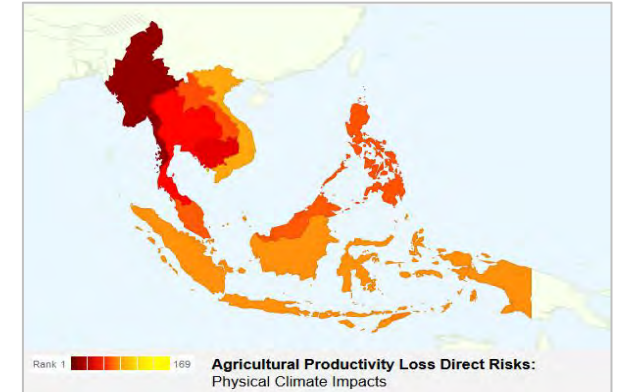


Genes Involved in Cellular Responses to Heat Stress in Thai Multibreed Dairy Cattle



Thawee Laodim¹

Skorn Koonawootrittriron^{1*}, Thanathip Suwanasopee¹, and Mauricio A. Elzo²

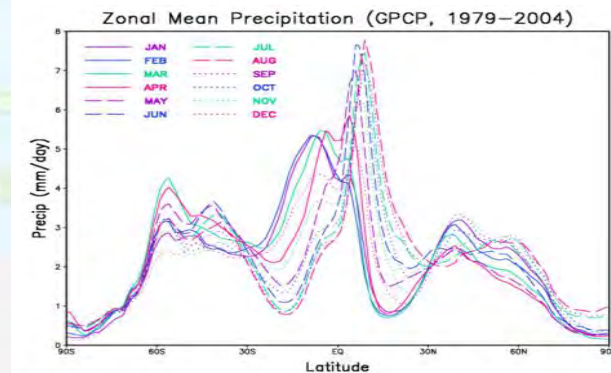
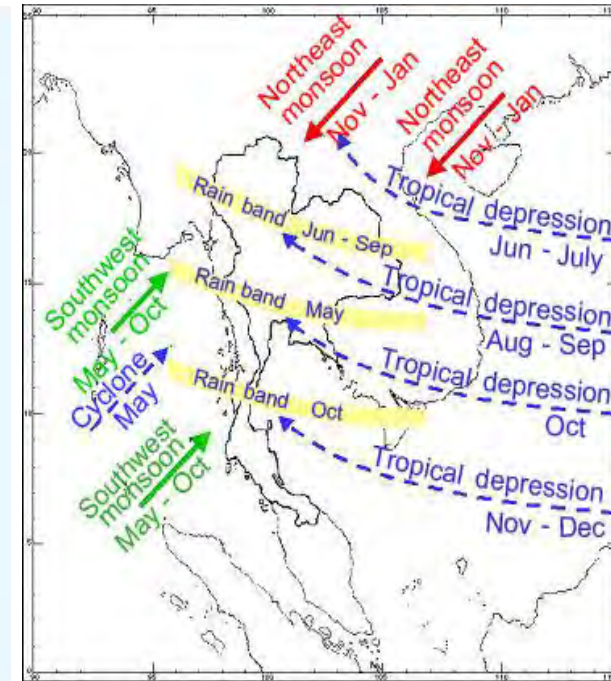
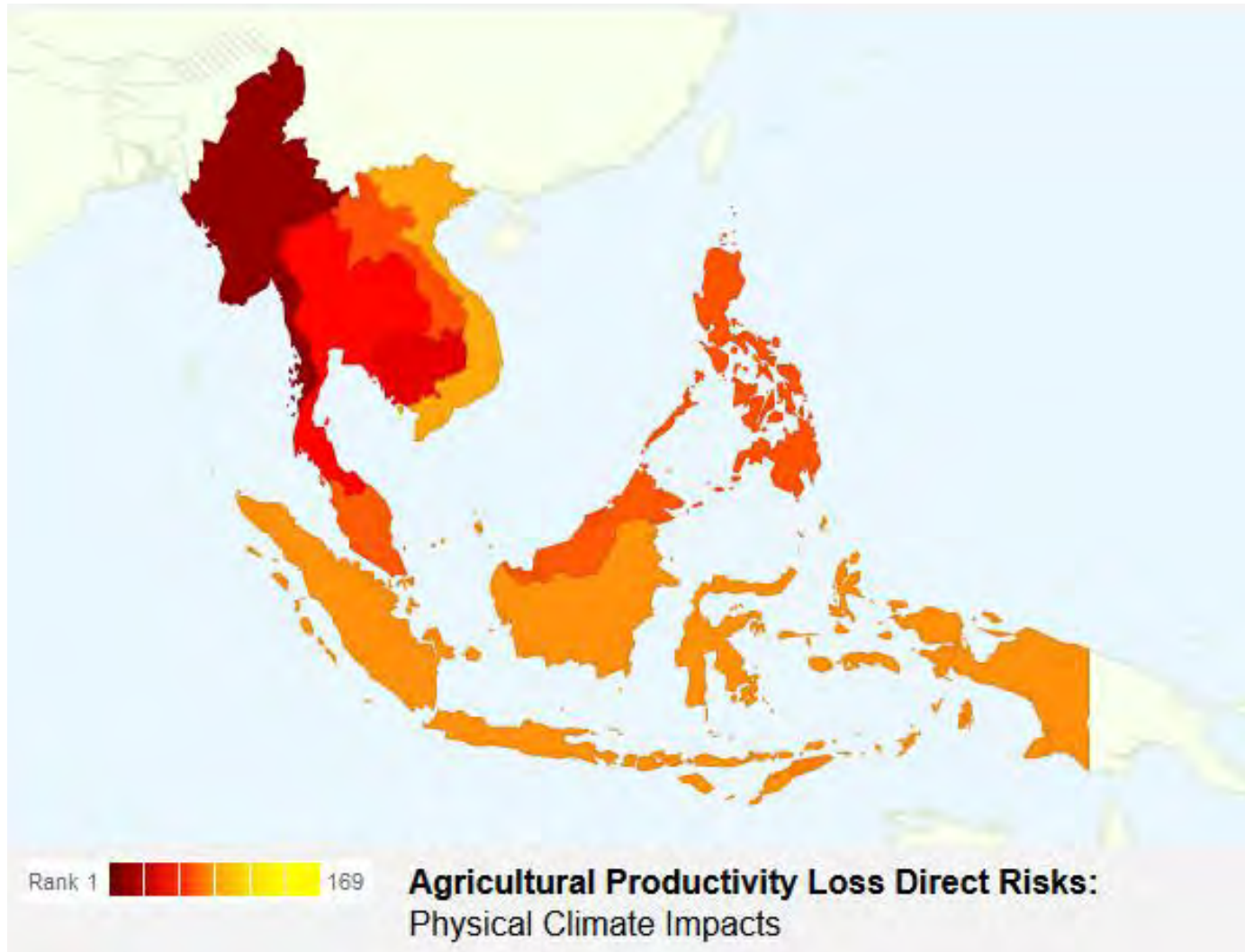
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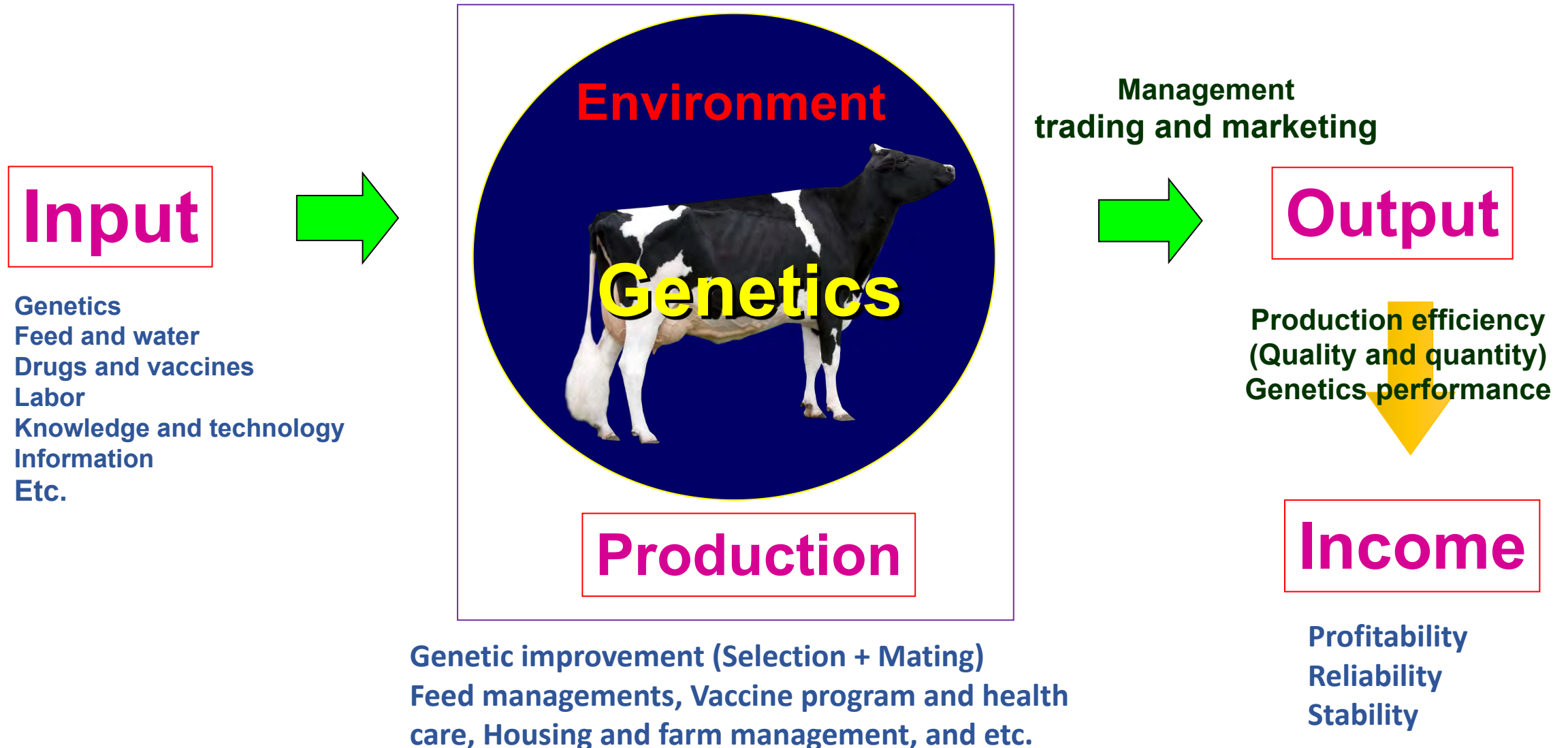
* Corresponding Author: aqrskk@ku.ac.th

Thailand is a Tropical Country in Southeast Asia

Dairy production under tropical conditions has some limitations
(i.e. climate, culture, natural resources)



Increase Production Efficiency under Stressful Conditions – Genetic Adaptability



Dairy Population in Thailand

Microsoft Excel - Book1

F72 65 5/8%HF, 18 3/4%BS, 6 1/4%SW, 3 29/32%RD, 3 1/8%BRA, 1 61/64%RS, 25/64%NA

	A	B	C	D	F
1	Anim ID	Birth Date	Dam ID	Sire ID	Breed
49	PK430558	15/09/2000	PK30807	9196	68 3/4%HF, 23 7/16%RS, 3 33/64%NA, 3 1/8%SW, 25/32%BS, 25/64%ZE
50	PK421029	27/09/1999	PK20911	9202	53 1/8%HF, 12 1/2%RD, 19 59/64%BS, 10 15/16%RS, 3 1/8%BRA, 25/64%NA
51	PK440363	06/07/2001	PK60230	72HO0830	81 1/4%HF, 3 29/32%RD, 1 61/64%RS, 6 1/4%BRA, 6 41/64%NA
52	PK440119	06/03/2001	PK400179	2227	86 23/32%HF, 6 1/4%JER, 1 9/16%RS, 25/32%RD, 1 9/16%SW, 25/64%BS, 25/64%BRA, 2
53	PK440184	14/03/2001	PK22465	9205	82 1/32%HF, 12 57/64%NA, 3 1/8%RS, 1 9/16%RD, 25/64%BS
54	PK431110	08/10/2000	PK390031	DPO-C-4005	85 15/256%HF, 7 1/32%RD, 6 1/4%SW, 1 9/16%RS, 25/256%NA
55	PK431112	27/10/2000	PK60007	DPO-C-4003	83 13/64%HF, 3 1/8%RS, 25/32%RD, 12 1/2%SW, 25/64%ZE
56	PK420395	29/07/1999	PK61268	9200	86 21/64%HF, 4 11/16%RD, 7 13/16%SW, 25/32%AIS, 25/64%NA
57	PK420393	10/10/1999	PK390316	9178	71 7/8%HF, 18 3/4%BS, 3 1/8%BRA, 6 1/4%SW
58	PK420333	14/09/1999	PK80700	9200	82 1/32%HF, 1 9/16%RD, 25/64%BS, 12 1/2%SW, 3 1/8%RS, 25/64%NA
59	PK420332	14/09/1999	PK80700	9200	82 1/32%HF, 1 9/16%RD, 25/64%BS, 12 1/2%SW, 3/1%RS, 25/64%NA
60	PK430414	10/10/2000	PK391051	DPO-C-4108	79 11/16%HF, 6 1/4%RS, 25/64%BS, 25/128%ZE, 12 1/2%SW, 125/128%NA
61	PK430412	18/07/2000	PK401472	9191	62 57/64%HF, 17 3/16%RS, 10 5/32%RD, 1 97/128RS, 8 1/128%NA
62	PK421092	02/11/1999	PK81855	9178	70 5/16%HF, 3 91/128%RD, 2 11/32%RS, 3 29/32%BRA, 18 3/4%BS, 125/128%NA
63	16420573	23/10/1999	PK391716	9200	84 3/8%HF, 3 41/128%RS, 25/64%BS, 1 61/64%RD, 1 9/16%BRA, 6 1/4%SW, 25/128%ZE
64	16420571	02/07/1999	PK82251	9200	87 1/2%HF, 12 1/2%SW
65	PK430193	22/03/2000	PK81584	9202	71 7/8%HF, 18 3/4%BS, 6 1/4%SW, 3 1/8%BRA
66	PK430195	15/07/2000	PK410145	9213	92 3/16%HF, 1 9/16%BRA, 6 1/4%NA
67	SD430125	21/08/2000	SD410599	9197	90 5/8%HF, 25/32%RD, 75/128%JER, 7 13/16%SW, 25/128%ZE
68	SD430121	17/09/2001	SD410201	2230	87 1/2%HF, 12 1/2%SW
69	SM430088	16/02/2000	SM400415	9191	84 3/8%HF, 3 1/8%RD, 1 9/16%BS, 3 1/8%RS, 6 1/4%SW, 1 9/16%NA
70	SM430086	28/04/2000	SM400416	9202	68 3/4%HF, 18 3/4%BS, 9 3/8%SW, 3 1/8%BRA

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Thai Multibreed Dairy Population

HF = Holstein Friesian; BS = Brown Swiss; BRA = Brahman; JER = Jersey; NA = Thai Native;
RD = Red Dane; RS = Red Sindhi; SW = Sahiwal; ZE = Other Zebu

Objective of this Study

To identify a subset of genes associated with milk yield that were also involved in cellular responses to heat stress in the Thai multibreed dairy population



Animals and Database



8,361 first-lactation cows from 810 farms
under Thai tropical environmental condition

Pedigree

- ❖ Animals ID
(animal, sire, and dam)
- ❖ Birth date
- ❖ Breed composition

Phenotypes

- ❖ Test-day milk yield
- ❖ Calving date
- ❖ Date of collected data

Genomic SNPs Information



```
1192 22012200212111012011111211111112
1457 22111100122111101102220222211012
1458 22122112112210212002211211111212
1764 22011200222101201002112212122012
1765 2211210022211110100211222222002
1783 21002210222011122002111222222021
2019 21122201212011212111210222211212
2020 11110121122101002010121222222011
2021 21102111212122211001210221222111
2225 11122111212202201012221122211011
2332 21001021222110012021202212111112
2333 22012121122111112011210121222111
2334 21021100222201101101211212122002
2335 22122200212112202112210212122012
2757 21122100222121101011201222211101
2758 22111211222110010002211222222011
2759 12101111212201101112201212122212
2760 11122111202102101002211122211012
3081 22011101122111101011211222222112
3082 12102200222212002111222212111122
3083 22121111222212111012111222222001
3084 11121111222112102021202222222112
3085 22102200122110211012202212111011
3086 22001111212111112002212121222002
3087 22002200202102101001202212100201
```

- ❖ Actual and imputed GGP80k SNPs makers (76,519 SNPs) from 2,661 animals
- ❖ 29 autosomes and X chromosome
- ❖ Quality controls:
 - ❑ Call rate lower than 90%
 - ❑ Minor allele frequency lower than 0.04
- ❖ 74,144 SNPs were used for this study

Genome-wide Association Analysis

- ❖ **Single-step genomic best linear unbiased prediction**
(Aguilar et al., 2010)
- ❖ **Genomic-polygenic model**

$$y = Xb + Za + e$$

Where

y = vector of milk phenotypes

b = vector of fixed effects

(herd-year-season, breed group, heterosis, and calving age)

a = vector of random animal additive genetic effects

e = vector of random residuals

X = incidence matrix related MY and FY records to elements of vector b

Z = incidence matrix related MY and FY records to elements of vector a

Percentage of Genetic Variance Explained by Individual SNP

$$\text{Genetic variance (\%)} = \frac{\text{Var}(\text{SNP}_i)}{\sigma_a^2} \times 100$$

Where

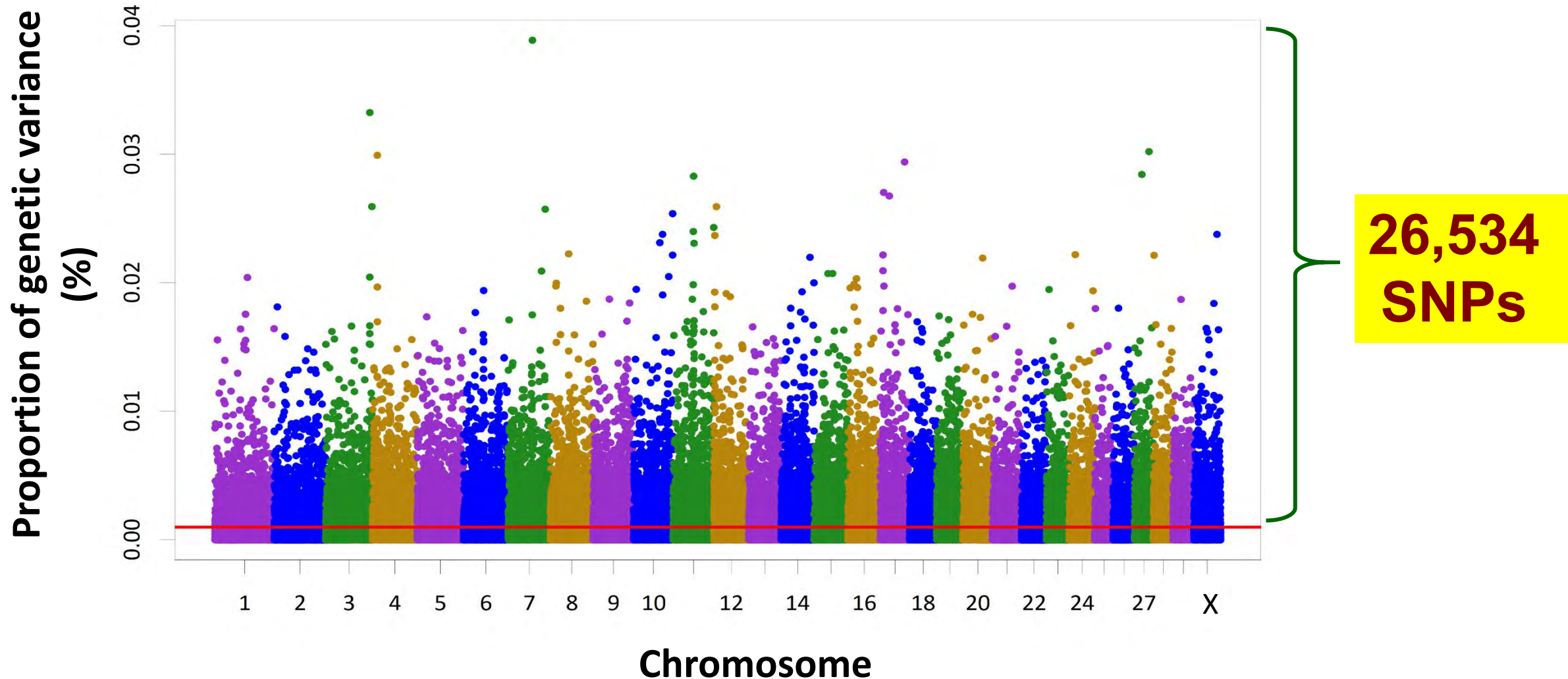
$\text{Var}(\text{SNP}_i)$ = genetic variance of the i^{th} SNPs

σ_a^2 = the total genetic variance

Identification of Genes Functions

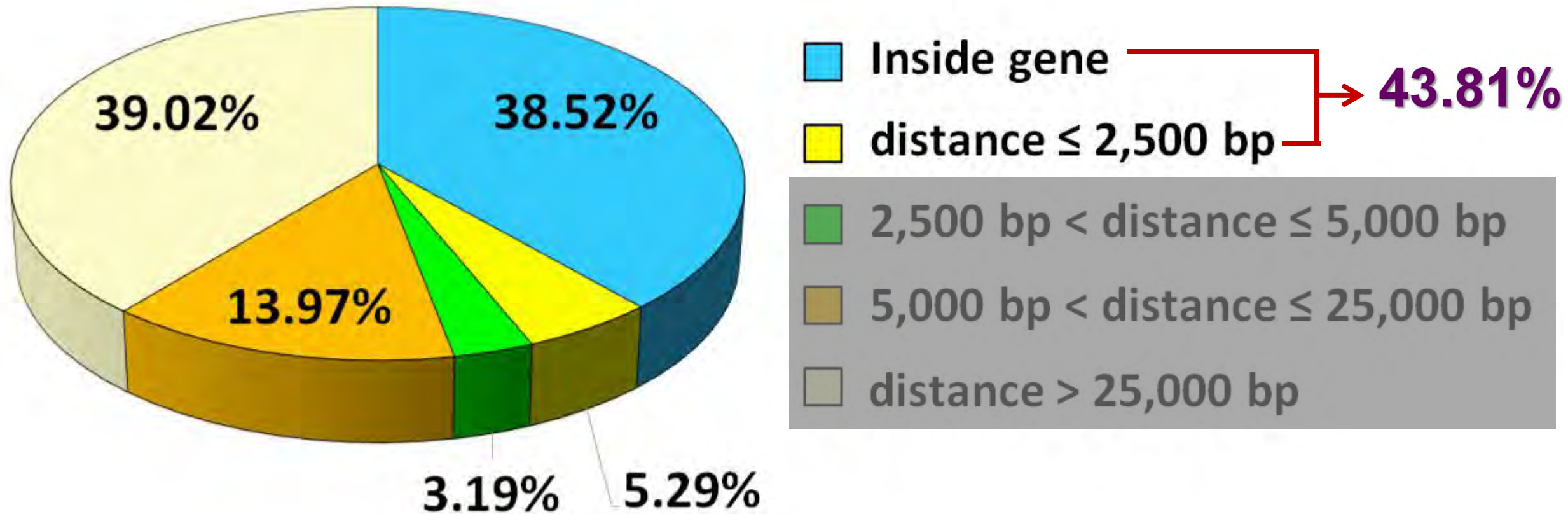
- ❖ 0.001% of the genetic variance for milk yield were selected
- ❖ **Map2NCBI** (Hanna and Riley, 2014)
- ❖ SNP located inside or at $\leq 2,500$ bp of genes in the NCBI database
- ❖ **GeneCards database** (<https://www.genecards.org/>)

Percentage of the Genetic Variance for Milk Yield Explained by each SNP



Proportion of the SNP Markers

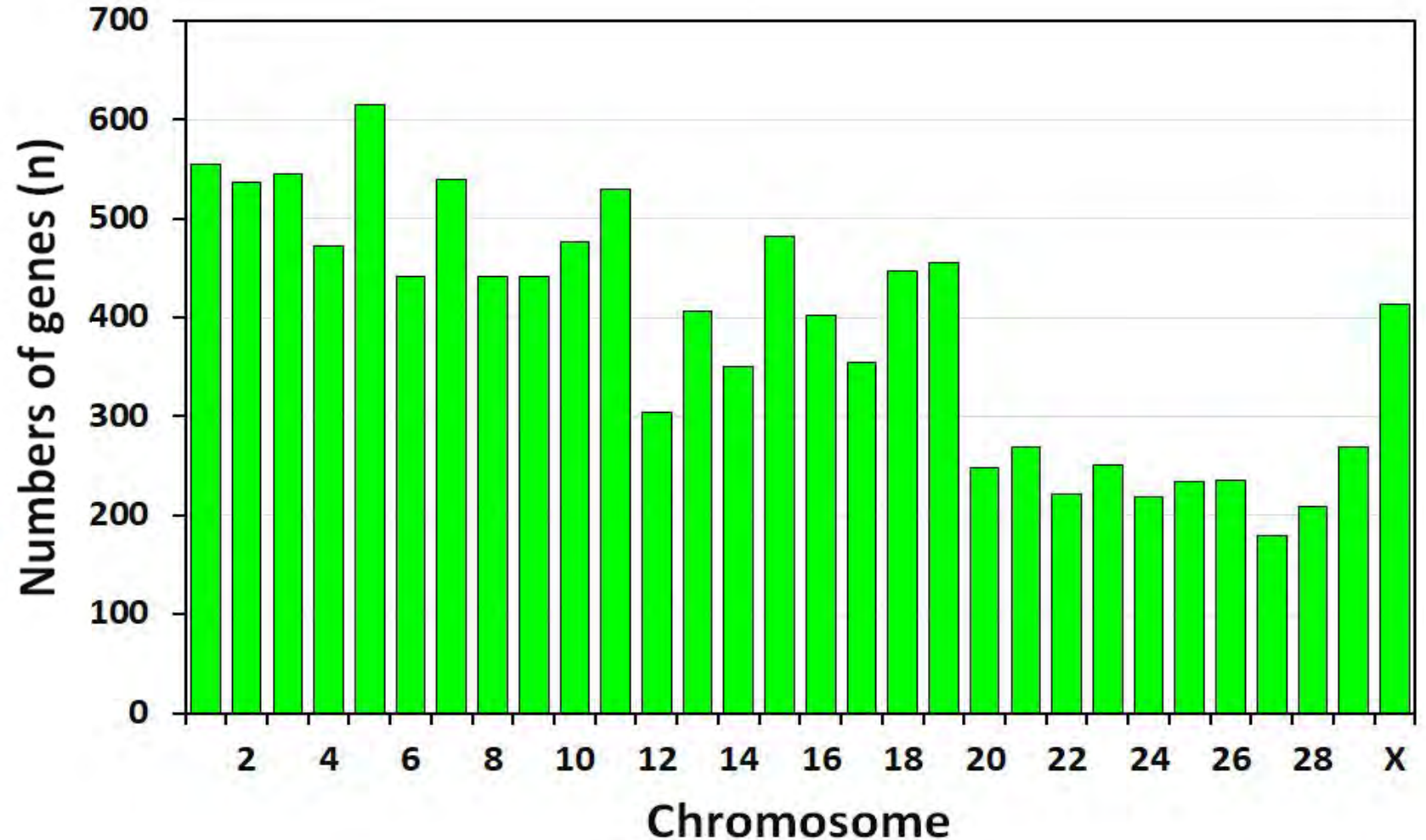
by Distance between SNP and Genes in the NCBI Database



N = 26,534 SNPs

Distribution of Genes Associated with Milk Yield on Chromosomes

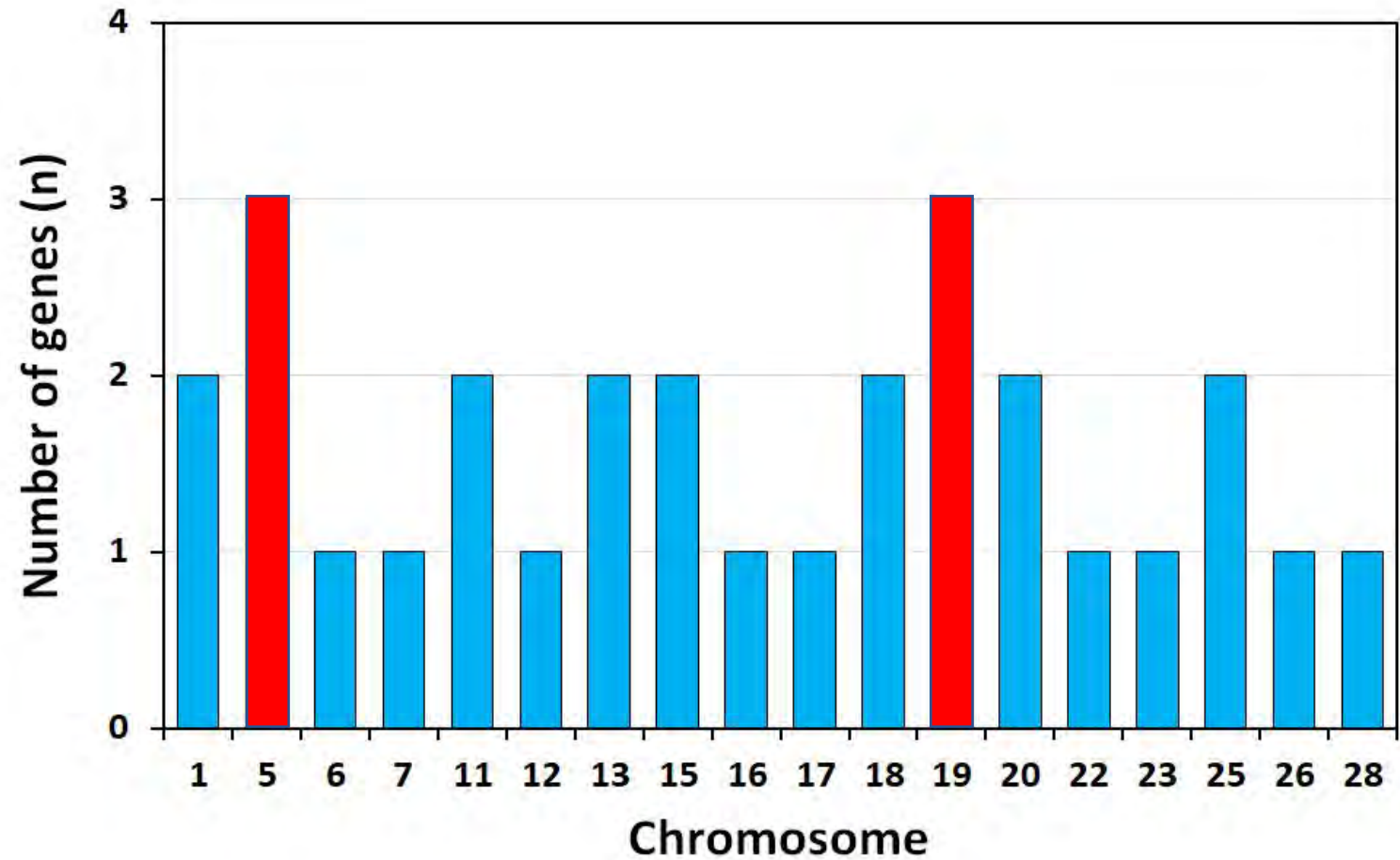
**11,542
genes**



Genes Involved in Cellular Responses to Heat Stress


29 genes

GSK3B, ATR, NUP107, NUP37, FKBP4, CAMK2D, CAMK2A, NUP188, NUP214, HSPH1, HSPA14, HSPA12B, ATM, NUP160, MAPKAPK2, HSPA4L, NUP93, NUP62, RPA1, RPTOR, NUP85, BAG1, NUP155, NUP210, NUP153, MLST8, CREBBP, HSPA12A, and NUP133

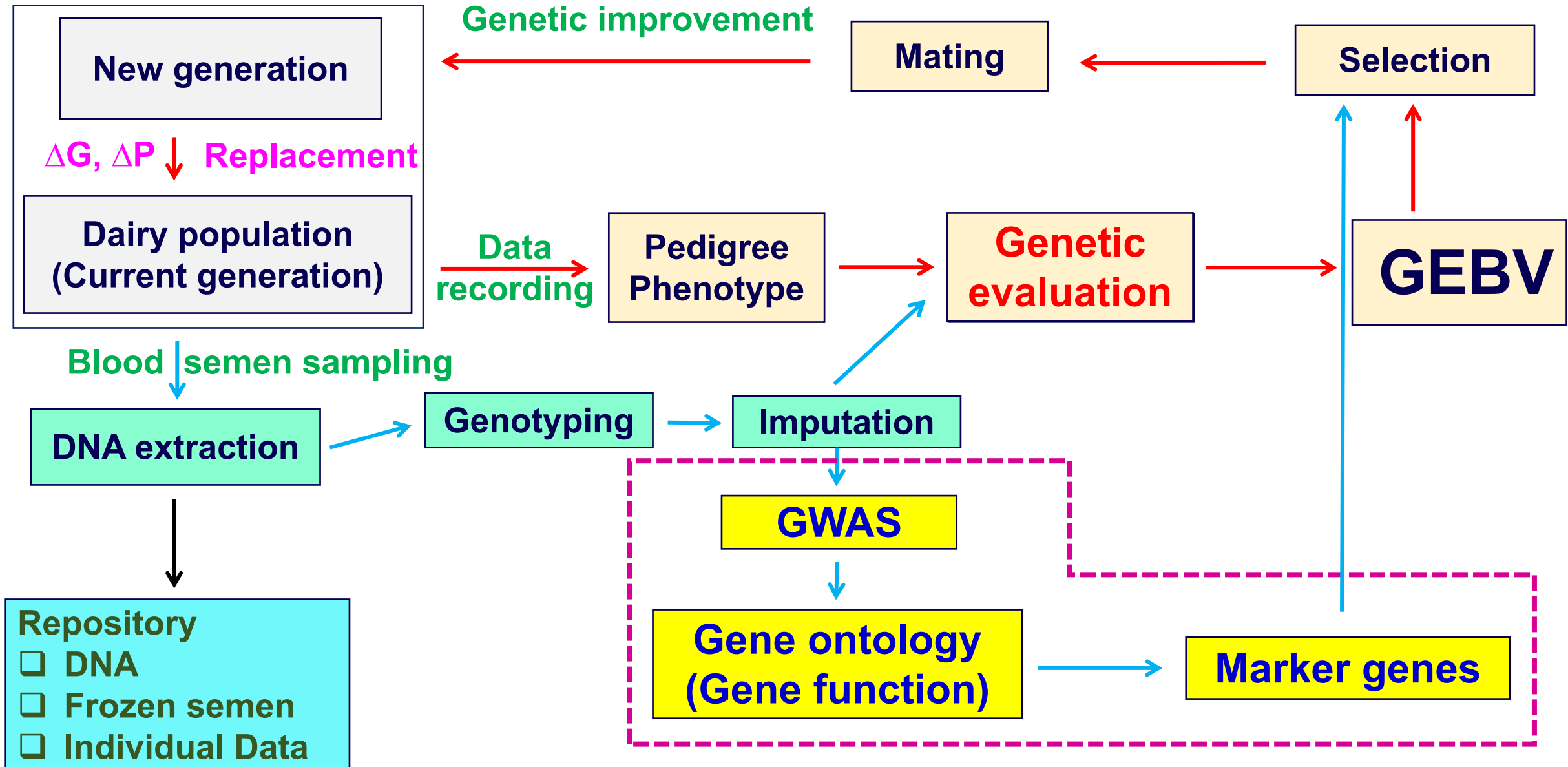


Heat Shock Protein Genes

- ❖ **HSPH1** (Heat shock protein family H (Hsp110) member 1)
- ❖ **HSPA14** (Heat shock protein family A (Hsp70) member 14)
- ❖ **HSPA12B** (Heat shock protein family A (Hsp70) member 12B)
- ❖ **HSPA4L** (Heat shock protein family A (Hsp70) member 4 like)
- ❖ **HSPA12A** (Heat shock protein family A (Hsp70) member 12A)

 Step into the World of Research	Journal of Dairy, Veterinary & Animal Research
Role of Heat Shock Proteins in Livestock Adaptation to Heat Stress	
Expression profiling of major heat shock protein genes during different seasons in cattle (<i>Bos indicus</i>) and buffalo (<i>Bubalus bubalis</i>) under tropical climatic condition	
Anil Kumar ^{a,*} , Syma Ashraf ^a , T. Sridhar Goud ^a , Anita Grewal ^c , S.V. Singh ^a , B.R. Yadav ^b , R.C. Upadhyay ^a	
Invited Review: Genes Involved in the Bovine Heat Stress Response¹	
R. J. Collier, ² J. L. Collier, R. P. Rhoads, and L. H. Baumgard Department of Animal Sciences, University of Arizona, Tucson 85721	
Polymorphism at 3'-UTR of the Heat Shock Protein 70 Gene and Its Relationship with Thermal Tolerance in Chinese Holstein	
DU Fang-lei ^{1,2} , WANG Hong-mei ¹ , HUANG Jin-ming ¹ , LI Jian-bin ¹ , ZHONG Ji-feng ¹ , ZHANG Ting-rong ² , LIU Jian-fei ² , LI Qiu-ling ¹ , WANG Chang-fa ¹	
(1. Dairy Cattle Research Center, Shandong Academy of Agricultural Science, Jinan 250100, China; 2. College of Animal Science, Qingdao Agricultural University, Qingdao 266109, China)	

Dairy Genetic Improvement



Conclusion

- ❖ There were 29 genes associated with milk yield involved in cellular response to heat stress
- ❖ These genes were located in chromosomes 1, 5, 6, 7, 11, 12, 13, 15, 16, 17, 18, 19, 20, 22, 23, 25, 26, and 28

Acknowledgments



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Kasetsart University, University of Florida



Development of a Dairy Genetic-Genomic Evaluation System in
Thailand Project

Dairy farmers in Thailand



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G
U

*Thank you
for your kind attention*

