BREED LINEAGE PREDICTION MODEL FOR SMALL RUMINANT FARM PRODUCTION

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ABSTRACT

Sheep are crucial for Malaysian Muslims, which account for 60% of the population. However, local sheep supply is limited due to high mortality caused by diseases such as Tetanus and Foot and Mouth Disease (FMD). Therefore, this study aims to identify the internal and external factors that influence sheep breed lineage continuity, to propose a breed lineage prediction model for small ruminant farm production, and to evaluate the accuracy and time efficiency of the developed model by utilising Feedforward Artificial Neural Network (FANN) deep learning. Qualitative Research (QR) interviews were performed in goat and sheep farms around Peninsular Malaysia for the first and second phase of the Delphi Forecasting Method (Delphi), while the final phase involved validation by experts in the field. From the study, internal and external factors were identified as breed, fodder, medicine, sanitisation, government collaboration, worker's knowledge, and climate. A new model and algorithm for sheep breed lineage were created and validated for accuracy and time efficiency. The data and analysis from this study will be integrated into the proposed FANN algorithm. In addition, future studies could adopt this method when studying other farm animals.

ABSTRAK

Biri-biri adalah penting bagi umat Islam Malaysia, yang merangkumi 60% daripada populasi. Bagaimanapun, bekalan biri-biri tempatan terhad kerana kematian yang tinggi disebabkan oleh penyakit seperti Tetanus dan Penyakit Kaki dan Mulut (FMD). Oleh itu, kajian ini bertujuan untuk mengenal pasti faktor dalaman dan luaran yang mempengaruhi kesinambungan keturunan baka biri-biri, untuk mencadangkan model ramalan keturunan baka untuk pengeluaran ladang ruminan kecil, dan untuk menilai ketepatan dan kecekapan masa model yang dibangunkan dengan menggunakan *Feedforward Artificial Neural Network* (FANN). Temu bual Penyelidikan Kualitatif (QR) dilaksanakan di ladang kambing dan biri-biri di sekitar Semenanjung Malaysia bagi fasa pertama dan kedua penggunaan Kaedah Ramalan Delphi (Delphi), manakala fasa terakhir melibatkan pengesahan oleh pakar dalam bidang tersebut. Daripada kajian, faktor dalaman dan luaran dikenal pasti seperti baka, makanan ternakan, perubatan, sanitasi, kerjasama kerajaan, pengetahuan pekerja dan iklim. Model dan algoritma baharu untuk keturunan baka biri-biri telah dicipta dan disahkan untuk ketepatan dan kecekapan masa. Data dan analisis daripada kajian ini akan diintegrasikan ke dalam algoritma FANN yang dicadangkan. Di samping itu, kajian masa depan boleh menggunakan kaedah ini apabila mengkaji haiwan ternakan lain.

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MOHAMMAD FARIZSHAH BIN ISMAIL KAMIL

JANUARY 2024

APPROVAL

The Examination Committee has met on **10 January 2024** to conduct the final examination of **MOHAMMAD FARIZSHAH ISMAIL KAMIL** on his Master thesis entitled '**BREED LINEAGE PREDICTION MODEL FOR SMALL RUMINANT FARM PRODUCTION**'.

The committee recommends that the student be awarded the Master of Science (Computer Science)

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Academic session : 2022/2023

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LIST OF ABBREVIATIONS

ADG	Average Daily Gain
ANC	Average Nutrient Composition
BCS	Body Condition Score
CL	Caseous Lymphadenitis
COREQ	Consolidated Criteria for Reporting Qualitative Research
E. coli	Escherichia coli
ECER	East Coast Economic Region
EM	Effective Microorganism
EPD	Estimated Pregnancy Due
DVS	Department of Veterinary Services
IT	Information Technology
SQ	Subcutaneous Injection
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

According to the United Nations Committee on World Food Security, access to a sufficient and secure food supply is a fundamental human right (CFS, 2021). In Malaysia, small ruminants such as goat and sheep are a significant food source for humans, besides cattle and poultry. Despite its significance to Malaysian Muslims, who make up approximately 60% of the local population (*In Depth: Sheep and Goat Meat to Malaysia | Meat & Livestock Australia*, n.d.), goat and sheep supply is limited by the high mortality rate caused by fatal diseases such as Foot and Mouth Disease (FMD) (Jouneau et al., 2020) and Tetanus (Lotfollahzadeh et al., 2019). Furthermore, animal inbreeding reduces variation in the gene pool and lowers disease resistance, fertility, prolificacy, vigour and survival. Inbreeding, in particular, reduces productivity and the average observable traits related to reproductive capacity (Milerski, 2021). When animals are more closely related, such as siblings, parents, or sons to mothers, they are said to be inbred (Doekes et al., 2019). This condition is known as inbreeding depression. The present study focuses on issues faced by Malaysian small ruminant farms.

Domesticated ruminants, including buffalo, cattle, goats and sheep, are susceptible to the contagious viral disease of FMD. This disease is mainly transmitted via the movements of infected animals that came into contact with vulnerable animals. The FMD virus (FMDV) is present in all animal secretions and the air they breathe.

The mortality rate of livestock caused by FMD is approximately 1% annually on average, but the morbidity rate is close to 100% (Marcos & Perez, 2019). Therefore, a sudden outbreak in an FMD-free country may lead to insurmountable losses due to reduced productivity (Takatsuka et al., 2020).

Infected animals can spread food-borne bacteria, such as Escherichia coli (E. coli), at various food preparation phases, contaminating the meat. Moreover, farm contamination can occur, where milk is contaminated with animal excrement, or the animals are already infected with pathogenic microorganisms. Pathogen transmission can also occur during slaughter when the meat comes in contact with the animal intestine, skin, or fur and in the kitchen where food is not prepared correctly (Ali & Alsayeqh, 2022).

Over time, outbreaks and isolated occurrences of the food-borne disease have been linked to the intake of two common pathogens: viruses (Norovirus or Hepatitis A) or bacteria (Salmonella (Ehuwa et al., 2021), Listeria, and E. coli (*Foodborne Pathogens | FDA*, n.d.)). The E. coli was initially discovered in 1982 after undercooked meat was found to be the cause of two outbreaks of gastrointestinal sickness. Since then, the bacteria have spread around the globe by way of water- and food-borne channels (Ekici, Gozde; Dumen, 2019). Shiga toxin-producing E. coli (STEC) is the most lethal of more than 700 E. coli serotypes identified so far (*Escherichia Coli O157:H7 Infection (E. Coli O157) and Hemolytic Uremic Syndrome (HUS) - Minnesota Dept. of Health*, n.d.).

According to a news article published by The Star newspaper in 2022, Malaysia is currently experiencing a food price hike due to supplier hoarding and the war between Russia and Ukraine. As 60% of Malaysia's food supply is imported, any consequential event in that region would impact the nation and the rest of the world.

Specifically, Malaysia relies heavily on imported mutton (88.8%) and beef (76.4%). At one point, Malaysia was self-sufficient in poultry production (Hussin, 2022), but that has now changed due to several factors such as closure of many farms and exports to Thailand due to high demand of chicken caused by swine flu. Sinar Harian has also reported that the ruminant population in Johore state is declining due to diseases and limited farmland in 2020 [15]. Nonetheless, meat demand remains high, with 4,791 carcasses expected in 2020, up from 4,308 in 2019 (Amin, 2022).

To solve the issue of insufficient local meat supply and expensive imported meat, a method to improve productivity in local farms needs to be addressed. Currently, small ruminant farmers are faced with weakened animals due to poor operational management around the farm, disease and inbreeding. To solve the issue of weakened livestock, pure-bred breeding methods were practiced in local farms. In doing so, goat and sheep breed identification is crucial for grouping animals according to their specific breed.

Previously, Agrawal et al. (Agrawal et al., 2021) employed the transfer learning model to determine the sheep breed by comparing the image of one sheep with hundreds of other sheep photographs. The front layers of a Deep Neural Network (DNN) model are transferred using this technique, which then directs the model to the target domain and uses it as a feature extractor (Y. Zhu et al., 2020). Similarly, Jwade et al. (Abu Jwade et al., 2019) used GoPro cameras to send video recordings of sheep on a weighing station to identify the breed using the transfer learning model. Furthermore, (Salama et al., 2019) utilised the Bayesian Optimisation (black-box) approach to compare photographs of sheep faces to a database containing hundreds of images to identify a specific sheep (Barqi). This method was chosen because of the automated procedure with a data-efficient optimisation algorithm (Berkenkamp et al.,

2021). Despite the success reported in each literature, all approaches utilised by the studies involved two lengthy processes: database search and image filtering.

1.2 Problem Statement

Local sheep meat is in short supply locally due to deaths caused by fatal diseases such as Foot and Mouth Disease (FMD), Tetanus and Scrapie. One of the contributing factors to this situation is known as inbreeding depression, where disease immunity in sheep is weakened due to close-proximity breeding such as between mother and son, or daughter to father. Remaining sheep that are alive with undetected disease may transfer foodborne bacteria such as E. coli to humans via contaminated meat produce. Unfortunately, imported sheep meat is experiencing price hike due to hoarding by suppliers and war across the globe. However, local produce is cheaper than imported products since it costs less in terms of handling, storage and shipping.

To solve the issue of weakened sheep, pure-bred sheep breeding methods were practiced in local farms. In doing so, sheep breed identification is crucial in order to group sheep according to their specific breed type. Previous studies (Agrawal et al., 2021)(Abu Jwade et al., 2019)(Salama et al., 2019), were done to identify sheep breed using image recognition. Although the methods proved to be precise, time taken to identify even a single sheep took between 8 to 27 minutes.

The amount of time taken would be unbearable for farms with a population of 500 animals or more. Therefore, this study aims to establish a method that can identify sheep breeds by using daily collected data from farmers in a very short time, compared to image recognition methods.

For this reason, Feedforward Artificial Neural Network (FANN) (Moldovan et al., 2020) is chosen due to its ability to receive text-based input that is non-linear and non-sequential in nature, compared to other forms of neural networks that are designed for image processing (Sharma, 2023). To be precise, this study focuses on goat and sheep that are locally bred in Peninsular Malaysian farms.

1.3 Research Objectives

The specific objectives of this study are:

i To identify the internal and external factors that influence sheep breed lineage continuity.

ii To propose a breed lineage prediction model for small ruminant farm production.

iii To evaluate the accuracy and time efficiency of the developed model by utilising FANN deep learning.

1.4 Research Questions

Below are the research questions of this study:

i What are the internal and external factors that influence sheep breed lineage continuity?

ii How can deep learning method solve the issue of collecting and managing factors for breed lineage prediction model for small ruminant farm production?

iii How can FANN deep learning be used to evaluate the accuracy and time efficiency of the developed model?

1.5 Research Scope

This study will develop a deep learning model for predicting breed lineage for small ruminant farm production. The research will involve farm visits and data collection via qualitative research interviews to identify internal and external factors that impact small ruminant breeding. The study aims to build an accurate and reliable predicting model that can help farmers identify weaknesses in their daily operations and manage losses before it grows too big to handle.

1.6 Justifications and Significance of the Study

In this research, a method using FANN deep learning model was proposed that will identify and predict breed lineage and inherited diseases in sheep. FANN was chosen as it is best suited for non-linear and non-sequential input. Utilising the model later, farms should be able to produce high quality output such as meat products and seed stocks to solve the issue of insufficient food supply, disease free produce and seasonal high demand. The method may also reduce time consumption in predicting breed lineage for farm production. Future areas of research may include adopting this method on other types of farm animals.

1.7 Research Contributions

Below are some theoretical contributions of the study in relation to using an online breed lineage prediction model compared to the current pen and paper method.

i Farmers will be able to identify which sheep breeds are better suited for their farm environment.

ii Farmers will be able to produce high quality breed that may someday come close to wagyu meat quality.

1.7.1 Practical Contributions to System Development

Farmers are currently recording farm related information using pen and paper. Even though there are farms that record digitally, there is no uniformity in terms of recorded information between each farm. Below are some theoretical contributions of the study in relation to the development of a model, algorithm and an online sheep data knowledge base.

i The system can someday simplify the process of recording since everything is accessible online.

ii Farmers can easily monitor farm progress by viewing statistical analysis using their mobile phone.

1.7.2 Contribution to the Research

By having farmers record their data on a unified online database later, all the information collected can be used for a wide range of study for example total number of farms in operation, total number of animals in farms, location, breed type, medicine administration, animals sold, animals culled and so on. With the use of an online database, recording time will be reduced and farmers will have more time to focus on important farm operations. The use of mobile devices for recording will ensure that data can be collected even with soiled hands.

1.8 Chapter Summary

Local sheep meat is in short supply locally due to deaths caused by diseases, while at the same time, infected animals can spread food-borne disease via contaminated food produce. Therefore, farm products such as meat and milk are imported to solve growing demand.

However, Malaysia is facing food price hike due to supplier hoarding and the war between Russia and Ukraine.

One of the key factors that contribute to food security is the availability of locally produced disease-free farm products to reduce dependency on imports and ensure a steady supply of meat produce for the population. This is especially important, particularly in times of prolonged global food supply disruptions.

For this reason, proper farm operational management and animal identification to sort out the healthy from the sick is required. Previous studies were made in identifying individual animal identity by sending camera images to a large database that contains images of said animals. Although precise, the methods used require high capital to acquire all the required digital devices and involve high maintenance costs.

In the next chapter, literature study is done to gain a deeper understanding of the food security issue and how it can be overcome by managing breed lineage continuity using deep learning methods.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In order to understand and find the connection between agricultural science and computer science, literature study into previous papers which encompass both fields were done extensively.

In relation to Section 2.2, the term food security refers to a situation where all people at all times have access to adequate food supply. To fulfil the growing needs of the nation, most of the food products such as beef and mutton were imported. Due to unforeseen circumstances such as the war in Ukraine, import export chain was disrupted, causing the price of goods to escalate.

As mentioned in Section 2.3, local farmers need to manage their sheep breeding method to manage quality and production output to solve the issue of local food supply. To maintain meat quality and disease resilience, sheep need to be bred within their specific breed type. Unfortunately, there is no centralised method for farmers to record their daily activity.

From previous studies, factors impacting the sheep breeding industry is explained in Section 2.4. Notable factors include Average Daily Gain (ADG), feed, medicine, sanitisation, collaboration, climate, and workers' knowledge.