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Heartbeat Modulation Device for Gender Identification of Embryonic Chicken in the Egg

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Abstract - The main goal of this study was to apply the heartbeat modulation technique into a device that determine the sex of a chicken embryo five days after incubation. The separation constant, embryo weight, and temperature are the essential factors in determining the embryonic chicken's sex which was the input data of the device for it to determine the gender of the embryonic chicken. The relationship between heartbeat rate, embryo weight difference, and beat rate as temperature changes can be expressed as first order and first-degree differential equation as expressed in the earlier study of the Heartbeat modulation technique. The device was composed of heartbeat sensor as the input, microcontroller which process the data, and the 4 x 16 LCD screen which shows the result. The result shows that the average heartbeat of a male chick is 64.5 beats per minute which is lower than the female chick of 73.875 beats per minute. The weight difference also differs wherein the male chick results for an average of 0.1825 grams vs of the female's 0.1213 grams. The female's twenty-five (25) average beat difference was also notable that it almost doubles versus of the males twelve and three hundredth seventy-five (12.375) average beat difference. For eight trials, the device results with an overall accuracy level of 89.3887 percent.

Keywords— Gender identification, embryonic chicken, heartbeat modulation device, University of Rizal System, Philippines

I. INTRODUCTION

Due to being regarded as unusable by the egg business; millions of male layer chicks are culled daily. With all the reasons to condemn the practice, World leaders and animal welfare bodies are furious at this practice that is basically animal abuse and intolerable. Within days after hatching, these chicks often fall victims to a totally unnecessary horrible end in industrial macerators or gas chambers.

It is especially vital to resolve the problem not only in the Philippines but the entire world, where chicken farming is a big industry and a contributor to each nation's economy. Because female layer hens comprise most of the entire nation's chicken supply for egg production, it is possible also to utilize the male chicks by dying their fur all types of colors and selling these to kids so they can play with it.

In the Philippines, this would be very much welcomed if technology could first determine the gender of chicks before they hatch. It would do its part in international moves to ensure animal welfare and moral ways in farming by stopping the senseless slaughter of millions of male chicks annually. While it reduces chick culling, the chicken industry can become more sustainable and efficient in its contribution to national food security and economic stability.

The Leipzig and Dresden universities' joint research project on spectroscopic sex determination in the egg is now well underway. Professor Kraulwald-Junghanns was recently awarded the Felix Wankel Animal Protection Research Award for her dedication to animal welfare.

Near-infrared Raman spectroscopy (NIR) is used to determine sex in chicken eggs, and it has the advantage of testing fertilized embryonated chicken eggs after 72 hours. The NIR method will be optimized and then automated to ensure that the process does not harm female embryos. Prior art CN103461218A utilized this technology with a hatching egg as its specimen, fiber optic probe, fourier spectrometer processing unit and other peripherals as the main components.

The Dresden University of Technology team, led by Roberta Galli and Gerald Steiner, has been developing an "in ovo" sexing method for several years with funding from the German Federal Office for Agriculture and Food. The goal is to prevent the annual culling of 40 million unwanted day-old cockerel chicks in the country.

Because birds' red blood cells have a nucleus, they also carry genetic sex information,' Galli explains. The team demonstrated that they could analyze fluorescence signals from embryonic blood vessels directly in the egg. They can illuminate the vessels with a near-infrared laser and measure the backscattered radiation after creating a tiny window in the shell.

Gerald Steiner and colleagues' work, which brought together a multidisciplinary team of chemists, engineers, veterinarians, and physicists, may offer a more humane alternative – sexing the chicks before they hatch, after three days of incubation. "The blood vessels have formed, but not the nerve cells," Steiner explains, "so they can't feel pain at this stage." The researchers believe that culling the chicks at this stage in their development is more ethical.

The researchers use a laser beam to cut a small, circular hole in the top of the egg to determine the chick's gender. The embryo's sex is then determined using near-infrared spectroscopy based on its DNA content, around 2% higher in male chicks. "We can't see the difference between male and female embryos with our eyes," Steiner says, "but the computer can if it's programmed to do so."

Eggs stored at 40 degrees Fahrenheit (rather than the recommended 60 degrees) hatch out more females than males, according to an Australian study (Australian Journal of Agricultural Research 11(4) 664 - 672). Male embryos are preferentially killed by colder storage temperatures, whereas female embryos are better able to withstand the chilling.

With the Prior Art WO2024086462A2-2024 or the GENDER IDENTIFICATION OF CHICKS USING DIGITAL IMAGE ANALYSIS, another method for gender identification procedure was through the utilization of the digital image as a source for identification of the gender of the chick.

Prior art CN109431484A also known as Device and method for gender identification of egg embryo based on heart rate measurement. This prior art utilizes heartbeat as the input for the egg embryo-based gender identification. This prior art compromises of laser module which cuts the eggshell and surface of the egg, pick and place module to remove the cutted eggshell, and the image aquisition

With the findings and conclusion of the preceding research conducted entitled “Gender Identification of Embryonic Chicken in the Egg by Heartbeat Modulation Technique”, the researcher found out that within five days of incubation, male chicks have an average beat rate of 62 beats per minute, while female chicks have an average beat rate of 74 beats per minute. On average, male embryotic chicks weighed 0.06 grams more than female embryotic chicks. The beat rate decreases as the embryo cools; however, the decrease is more gradual in female embryos. It can use a differential equation of the first order and first degree to express the relationship between heartbeat rate, embryo weight difference, and beat rate as temperature changes.

The invention would not only eliminate the ethical problems of chick culling but also help to embrace environmentally friendly practices in the chicken industry. We can have a more humane form of poultry farming by lowering the number of male chicks that are killed for no reason. It will also make the process more productive and less harmful for the environment. Additionally, for the chicken production industry, this invention and study will enhance the productivity from 50-50 percent due to male and female chicks to a percentage in favor of female, enhancing the cost-benefit of production

Beyond the moral considerations, the development and deployment of gender detection technologies by the Philippines will foster innovation in agricultural sciences and research. It will spur local companies to invest in creative solutions that help increase yields besides proper, dignified handling of animals which falls in the compliance of the Sustainable Development Goal no. twelve (12) which are Responsible Consumption and Production .

METHODS

To include research designs, participants/respondents/subject, research instruments, data gathering procedure, data analysis, and ethical

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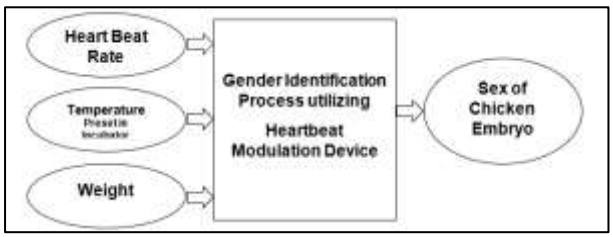

Figure 1. Combination of Logical Connection for Sex Determination of Egg Embryo and IPO Model for the Development of Heartbeat Modulation Device for Gender Identification of Embryonic Chicken in the Egg

With the consideration of the related literature and the preceding research, the system is designed with an enhanced heartbeat sensor connected to a microcontroller to analyze the specimen's data and process it with the gender identification technique formula and to collect data for the heartbeat modulation. The system was programmed to automate the mathematical computations utilizing the gender identification technique, inputting the constant temperature required for the chick's gender to be identified, the average weight of the egg.

Initially, the egg was candled to ensure that blood vessels were visible after five days of incubation. The heart began to beat shortly after the paired heart rudiments fused, which will be used as the primary source of information to distinguish male and female embryos. After five days of incubation, 200 eggs (25 eggs per trial) were randomly selected to be processed on day zero.

The egg was kept inside a portable incubator at 37.5 oC, a suitable temperature for the embryo, and it slowly cooled the temperature down before measuring the beat difference.

The egg then placed in the device for heartbeat collection and automated data collection, and after a minute of data collection the device identified the heartbeat rate per 60 seconds. The 25 chicks in each trial were chosen at hatch and were placed in a brooding pen about 8 hours after hatching and fed a starter diet with ad libitum access to feed and water and was grown out for 2 – 3 months to check the sex accurately.

The final analysis, interpretation, and accuracy were performed using 200 eggs (25 eggs per trial), with the first 100 samples being observed and analyzed and the remaining 100 samples being identified as embryotic sex.

RESULTS AND DISCUSSION

The result shows that the average heartbeat of a male chick is 64.5 beats per minute which is lower than the female chich of 73.875 beats per minute. The weight difference also differs wherein the male chick results for an average of 0.1825 grams vs of the female's 0.1213 grams. The female's average beat difference was also notable that it almost doubles versus of the male's average beat difference.

Egg Embryo Sex Determination				
Trial	Average Number of Beats 60 secs	Average Weight Difference Before and After 5 Days	Beat Difference in terms of Temperature Changes (Average)	Sex After three month
1	65	0.19 grams	12	Male
	73	0.13 grams	25	Female
2	67	0.18 grams	12	Male
	74	0.11 grams	24	Female
3	62	0.17 grams	12	Male
	73	0.12 grams	26	Female
4	65	0.18 grams	12	Male
	75	0.13 grams	25	Female
5	64	0.18 grams	13	Male
	72	0.13 grams	25	Female
6	65	0.19 grams	12	Male
	73	0.12 grams	25	Female
7	65	0.18 grams	14	Male
	75	0.10 grams	26	Female
8	63	0.19 grams	12	Male
	76	0.13 grams	24	Female
Average	64.5	0.1825 grams	12.375	
	73.875	0.1213 grams	25	

Table 1. Egg Embryo Sex Determination Concerning Number of Heartbeat, Weight Difference, and Beat Difference in Terms of Temperature Changes

The table 2 displays the device result, sex after 30 days of hatching, sex after ninety days of hatching, accuracy, and the error for eight trials. With an overall accuracy level of 89.3887 percent.

Trial	Sex	Device Result	Number of gender after 30 days	Number of actual gender after 90 days	Accuracy	Error
1	Male	13	10	11	81.8182	18.1818
	Female	12	15	14	85.7143	14.2857
2	Male	12	10	10	80.0000	20.0000
	Female	13	15	15	86.6667	13.3333
3	Male	15	13	13	84.6154	15.3846
	Female	15	12	12	75.0000	25.0000
4	Male	12	12	11	90.9091	9.0909
	Female	13	13	14	92.8571	7.1429
5	Male	10	11	9	88.8889	11.1111
	Female	15	14	16	93.7500	6.2500
6	Male	11	10	10	90.0000	10.0000
	Female	14	15	15	93.3333	6.6667
7	Male	12	12	12	100.0000	0.0000
	Female	13	13	13	100.0000	0.0000
8	Male	15	15	15	93.3333	6.6667
	Female	15	15	15	93.3333	6.6667
Ave	Male	12.375	11.625	11.375	88.6956	11.3044
	Female	13.875	14	14.25	90.0818	9.9182
Overall					89.3887	10.6113

Table 2. Egg Embryo Sex Determination Concerning Number of Heartbeat, Weight Difference and Beat Difference in Terms of Temperature Changes

CONCLUSION AND RECOMMENDATIONS

Heartbeat Modulation Device for Gender Identification of Embryonic Chicken in the Egg was fully developed based on the gender identification technique integrated in the developed technology in order for the local and non-technical people to identify the gender of the chicks, preventing the culling of male chicks which results to implementing the SDG 12 – Responsible consumption and production by consuming the egg when there is no pain receptor or when it is still just raw egg.

The device was developed in relation to the Input-Process-Output framework which considers the past literature and studies, as well as the new emerging technologies that can detect the pulse inside the egg. Prior art CN109431484A would be the nearest prior art of the study. However, methodology and technology are different and have many advantages which solves the patentability in terms of new, inventive steps and industry applicability requirements of the research output. With the differences of characteristics between the male and female chicks, the female chicks have higher average heartbeat per minute, has lower weight, and has double average beat difference than the male chicks.

The developed device in relation to the first table, results a precision of 89.8887% accurate with eight (8) trials using two hundred (200) embryonic eggs enhancing the productivity and cost-benefit of production line from 50-50% Male-to-Female Ratio, increasing the income with less capital of poultry industry.

This research can be a spearhead in halting the fate of the male eggs by culling it in the shredder along with the eggshell. This research is one of the answers to end animal cruelty and an answer for the SDG12 Responsible consumption and production. By consuming the egg where it still has no pain receptor, it is an act of mercy to the egg unlike the shedding, a method what the industry is still using.

It is recommended that the technology readiness level (TRL) of the device is upgraded, from TRL 6 to TRL 7 and TRL 8 to be a complete technology for commercialization. Additionally, improvements in physical appearance, and multiple parallel operations are recommended for a quicker analysis using the device. It is also recommended to further research the device, instrumentation and calibration processes to increase further the accuracy.

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