing production loss of health, reproduction, and milk yield.

Two major physiological pathways have been reported to be involved in stress responses in mammals. First, stress increases the activity of the hypothalamic-pituitary-adrenal (HPA) axis, which leads to an elevation in the blood circulation levels of cortisol (Ulrich-Lai and Herman, 2009). Blood cortisol level is thus one of the parameters to evaluate the activity of the HPA axis and is, therefore, used to estimate stress intensity in farm animals (Mormede et al., 2007). However, measurement of blood cortisol levels needs blood sampling, which requires restraining the animals and that may give additional stress to the subjects. In addition, a cortisol assay usually requires a couple of days to get the final data. The second physiological response is the change in activity of the autonomic nervous system under stress: stress increases sympathetic nervous activity and decreases parasympathetic nervous activity (Ulrich-Lai and Herman, 2009). Heart rate variability (HRV) is a parameter that reflects the balance between sympathetic and parasympathetic nervous activity (Baselli et al., 1986; Kovacs et al., 2015; von Borell et al., 2007). HRV needs only a record of electrocardiograms, and it's a low-invasive method.

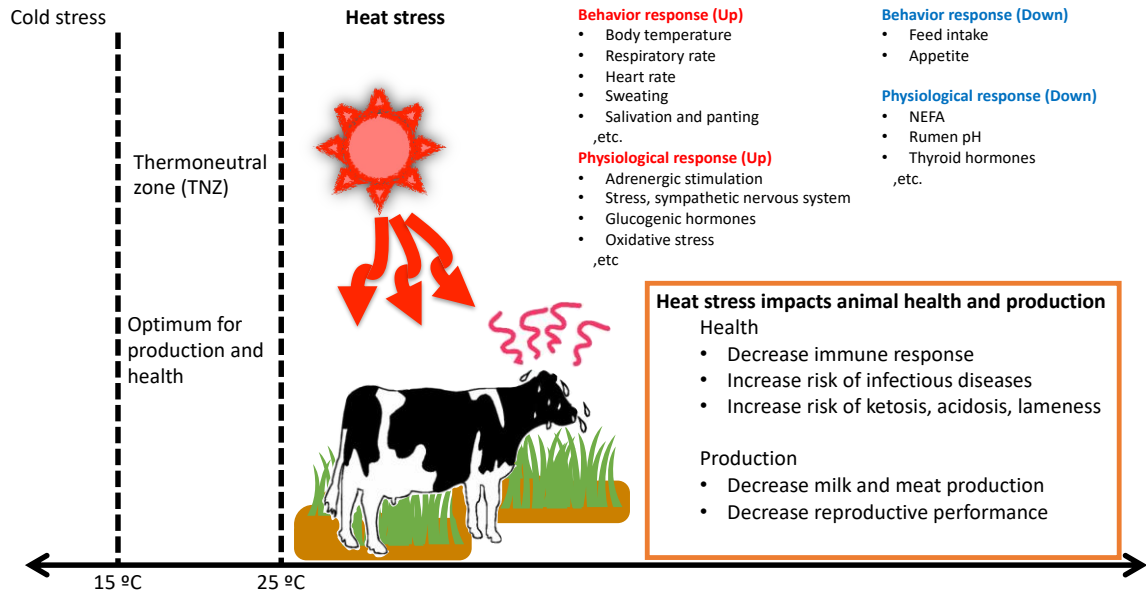


Fig.1 Summary of various heat stress-related behavior and physiological changes and production impacts from heat stress in dairy cows.

The authors focus on HRV for stress evaluation in cattle and analyze the relationship between treatment and HRV response. Our previous study examined the effect of tropical temperatures on the autonomic nervous activities in crossbred Cambodian dairy cattle by analyzing HRV (Bun et al., 2017). Holter-type electrocardiograms were recorded in adult 5 crossbred cows (Cambodian native × Holstein) either in a sheltered area or under direct sunlight. Rectal temperatures and heart rates increased in animals under direct sunlight as compared to those in the shelter. The power spectral analysis of HRV revealed that three out of the five cows studied underwent a decrease in parasympathetic nervous activity under direct sunlight with the remaining two cows showing no apparent change. The HRV analysis would prove to be a useful tool to reveal information about heat tolerance in dairy cows (Fig.2).

## ***2.2 Heat stress and oxidative stress***

High environmental temperatures can cause oxidative stress in livestock, which reduces productivity through several pathways. Previous studies have indicated that oxidative stress increases in cattle under heat stress (Bernabucci et al., 2002; Sakatani et al, 2012). Therefore, suppressing oxidative stress could be important for improving cattle production during summers and in other heat-stress conditions. Oxygen species (ROS) is one of the oxidative stress agents, inducing DNA damage and leading to apoptosis, lipid peroxidation, and disrupt the mitochondrial function, causing abnormal gene expression and protein synthesis and finally resulting in cell death (Sakatani et al, 2012; Lord-Fontaine and Averill-Bates, 2002).

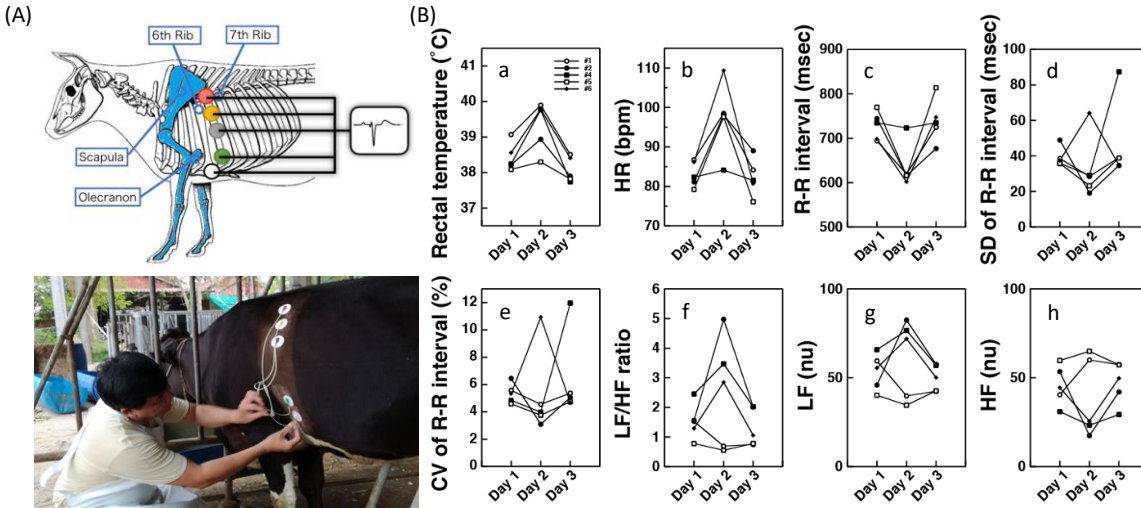


Fig. 2 Placement of electrodes for recording A-B lead electrocardiogram in cattle (A). Individual changes in rectal temperature (a), heart rate (b), R-R interval (c), SD (d) and CV (e) of R-R interval, LF/HF ratio (f), and normalized LF (g) and HF (h) powers in the five cows on pre- (Day 1), heat- (Day 2), and post- (Day 3) treatment days during daytime (09:00-15:00 hr)(B: Bun et al., 2017). HR, heart rate; SD, standard deviation; CV, coefficient of variation; LF, low frequency; HF, high frequency; nu, normalized unit.

The balance of ROS production and the availability of antioxidant defenses is important, in particular, during the periparturient period because cows may be suffered from oxidative stress compared with other life stage. Previous studies suggest that oxidative stress is significantly related to dysfunction of host immune and inflammatory responses, increasing the susceptibility of dairy cattle to infectious diseases, reproduction and metabolic disorders (Bernabucci et al., 2005; Sordillo, 2005; Wilde, 2006).

### **3. Heat stress impacts cattle productivity**

#### ***3.1 Heat stress decreases cattle production***

The heat stress decreased productivity in cattle such as a decrease in milk yield in dairy cows and meat productivity in feedlot heifers due to decreased their growth rates (Mitlöhner et al., 2001; Rhoads et al., 2009). The quality and amount of milk yield and meat production rely on feeding management. Beyond maintaining their health, cattle require a balanced diet to better their production. Cattle need good feed components including carbohydrates and fats as energy, protein, fiber, minerals, vitamins, and water. Feeds must be digestible so that the nutrients can be absorbed and it should not contain toxic substances. Cattle require more energy to deal with heat stress because maintenance energy requirements increase against heat stress (West, 1999). However, feed intake is affected by heat stress, resulting in a decrease in DMI (Gorniak et al., 2014).

### ***3.2 Heat stress decrease reproductive performance***

Previous reports suggest that heat stress also impacts reproductive physiology: Exposure to heat stress causes impaired function of reproductive system in cows: The major problem is a decrease in hormone secretion related with reproduction, such as progesterone, estradiol, and luteinizing hormone (Gilad et al., 1993; Gwazdauskas et al., 1981; Ronchi et al., 2001), resulting to induce weak estrus behavior (Gangwar et al., 1965), ovulation fail (Wilson et al., 1998), and early embryonic death (Wolfenson et al., 1988), which finally leads to a decrease in conception rates. There must be many ways to keep the cattle by improving good housing management and feed refinement by forages and silage that would avoid direct sunlight which causes heat stress especially during hot/dry season.

## **4. Improving cattle productivity under heat condition**

In order to minimize heat stress, two possible options could be considered. First is advanced method on applying good management, proper housing and equipment with sprinkler and ventilation, and quality feed. Second is establishing new breed of dairy cows which can adapt to high temperature. Indigenous/local cows have the most adaptation to high temperature in tropical countries. Therefore, cross breeding between indigenous/local cows with dairy cattle would possibly produce new crossbred dairy cattle which can produce milk and is also tolerable with high temperature.

#### **4.1 Facility improvement**

Housing is an important shelter to protect from hot temperatures, excessively cold temperatures, sunlight, storms, rain, and other adverse weather conditions. Cows kept outside the stall spend less time eating (Tucker et al., 2007) and face direct sunlight particularly when the temperature becomes hot, thus proper housing is indispensable for cattle in tropical countries.

Grazing in open fields in tropical countries would harm cattle. Even though there must be many types of forages to provide enough feed for cows, open grazing is subject to direct sunlight which causes heat stress, especially during the hot season. Heat stress has many negative impacts on cattle such as an increase in body temperature, rapid breathing, panting, and sweating. Without proper management, grazing cattle could get infected with germs and parasites. Previous study showed summer grazing had a significant negative effect on injuries, lameness, and less feed consumption (Kivling, 2013).

The authors showed the usefulness of shade management for improving reproductive performance under heat conditions in the grazing land. The results showed that cows grazing under sunlight resulted in heat stress with delayed luteolysis and ovulation during the hot-dry season and suggest that the shaded stall rescues reproductive performance in cows even in the hot-dry season in tropical regions.

Other researchers showed a relative humidity and air velocity significantly affected the responses of physiological response, such as respiratory rate, body temperature, and productive performance of high-producing Holstein cows (Zhou et al., 2022). These responses already occurred at moderate ambient temperature of 19 to 26°C.

Therefore, we should consider the facility environment with shade (heat insulation), air temperature and humidity, and wind speed for improving cattle productivity under heat conditions. In addition, in the field, we should monitor the ambient environment of cattle with objective evaluation, such as temperature humidity indexes (THI, Table 1). In hot and humid tropical regions, we should consider that humidity significantly impacts cattle production.

## ***4.2 Feeding improvement***

### ***4.2.1 Heat stress and nutrition***

Heat stress reduces the efficiency of energy utilization owing to the higher requirements for maintenance energy (Conte et al., 2018); therefore, cattle need to increase their energy intake. However, heat stress decreases DMI, and farmers must feed their cattle high concentrate diets to meet their energy requirements. On the other hand, decreased DMI and increased concentrate diets result in lower ruminal pH causing ruminal acidosis (Owens et al., 1998; Soriani et al., 2013), which could change ruminal microbiota and fermentation (Mao et al., 2013).

Table 1: Formula for calculating each THI value

<b>Authors</b>	<b>year</b>	<b>Calculation Formula</b>
Thom	1959	$THI=[0.4 \times (Tdb+Twb)] \times 1.8+32+15$
Bianca	1962	$THI=(0.35 \times Tdb+0.65 \times Twb) \times 1.8+32$
Kibler	1964	$THI=1.8 \times Tdb-(1-RH) \times (Tdb-14.3)+32$
National Research Council (NRC)	1971	$THI=(1.8 \times Tdb+32)-(0.55-0.0055 \times RH) \times (1.8 \times Tdb-26)$
Yousef	1985	$THI=Tdb+(0.36 \times Tdp)+41.2$
Mader et al.	2006	$THI=(0.8 \times Tdb)+[(RH/100) \times (Tdb-14.4)]+46.4$

Tdb: dry bulb air temperature (°C), Twb: wet bulb air temperature (°C), Tdp: dew point temperature (°C), RH: relative humidity (%), In Kibler formula, RH is fraction of the unit (Herbut et al., 2018)

#### *4.2.2 Microbiota*

Ruminants have diverse ruminal flora, which are important and influence the efficiency of cattle production. Ruminal bacteria, archaea, viruses, fungi, and protozoa form symbiotic relationships and interactions (Firkins et al., 2015). In addition, specific ruminal microbes significantly influence ruminal fermentation in the host by reducing feed efficiency and nitrogen digestibility, and increasing methane generation (Paz et al., 2018; Elolimy et al., 2018; Mitsumori et al., 2008; Schären et al., 2018). The authors analyze ruminal microbiota under heat conditions and elucidate how heat conditions affect ruminal microbiota. As ruminal microbiota could play an important role in the feed efficiency of cattle production in hot environments and the situation of global warming, understanding them could help in improving livestock production.

#### *4.2.3 Water*

Water is the most important feed for health and performance in dairy cows because dairy cow produces large amount of milk every day. In feeding management, water access is important in all ambient environments, and the freshness of water is also important because of their preference (Polsky and von Keyserlingk, 2017). In heat conditions, cattle need more water, this physiological change is one of the major responses/indicators to heat stress (Fucquay 1981). In heat conditions, exceeding the TNZ, cattle need more than 1.2 to 2 kg water per degree Celsius increase (West, 2003), and if cattle cannot drink enough water, not only production but health

deteriorates (Cardot et al., 2008). Previous study indicated that water intake was decreased under shade management compared with no shade environment (Hoffman and Self, 1972). This result indicated shade management decreases body water loss, and maintains their homeostasis. Therefore, water management is important for maintaining/ improving cattle production in heat conditions.

## **5. Genetic improvement**

Genetic pure strain of cattle is not resistant to tropical weather, particularly dairy breed, while native strain cattle, such as both local *Bos taurus* and *Bos indicus*, has adapted to tropical circumstance. Genetically adaption is one of the best ways required, so that dairy cows would make crossbred between pure strain of dairy and native cows. Therefore, we have to clarify the physiological characteristics in crossbred cows to make success in rearing under tropical circumstance.

### **5.1 Crossbreeding**

Dairy cattle are weak resistant to hot temperature than other ruminants because of their high metabolic rate and poor water retention mechanism in kidney and gastrointestinal tract (Bernabucci et al., 2010). For instance, when environmental temperature reaches 27 °C or more the feed consumption decline (Das et al., 2016).

On the other hand, in general, the cattle breed originated from warm region have the capacity of adaptation to

heat condition, and this theory had been supported by many previous reports and trials in subtropical and tropical countries, such as West Indies, Philippines, Egypt, Jamaica, India, Cochin China, Cambodia, Malaysia, and East Africa (Berman 2011). Therefore, in subtropical and tropical regions, importing tropical breeds developed in the same temperature areas or backcrossing local breeds to these breeds has been conducted. In fact, in Cambodia, many cattle breeds were imported from Southeast Asian countries to develop dairy production. However, crossbred dairy cattle have had little success. Because crossbred cattle usually produce much less milk than Holstein, although the crossbred dairy cattle have a tolerance to heat stress much more than the pure Holstein breed (Ravagnolo, Misztal 2000). Holstein breed needs more comfortability conditions such as THI below 72 and should be reared with well-formulated feed. On the other hand, crossbred dairy cattle can adapt to higher temperatures and humidity because crossbreeding with local breeds could increase survivability in a tropical environment. However, genetic variation between breeds for most quantitative traits presents an opportunity to combine breeds to improve breeds' productivity. The crossbreeding between local breeds and pure dairy breeds with high productivity has more benefits than pure breeding in dairy production in the tropics.

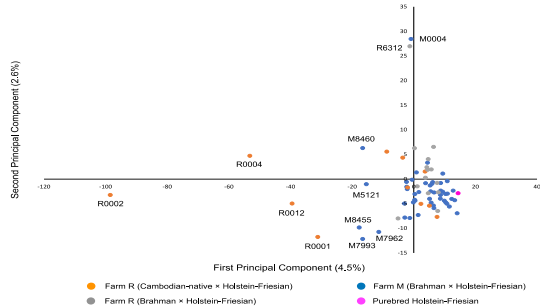
## ***5.2 Genetic markers***

During the last decade, several cost-effective approaches have been developed for analyzing genome-wide single nucleotide polymorphisms (SNPs) in many individuals

with high genetic diversity, including restriction site-associated DNA sequencing (RAD-seq and ddRAD-seq) (Baird et al. 2008; Peterson et al. 2012), and multiplexed inter-simple sequence repeat genotyping by sequencing (MIG-seq) (Suyama et al. 2015). Recently, attention has been paid to genotyping by random amplicon sequencing-direct (GRAS-Di) (Hosoya et al. 2019), as another cost-effective genome-wide genotyping method (Miki et al. 2020; Yoshikawa et al. 2021). GRAS-Di performs genotyping for PCR amplicons which are retrieved throughout the genome using random primers. GRAS-Di produces fewer missing data than RAD-seq (Miki et al. 2020) and more SNPs than MIG-seq (Yoshikawa et al. 2021). Thus, GRAS-Di has been used widely, for example, to assess the population genetic structure of mangrove fish (Hosoya et al. 2019), the Tsushima leopard cat (Ito et al. 2020), and small apes (Matsudaira et al. 2021).

The authors showed genetic variation and useful genetic character in local tropic breeds using GRAS-Di approach (Mam et al., 2022). A genome-wide analysis of the genetic characterization for 75 cows in the two dairy farms implies that some cows in one farm are genetically far from other crossbred cattle and retain a higher proportion of genetic background derived from tropical-native cattle (Fig.4). The present study indicated genetic characteristics and milk composition in tropical crossbred cattle. Genetic character in tropical local crossbred cattle could contribute to milk production in the tropical dairy system.

(A)



(B)

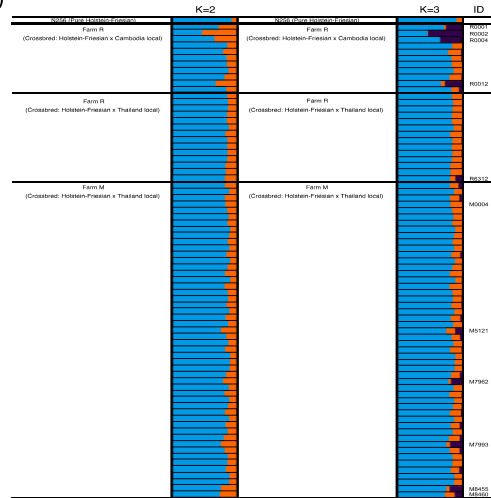


Fig.4 PCA of the first two principal components. Individuals of crossbreeds between Cambodian-native cattle and Holstein-Friesian in Farm R, individuals of crossbreeds between Brahman and Holstein-Friesian in Farm R, individuals from Farm M, and the pure Japanese Holstein-Friesian in-dividual are indicated with orange, grey, blue, and magenta-filled circles, respectively (Mam et al., 2022). Eleven individuals that are distantly placed from the other individuals are shown with their ID (A). STRUCTURE plots for the probability of assignment to two ( $K = 2$ ) and three ( $K = 3$ ) genetic clusters, for the pure Japanese Holstein-Friesian breed, and 75 Cambodian dairy cattle, from two different farms (B). Each horizontal bar indicates an individual, and each color indicates the probability of assignment to one of the genetic clusters.

### **5.3 Embryo transfer**

Heat stress induces body temperature increase and damages to the oocyte and early embryos caused by hyperthermia, therefore embryo transfer (ET) is an effective tool to increase fertility during heat stress (Baruselli, et al., 2020; PHansen and Aréchiga, 1999). The reason for recommending ET during the heat stress period is that ET uses the embryos at the morula or blastocyst stage, which have acquired resistance to elevated temperature. Although further discussion is needed, usage of embryo produced in cooler season could improve fertility in hot season. In addition, ET can be used strategically for genetic improvement. ET is useful management tool to improve fertility and breeding in heat condition.

### **6. Conclusion**

Here, several aspects of heat stress influence cattle productivity, and several pieces of information to help resolve this production loss. For resolving the issue related to heat stress, the optimal evaluation of cattle stress and impacts is needed. If optimal monitoring and evaluation are conducted early, the farmers can reduce heat stress risk and perform early measures to prevent production loss and improve animal welfare related to cattle production. Then, the farmer, veterinarian, and livestock specialist should work closely on the issues. They should tackle the measures to improve production in heat conditions from several aspects, such as facility, feeding, and genetics, and these measures should be integrated. Therefore, to improve cattle production in the tropics, we should work together and address the problem comprehensively.

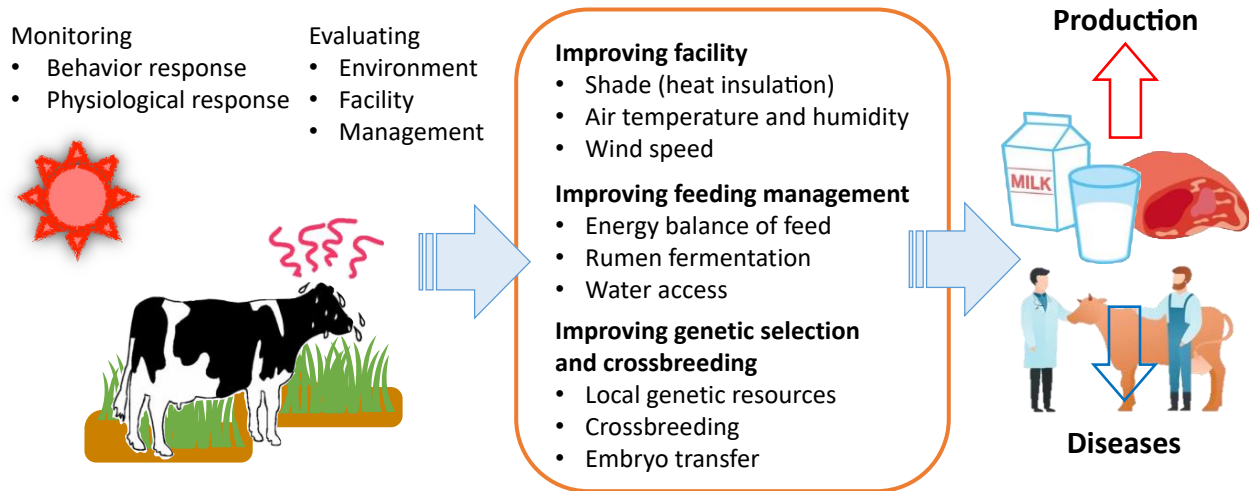


Fig.5 Strategy for improving cattle production under heat conditions, particularly in the tropic

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