EGG PRODUCTION RECORDING SYSTEM
OF TAIWAN NATIVE CHICKEN

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ABSTRACT

To save the labor cost of chicken egg production records input and reduce the probability of incorrect data input, we use the existing 134.2kHz full-duplex animal electronic tag and 125kHz electronic tag in Asia, combined with the Radio Frequency Identification (RFID) multi-frequency reader to record hen's egg-laying data. The concept of living in an apartment and living in a hotel was also introduced into chicken position management of this egg production recording system. During the egg production performance testing, the hen's egg production record is handwritten on the paper of the egg production record table, and then the data of the egg production record is input into the chicken breeding database. It spent much time and labor cost to input the egg production records of hens into the database. And it's hard to avoid the occurrence of erroneous data generated. In RFID egg production recoding system, the serial number of the chicken's position in the breeding database was written into the RFID electronic tags, and each RFID tag hangs on the cage in the chicken house representing a specific unique chicken position. During the period of egg production performance testing, we were using RFID reader to record the hen's egg-laying date, position and egg production status of each hen every day. Added to this are the commercially available dual-band reader random transfer software, where the data file is transferred to the notebook after Bluetooth or to the personal computer connected with the reader. The EXCEL sorting and LOOKUP functions are used to eliminate the labor cost and time of data input, avoiding the occurrence of erroneous data generated by manual input and achieving easy and efficient collection and establishment of the information on the number of eggs laid.

Keywords**:** Radio Frequency IDentification (RFID), chicken, egg production recording system

INTRODUCTION

In 2016, poultry meat represented about 36% of global meat production and Asia is the largest egg-producing region, with more than 60 % of global output (FAO, 2019). Being the most extensively distributed of the poultries, the domestic chicken (Gallus gallus domesticus) provides humans with a stable sources of protein, including both meat and eggs (FAO, 2007). Chicken is the largest number of domesticated birds, and is the most widely distributed and most commonly used domesticated animal in the world. Chickens play various roles ranging from food and entertainment to religion and ornamentation (Miao et al., 2013). The chicken industry consists of two major elements, the egg industry and the meat industry. In the former, most birds are kept in cages in large commercial farms.

Chicken is an important animal husbandry industry in Taiwan. The chicken industry can be divided into the laying hen industry and the broiler industry. The laying hen industry can be mainly divided into white-shell hens and brown-shell hens, and very few laying hens of other color eggs. The broiler industry can be divided into white broiler chickens and colored broilers. In 2017, the annual output value of the chicken industry is about 58 billion NT dollars, accounting for nearly 36% of the livestock production value. The annual output value of laying hens, white broilers and colored broilers is about 19.1 billion NT dollars, 19.4 billion NT dollars and 19.8 billion NT dollars, respectively (COA, 2019a). The livestock and poultry statistics survey results calculated to the 2[nd]quarter in 2019 (COA, 2019b) shows there are 1,900 farms rear 42,566,000 layers, and 1,325 farms rear 29,260,589 broilers and 3,474 farms rear 29,260,589 colored broilers (Figure 1).
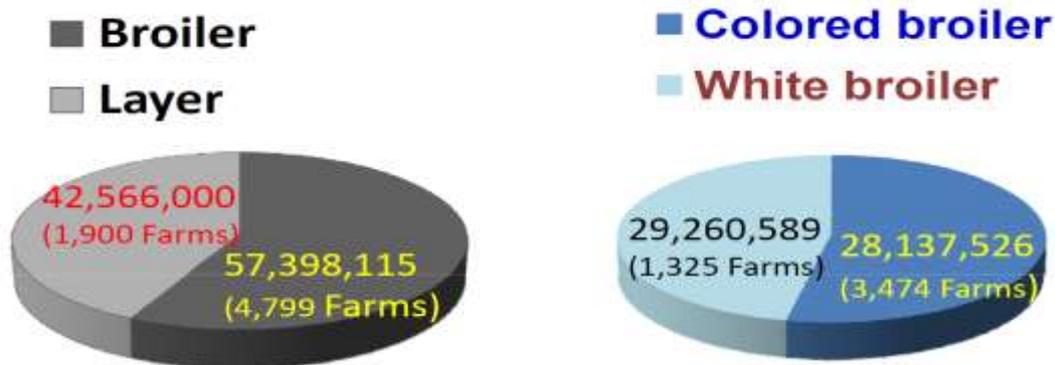
Figure 1. The number of chickens and farms in Taiwan

Indigenous chickens comprise about 80% of the national flocks in Africa and Asia. Despite their low growth rates and egg production, indigenous chickens are generally better in disease resistance and could maintain higher level of performance under poor nutrition and high environmental temperatures compared to commercial strains under village systems (Horst, 1989).

At present, Taiwan's commercial colored broiler chickens include red-feathered chicken, black-feathered chicken, black-bone chicken (silky chicken), game fowl chicken, naked neck chicken and traditional chicken (native chicken and others). In the consumer market in Taiwan, the red-feathered chicken and the black-feathered chicken are the main flocks and the number of rearing are 15,263,554 birds and 10,684,066 birds, respectively (COAb, 2009) which occupied 54.25% and 37.97% of birds rearing on farm on the 2nd quarter in 2019, respectively (Figure 2). The number of native chickens is rare and only be kept in specific farms. Although they have a longer feeding period and higher cost, native chickens are widely welcomed by consumers and usually are sold at a higher price in Taiwan. Furthermore, the native chicken has the characteristics of good meat quality (Li and Lin, 1993), good food supplement, good heat resistance, strong disease resistance, resistance to extensive management, suitable stewing and Chinese style cooking, and is very popular among domestic consumers. There are approximately 11 breeds of native chickens kept at National Chung Hsing University (NCHU) and Taiwan livestock Research Institute (TLRI) from 1973 in Taiwan (Table 1). All breeds are small body type and could be identified by their outward appearance. The body weight of those chickens is uneven; some of those hens are with strong broodiness and small average egg numbers during laying period (Lin et al., 2010).

The development and niche of the breeder industry lies in how many chicks each hen can produce in egg laying period. The hens must produce a high number of eggs to produce multiple chicks. The number of eggs laid is not only an important economic trait of laying hens, but also an important factor affecting economic benefits for breeders and broiler producers. In Taiwan, hens' egg production number and egg production rate of colored broiler breeds are low. Red feathered chickens have fewer eggs than black feathered chickens because of the late age of production, the low age of laying eggs and the low egg production rate during laying period (Lee et al., 2005). Native chicken has low egg production performance and strong broodiness (Lee, 1992). It is necessary to properly increase the number of egg production and the laying rate of native chickens.
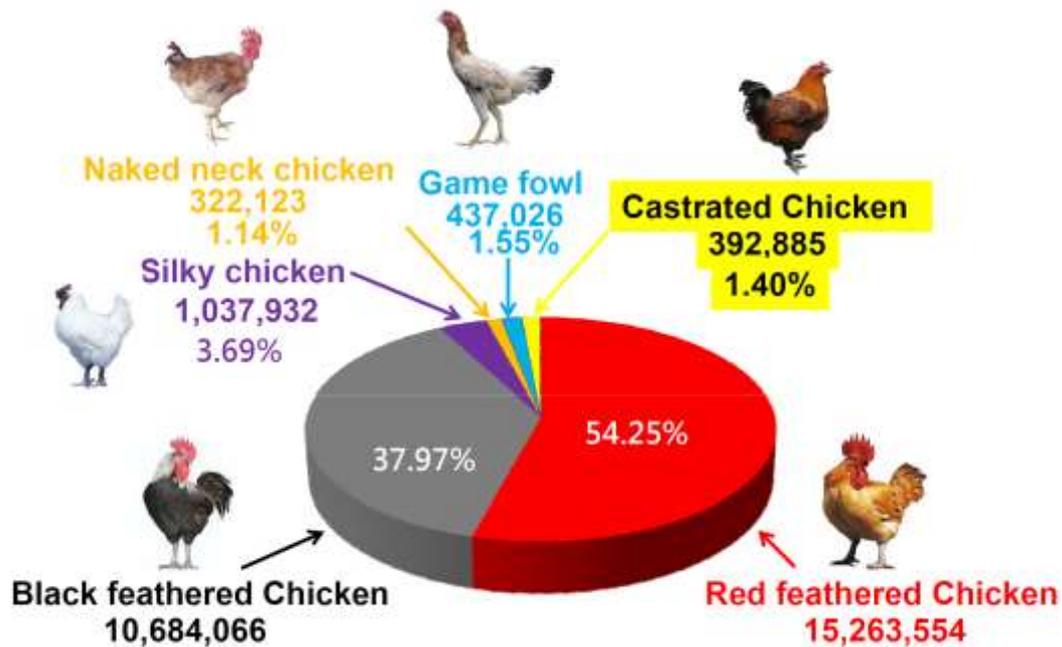
Figure 2. The colored chickens rearing on farm on the 2nd quarter 2019 in Taiwan

Table 1. The breeds of Taiwan native chickens

Chicken name	English name	Conservation unit	Collected position
金門土雞	Chin-Men Native Chicken	NCHU	Chinmen village of Hsinchu County
竹崎土雞	Ju-Chi Native Chicken	NCHU	Juchi village of Chiayi County
峨眉土雞	Erh-Mei Native Chicken	NCHU	Erhmei village of Hsinchu County
信義土雞	Theen-Yee Native Chicken	NCHU	Theenyee village of Nantou County
內門土雞	Nei-Mong Native Chicken	NCHU	Neimong village of Hsinchu County
關西土雞	Kan-Sai Native Chicken	NCHU	Kansai village of Hsinchu County
花東土雞	Hua-Tung Native Chicken	NCHU	Hualien County
近親品系 7	Inbreeding Line 7	TLRI	Chiayi County
近親品系 9	Inbreeding Line 9	TLRI	Taitung County
近親品系 11	Inbreeding Line 11	TLRI	Tainan County
近親品系 12	Inbreeding Line 12	TLRI	Taichung County

NCHU : National Chung Hsing University.
TLRI : Taiwan livestock Research Institute.

In the chicken industry, birds are raised entirely in a closed or open house. The housing systems of the modern intensive poultry industry developed in the 1940s and 1950s to reduce the land areas required to run poultry and to provide better control of the birds' environment. Under intensive systems, food and water are always available, the duration and intensity of light can be controlled and disease control is enhanced. Birds can be inspected regularly, leading to more rapid disease diagnosis and allowing more effective treatment through better controlled water or feed medication (UFAW, 1994). While conventional cages are more hygienic, contribute to a lower incidence of infectious diseases, allow easier management, and are cheaper to operate, they do not provide adequate space per hen, hens experience extreme behavioral restriction, and the lack of movement causes metabolic disorders, high rates of disuse osteoporosis, and the birds experience severe frustration due to the prevention of normal

behaviors such as nesting (Duncan, 2001). Conventional cages lack adequate space for movement, and do not include features to allow behavioral expression. Hens therefore experience extreme behavioral restriction, musculoskeletal weakness and an inability to experience positive affective states. Furnished cages retain the benefits of conventional cages in terms of production efficiency and hygiene, and offer some benefits of cage-free systems in terms of an increased behavioral repertoire, but do not allow full behavioral expression (Hartcher and Jones, 2017). The housing system is an external factor that influences both the performance of hens and the egg quality characteristics. Comparing the performance, egg quality, and microbial contamination of egg shells from hens maintained in different housing systems, such as conventional and enriched cages, litter, and aviaries. The housing system significantly influenced the performance characteristics. The highest egg production, higher egg shell and albumen qualities, lowest daily feed consumption, feed conversion ratio, and lower values for the total count of bacterial contamination were found on eggs surface were measured in conventional cages compared to litter and aviaries (Englmaierová *et al*., 2014). Although conventional cages have been banned in the European Union since 2012, and the housing of laying hens is permitted only in enriched cages or in alternative systems, such as litter housings, aviaries or free range, to improve the welfare of the hens. Conventional cages almost are used in laying and breeder hens in Taiwan and many countries (Figure 3).

Figure 3. Conventional cages of housing system in Taiwan

There are three main feeding types of laying hens in Taiwan, including traditional cages, high bed cages, and closed curtains cages. The various feeding styles are briefly described as follows:

1. The traditional laying hen houses are mostly one-floor open brick buildings with movable canvas coverings on both sides for summer sun protection and winter wind protection. Inside the house is a row of three-tiered chicken cages with a walkway between the two cages. The traditional mechanization is low, and eggs are mostly collected by handled manually, except for the semi-automatic feed tube to transport the chicken feed.
2. The high bed type is mostly a two-story semi-open iron building, the ground floor is used to pile chicken excrement, and the second floor is the laying area. It is divided into two-layer structure which is separated from the feeding area on the second floor and easy to maintain the sanitation of the feeding area. and let the chicken's excrement fall directly to the ground floor   and it is also conducive to the composting of chicken manure reuse. It is quite high mechanization; the feed transport and egg collection have been automated and even directly connected to the egg grading and washing equipment. The demand for manpower can be greatly reduced.
3. The basic structure of the closed curtain is similar as that of the high bed, but the difference is that the metal factory is a closed building for matching the "water curtain" facilities. "Water curtain" is a kind of temperature control device. It uses the principle of heat exchange. When the hot air outside enters the interior of the chicken house, it will first pass through a water curtain and naturally cool down through the running water, so that by one in and one out. The air circulation keeps the temperature in the factory cool, and the principle is similar to the central air conditioner on the top floor of the building. Especially in the summer, the hens will not be reduced laying egg due to sultry

heat, and the egg production rate will naturally be better. Therefore, the closed water curtain type is one of the more advanced types of laying hens.

The laying hen cage is an intensive management method for modern laying hens. It is the most common breeding method at present. Almost all large, medium and small farms adopt this method, because modern high-yielding laying hens are suitable for intensive production. Breeding hens of broiler and layer are often housed in cage systems for egg production performance data collection, and artificial insemination processing conveniently and easy management. Therefore, cage cultivation is the best choice for laying hens.

Radio frequency identification (RFID) is a wireless technology capable of automatic and unambiguous identification without line of sight by extracting a unique identifier from microelectronic tags attached to objects (Wu *et al.*, 2011). A standard RFID system is consisted of Tag, Reader, and Application. And it is also a wireless communication technology that uses radio signals to identify specific targets and read and write related data without the need to identify mechanical or optical contact between the system and a particular target. The radio signal is transmitted from the tag attached to the item by an electromagnetic field that is modulated into a radio frequency to automatically identify and track the item. RFID systems have been successfully applied in areas of manufacturing, supply chain, agriculture, transportation, healthcare, and services to name a few. However, the different advantages and disadvantages expressed in various studies of the challenges facing the technology of the use of the RFID technology have been met with skepticism by managers of healthcare organizations (Ajami and Ahmad, 2013). We can combine database management system, computer network and firewall technology to handle RFID reader data transmission, identification, management and various applications. Although RFID faces so many challenges to overcome, it is undeniable that it is indeed one of the most popular communication technology, and the prospects are limitless. It can be expected that in the near future, when RFID technology becomes more mature and its application scope becomes wider, it will affect people's daily life extensively, not only in food, clothing, housing, transportation, education, and sputum. It is possible to bring all the conveniences of life through RFID technology.

Egg production recording system

The commercial laying bird is selected for light body weight, high egg production, feed conversion efficiency, egg weight and livability. All the commercial broilers have been developed for rapid growth and efficient feed conversion. Genetic selection for high production efficiency may produce correlated responses in other traits (Shanmugam, *et al.*, 2013). Although nowadays a higher pressure is given on the quality rather than on the quantity of a product due to consumer demands, egg production remains the most important trait in layer selection programs. Consistent selection led to doubtless progress that was achieved in this trait (Wolc*et al.*, 2007). Under commercial conditions, data on egg production in laying hens are usually collected per cage rather than individually. In current breeding programs, genetic evaluations are, however, based on individually recorded egg production. Because commercial flocks are not maintained in single cages, this environmental difference between the breeding and commercial setting may result in a genotype x environment interaction (Biscarini*et al.*, 2010). In order to improve the laying performance of native chicken hens in TLRI, we keep hens in individual cages to record the daily egg production records of each hen. Usually, the egg production data of each hen is recorded by the on-site egg production record form, and the egg production record is input into the computer according to the egg production record table, and then the subsequent statistical analysis is performed.

In early days, the hens' egg production record is handwritten on the egg production recording table during the egg production performance testing (Figure 4). And then bring these egg production records back to the office and input them to the chicken breeding database by specialists (Figure 5). Specialists have to check if there is any typing error after they key in the data, and make sure the input data is correct. It will take a lot of labor and time. Generally, it spent more than 40 minutes to input the monthly egg production records of 50 hens into database. Since it is necessary to input a large amount of data each time, data input errors are inevitable.

Figure 4. Handwrite hens' daily laying egg data on the egg production recording table

Figure 5. Input hens' daily laying egg data on the egg production recording table to database by specialist

To save the labor cost of chicken egg production records and data input, and reduce the probability of erroneous data input, this experiment intends to apply dual-frequency readers and electronic tags to develop a method to assist in collecting chicken eggs. With the concept of lodging in a hotel, we recorded everything that happened in a special hen cage as rent a room in the hotel during stay. The number of each cage, room number, address of the hen and the corresponding serial number in the database are all written into the 125 kHz RFID tag, and then take the tag to the chicken house to hang on each cage. The 134.2 kHz RFID tags were used to assign the type of egg collected and laying behaviors of hen, such as broodiness, broken egg, soft egg and two eggs etc. The staff took the RFID reader to the chicken house and scans the RFID tag on the chicken cage to record the laying status of each hen every day (Figure 8). If a normal one egg is recorded by the cage number, a 125 kHz cage tag was scanned only. The 134.2 kHz tag was scanned after the 125 kHz tag only in the case as described above.

Figure 6. The RFID reader and tags

Figure 7. Cage information is written into the 125 kHz RFID tag

In general, the application of RFID in animal science is usually to tagging on the animal as a unique ID of the animal for traceability. Commonly, the tag is not rewriteable and not reusable. In our system, the RFID tag is fixed on cage as part of construction facility. Different batch hen can stay in the same cage and he tag on the cage still can serve the the new occupant. The cost of RFID tag is can be reduced considerably. After the data collection, The staff took the RFID reader to the office, and then use the commercially available dual-frequency reader random transfer software to transmit the data file by the Bluetooth to notebook or directly connect reader by USB to computer (Figure 9), the EXCEL sorting and LOOKUP functions are used to eliminate the labor cost and time of data input, avoid the occurrence of erroneous data generated by manual input, and achieve simple and efficient data collection. In addition of raw data process, we set up a set of personal computer programs can process the excel raw tables to the egg production statistics for chicken breeding farms. In Taiwan Livestock Institute, the collected different date downloaded EXCEL files were sent to a SQL severer temperate tables and transfer to the egg production data of each cage/hen by an set of Active Server Pages. Finally, the report of egg production performance of each hen and breeding statistics were completed.

Figure 8. Cage information is written into the 125 kHz RFID tag

Figure 9. use the commercially available dual-frequency reader random transfer software to transmit the data file

CONCLUSION

In RFID egg production recoding system, the serial number of the chicken's position in the breeding database was written into the RFID electronic tags, and each RFID tag hangs on the cage in the chicken house representing a specific unique chicken position. During the period of egg production performance testing, we using RFID reader to record the hen's egg-laying date, position and egg production status of each hen every day, coupled with the commercially available dual-band reader random transfer software, the data file is transferred to the notebook after Bluetooth or to the personal computer connected with the reader. And the EXCEL sorting and LOOKUP functions are used to eliminate the labor cost and time of data input, avoiding the occurrence of erroneous data generated by manual input and achieving easy and efficient collection and establishment of the information on the number of eggs laid. In the future, it can be combined with 134.2kHz half-duplex tag, RFID multi-frequency reader and with the technology of commercially available tri-band reader random transfer software, using the characteristics of multi-frequency reader, combined with important elements of animal management: time, Animals, humans, and operational actions and animal locations will be used for animal husbandry test data collection and construction, animal drug records, and livestock and poultry production management.

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