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DEVELOPMENT OF A LIGHT SENSOR FOR USE IN FARM ANIMALS

Luiz Arthur Malta Pereira
Universidade Brasil, UB
Descalvado- SP
http://lattes.cnpq.br/3886365300128445

Barbara Martins Duarte
Universidade Brasil, UB
Descalvado- SP
http://lattes.cnpq.br/1090654894056775

Käthery Brennecke
Universidade Brasil, UB
Descalvado-SP
http://lattes.cnpq.br/5772754247707035

Liandra Maria Abaker Bertipaglia
Universidade Brasil, UB
Descalvado-SP
http://lattes.cnpq.br/6395901509400650

Cynthia Pieri Zeferino
Universidade Brasil, UB
Descalvado-SP
http://lattes.cnpq.br/3106899025626838

Cássia Maria Barroso Orlandi
Universidade Brasil, UB
Descalvado-SP
http://lattes.cnpq.br/3278725857184504

Abstract: Studies show that the photoperiod (duration of the light period to which the animal is exposed in a day) has a great influence on productivity when associated with other management factors, such as welfare, ambience, nutrition, and disease control. The ideal amount of light varies for each animal species. This is the context of this work, which aimed to develop an equipment to monitor the luminosity of zootechnical facilities, capable of measuring and comparing with the ideal conditions of each species, providing important information for the rural producer. The box of the device was built in a 3D printer, with the help of the Arduino IDE, the C programming language was used to program the controlled micro of the device and to obtain the brightness a temt6000 brightness sensor was used. Using the parameters of light requirements for each animal species, taken from the scientific literature, the equipment developed showed efficiency to measure and classify the luminosity of facilities for production animals.
Keywords: Ambience, electronic device, photoperiod, Arduino platform, animal productivity.

INTRODUCTION

The importance of light in the agricultural sciences is undeniable, since it is a management factor that maximizes productivity in various sectors of agribusiness. Regarding animal production, studies show that the photoperiod (duration of the light period to which the animal is exposed in a day) has great influence on productivity when associated with other management factors such as welfare, ambience, nutrition, disease control (DAHL et al. 2010). This set of measures allows the animal to better express its genetic potential.

The light intensity can be given in the measurements of photon, lumen and lux. Lux, consists of the lighting unit of one lumen (unit of luminous flux) per square meter(COSTA, 2006).

The ideal amount of light varies for each animal species and the photoperiod directly influences the physiology of beings. The interference of light is notable in several branches of agribusiness, therefore, it is necessary to control the levels of light so that it can be applied correctly in their respective productive sectors. This control and measurement can be performed through devices and sensors developed for this function, thus promoting good productive, reproductive, and, consequently, economic and socio-environmental results.

Ruminant animals are sensitive to seasonal variations throughout the year and, with this, present changes in reproductive characteristics (sexual behavior, scrotal circumference, testicular weight, semen quality, plasma testosterone levels) and productive (meat, milk and wool) (SILVA et al., 2018).

In the sheep industry, the effects of photoperiod have repercussions on hormonal control, which is mediated by pineal melatonin. This melatonin transforms the photoperiodic message into a chemical message and its daily secretion is proportional to the length of the night (COELHO et al., 2006).

Cattle reproduction is also influenced by luminosity (Dahl et al., 2010). Maia et al. (2017) found that females exposed to a greater number of light hours per day reach puberty at a younger age compared to females exposed to fewer light hours. In agreement, Barcellos et al. (2003) state that heifers kept under long days reach puberty earlier than those kept under short days, usually around one month, this stemming from the greater release of luteinizing hormone (LH) in response to estradiol.

For dairy heifers, Dahl et al. (1998) and Reksen et al. (1999) recommend a light intensity of 200 lux, however, it can be reduced to 150 lux, in order to reduce the energy cost of the farm, without compromising milk production.

In the area of non-ruminants, specifically poultry, artificial lighting is an alternative for increasing production levels. Campos (2000) submitted layers to variations from 1 to 500 lux and noticed that in the range of 50 to 500 lux the effects on the animals were not significantly altered. Zhang et al. (2012) observed better embryonic development linked to better hatching rates, in addition to hypotheses raised regarding the reduction of stress in the birds.

In broilers, Brito (2009) recommends the intensity of 20 lux in the first week of life, 5 lux from the second week on, until the end of the rearing period of the flock (around 42 days) and 10 lux in the three days before slaughter.

In equine breeding, luminosity has an influence on the cyclicity of mares, which are considered seasonal and photoperiod positive species, with the apex of reproductive activity reached during maximum luminosity (GINTHER et al., 2004).

The manipulation of the photoperiod in mares submitted to reproductive biotechnologies in reproduction centers consists of providing artificial light in environments such as: stalls, pens or pens, with variations in light capacity, height and frequency of light availability.

However, most studies have shown the effectiveness of the photoperiod characterized by 16 hours of light and 8 hours of dark (DAELS PF, 2006). Restoration of cyclicity and ovulation in mares has also been reported with the use of direct artificial light by face mask (KIM S, et al., 2022).

In addition to reproductive aspects, changes in the coat of equines over the course of the year reflect adaptations to seasonal variations in specific environmental conditions and studies have demonstrated the effects of light on this phenotypic trait.

In this sense, the manipulation of the photoperiod in horses has shown to be efficient, presenting promising results in the modulation of hair growth by prolonging the phase of light exposure through devices (Equilume Ltd, Ltd., Naas, Co. Kildare, Ireland) with blue fluorescent light, attached directly to the surface of the animal's face. The authors pointed out that different climatic conditions, thermoregulatory requirements, keeping the animals in pens or enclosed in stalls had an influence on the results of coat growth modulation (O`BRIEN et al., 2020).

Based on the above, the objective of this study was to develop an electronic device to measure the luminosity in animal facilities and thus assist in the management of the photoperiod for production animals.

MATERIAL AND METHODS

The luminosity equipment was developed through the Arduino platform, a resource created in 2005 with the objective of allowing the development of functional, low-cost and easily programmable devices, intended for students and amateur designers, by adopting the concept of free hardware, which means that anyone can assemble, modify, improve or even customize this electronic prototyping platform (MOTA, 2017).

The platform is composed of an Atmel microcontroller, electronic circuits for data input and output, and other components that facilitate the development of electronic applications. It has a USB port that allows easy connection to a computer, which makes it possible to program it according to the project, using a free IDE (Integrated Development Environment), which uses language based on C/C++ (MOTA, 2017).

For the development of the electronic device, a light sensor of the phototransistor type was used, which consists of a transistor activated by light. In the common transistor there are in its composition three pins called base, collector and emitter, where in its simplest configuration, the passage of electric current from collector to emitter occurs when the base pin receives an electric current. The difference in the phototransistor is that its activation occurs by the incidence of light on its base and the subsequent formation of a current in the collector towards the emitter (NOGUEIRA, 2020).

To the device was attached a 16x2 liquid crystal display (two lines and sixteen characters each line), in order to present the reading of the ambient light, the maximum and minimum. In addition, it compares them with the ideal data cited in the literature, in order to inform whether the environment is suitable or not for the species: cattle, sheep, layers, broilers and horses.

The whole system was protected and conditioned in a project box, designed with the use of 3D software and printed in a 3D printer with PLA material. The working scheme is shown in figure 1.

The programming flowchart (Figure 2) was designed to measure the luminosity in the environment and relate it to the ideal ranges for each animal species, enabling the producer to diagnose the conditions of his zootechnical installations, in order to facilitate correct decision making.

RESULTS

The prototype box was designed using the Tinkercad tool. This tool allows the design of 3D models, and promotes the development of digital and electrical circuits.

The 3D design was saved on an SDcard, and this was imported into a 3D printer, where it was printed with PLA filament.

The assembly of the device involved five main components: the first was the LCD16x2 display, along with the I2C electronic board. This board facilitates the integration with the Arduino platform, so it is a communication protocol that reduces the number of pins to perform a certain task. The display consisted of 16 columns, 2 rows and a blue background, and was used to display messages and data to the user of the device.

The Arduino board and the display were fixed to the box structure and interconnected by jumpers. It is noteworthy that a data logger shield was also connected to the arduino, i.e., a board that fits the pins of the arduino, allowing it to have an internal clock and to record data on SD cards, allowing the equipment to become a datalogger. Figure 4 shows the inside of the device, where the components were connected.

For the brightness measurement the temt6000 brightness sensor was used, which was attached to the outside of the prototype box and connected by jumpers to the pins (5V, GND, 7). Figure 4 shows the sensor installed on the side exterior of the prototype.

After the device was assembled (according to the flowchart design shown), the programming that guides the arduino's operation was developed in C language and loaded onto the Arduino board. The code is presented in figure 5.

The programming was compiled and loaded onto the arduino board. After the assembly was finished, the prototype was submitted to initial tests in environments with different luminosities. Aiming to prove the efficiency of luminosity measurement by the developed electronic device. A commercial luxmeter (digital luxmeter luminosity meter - MT30) was used to compare the results.

The measurements were performed in environments corresponding to three production animal facilities, where the measurements of the prototype and the commercial equipment (luxmeter) were compared. In addition to this comparison,

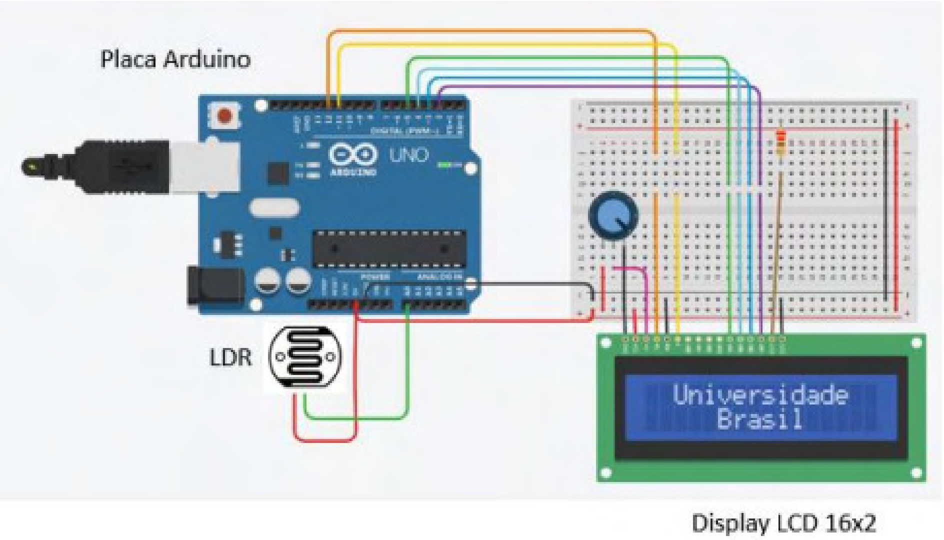

Figure 1 - Proposed Electronic Circuit.

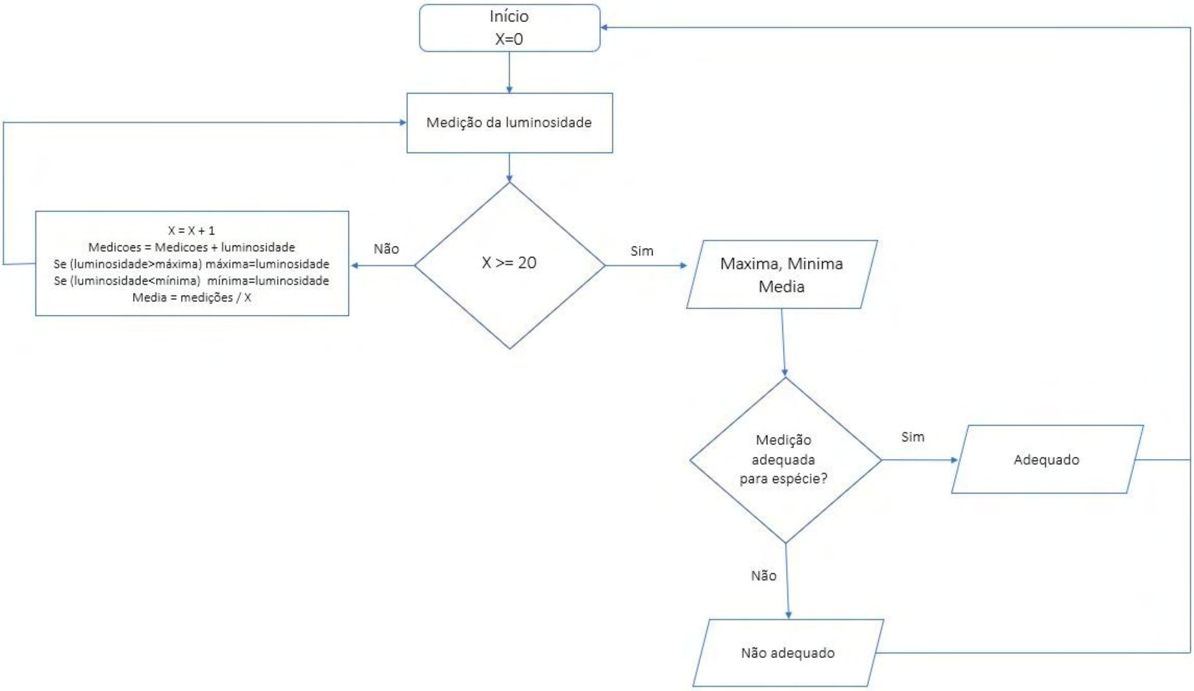

Figure 2 - Flowchart of the developed programming.

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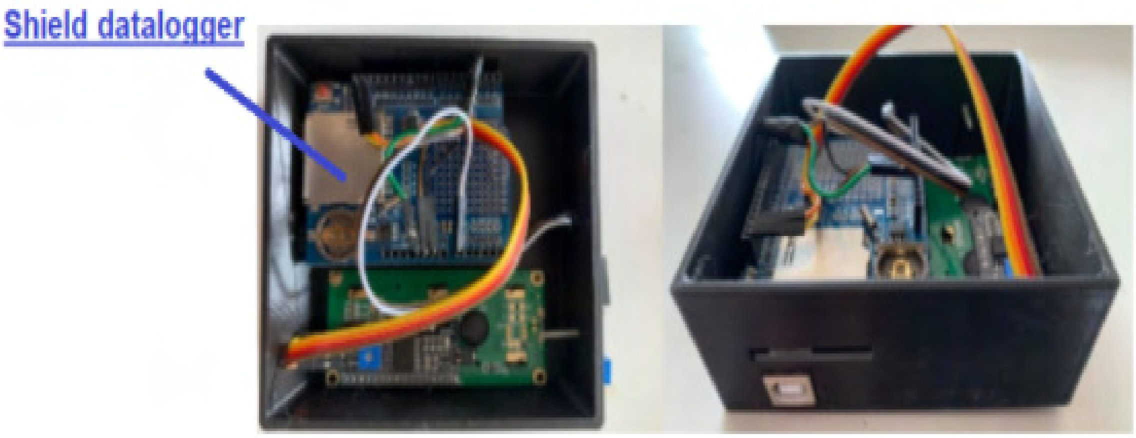

Figure 3 – Inner part of the developed device.

Figure 4 - Front view of the temt6000 attached to the outside of the prototype box

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```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
#include <SPI.h>
#include <SD.h>

#define porta     4
#define frequencia 1
#define light     A0

int     vezes, vezes2 = 0;
float   tt, th = 0;
float   medidas, media, maxima, minima = 0;

LiquidCrystal_I2C lcd(0x27,       16,       2);
// Criando um LCD de 16x2 no endereço
0x20

void setup()
{ Serial.begin(9600);
  lcd.init();
 lcd.backlight();
 lcd.setCursor(0, 0);
 lcd.print("Universidade");
 lcd.setCursor(0, 1);
 lcd.print("BRASIL");
 delay(2000);
 lcd.clear(); }
void loop()
{
 //Luminosidade
 int reading = analogRead(light);
 int mVolt = map(reading, 0, 1023, 0, 5000);
 float volt = (double)mVolt / 1000; //mV para
V
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("Luminosidade : ");
 lcd.setCursor(0, 1);
 float lum =  mVolt;
 if (lum > 300)
 {
  lum = lum * 2;
 }
 lcd.print(lum);
 lcd.print( " LUX");
 delay(1000);
 if (minima == 0) {
   minima = lum;
 }
 if (lum < minima) {
   minima = lum;
 }
 if (lum > maxima) {
   maxima = lum;


 }

medidas = medidas + lum;
 vezes2 ++;
 if (vezes2 == 20)
 { media = (medidas / vezes2);
   vezes2 = 0;
   lcd.clear();
   lcd.setCursor(0, 0);
   lcd.print("Lum Media: ");
   lcd.setCursor(0, 1);
   lcd.print(media);
   lcd.print( " LUX");
   delay (2000);
   lcd.clear();
   lcd.setCursor(0, 0);
   lcd.print("Lum Maxima:");
   lcd.setCursor(0, 1);
   lcd.print(media);
   lcd.print( " LUX");
   delay (2000);
   lcd.clear();
   lcd.setCursor(0, 0);
   lcd.print("Lum Minima: ");
   lcd.setCursor(0, 1);
   lcd.print(minima);
   lcd.print( " LUX");
   delay (2000);
    lcd.clear();
   lcd.setCursor(0, 0);
    lcd.print("Equinos");
  lcd.setCursor(0, 1);
  if (media >= 100)        {
    lcd.print("Adequado");
  }
  if (media < 100)          {
    lcd.print("Nao Adequado");
  }
  delay (2000);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Bovinos");
  lcd.setCursor(0, 1);
  if (media >= 200)        {
    lcd.print("Adequado");
  }
  if (media < 100)         {
    lcd.print("Nao Adequado");
   delay (2000);

 lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Poedeiras");
  lcd.setCursor(0, 1);
  if (media >= 50)        {
    lcd.print("Adequado");
  }
  if (media < 50)         {
    lcd.print("Nao Adequado");
  }

 delay (2000);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Frango Corte");
  lcd.setCursor(0, 1);
  if (lum >= 5)         {
    lcd.print("Adequado");
  }
  if (lum < 5)          {
    lcd.print("Nao Adequado");
  }
  delay (2000);
  medidas = 0;
  vezes2  = 0;
  media   = 0;
}
```

Figure 5- Code of the programming language used.

the measurements were noted and calculated to ensure that the average, maximum and minimum values calculated by the developed prototype were correct.

The tests showed good results in environments with lower luminosity (up to 100 lumens), however, in brighter environments (above 450 lumens), the prototype presented a higher value in lumens in relation to the commercial equipment. Thus, a correction factor was added to approximate the values.

After adjustment, the electronic device was submitted again to tests in three installations. Environment 1 was considered to be the darkest (up to 50 lumens); environment 2, medium (up to 150 lumens), and environment 3, light (above 400 lumens). The measurements presented the following results, according to Tables 1, 2 and 3.

Monitored environment 1 proved to be inefficient for layers, dairy cattle, and horses to express their genetic potential in production and reproduction. Environments 2 and 3, on the other hand, met the particular needs of the different species.

The calculations show that in the measurement performed in darker environments, up to 50 lumens, the maximum variation reached 13.3% (Table 1). In medium environments up to 150 lumens the maximum variation reached 6.3% (Table 2) and in brighter environments, above 400 lumens the maximum variation was 30% (Table 3).

Considering that the measurement tolerance of the commercial equipment is 4% and the prototype sensor has 5% variation, it must be positioned at 60 degrees for a more accurate measurement. It is understood that for environments with up to 150 lux, the electronic device developed presented efficiency, despite the small difference between the measurements. However, for environments above 400 lux, this variation is up to 30%.

According to the methodology presented, the equipment was programmed based on the appropriate light levels for each species, as shown in table 4.

Following this regulation, the following conditions were determined: for broilers the luminosity must be greater than 5 lux; for layers, luminosity greater than 50 lux; for dairy cattle, luminosity greater than 200 lux, and for horses, luminosity greater than 100 lux.

It is important to point out that the equipment has the capacity to store the luminosity value every 1 minute, so it is possible to use this data for various studies.

As an example, figure 6 shows measurements taken in an environment with a luminosity above 50 lux, which results in adequate conditions for all the species monitored.

CONCLUSION

We concluded that the objective of the study was achieved with the development of an electronic device to measure the luminosity and ascertain the conditions of zootechnical facilities for production animals. The developed equipment monitors environments for broilers, horses, cattle and layers, showing in its display whether the environment is adequate or not. However, it is noteworthy that the equipment only measures if the environment luminosity is low or not for a certain type of animal, therefore, the study must be expanded to make the equipment more efficient to ensure the proper conditions of low and high luminosity and also monitoring the growth phases of the animals.

	Commercial equipment	Prototype
Brightness	44 lux	39 lux
Average Luminosity	44,1 lux	38,9 lux
Maximum Luminosity	44,1 lux	38,9 lux

Table 1 - Measurements in an environment with up to 50 lumens (Environment 1).

	Commercial equipment	Prototype
Brightness	103 lux	110 lux
Average Luminosity	106,1 lux	110 lux
Maximum Luminosity	106,1 lux	110,1 lux

Table 2 - Measurements in an environment with up to 150 lumens (Environment 2).

	Commercial equipment	Prototype
Brightness	454 lux	594 lux
Average Luminosity	454,7 lux	592,15 lux
Maximum Luminosity	454,7 lux	592,15 lux

Table 3 - Measurements in an environment above 400 lumens (Environment 3).

Species	Lux
Broiler chickens [1]	20 lux in the first week, 5 lux until the end of rearing and 10 lux for 3 days before slaughter.
Layers [2]	50 lux
Dairy Cattle [3]	200 lux (150 with energy cost adaptations)
Equines (breeding mares)[4]	100 lux/m²

[1]Brito (2009); [2]Campos (2000), [3]Dahl et al. (1998) e Reksen et al. (1999); [4]Burkhardt (1947).

Table 4 - Optimal luminosity for the different farm animal species.

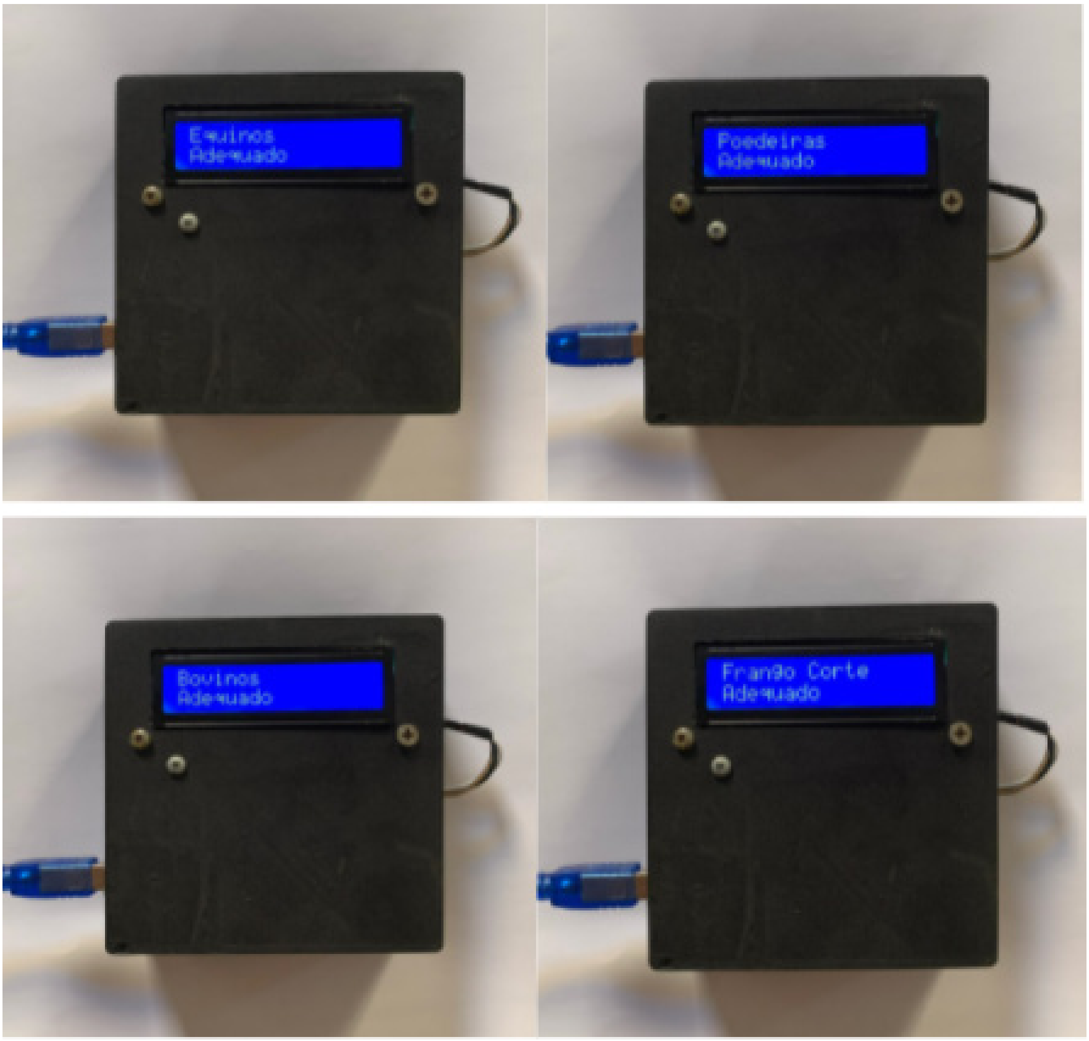

Figure 6 - Test of luminosity classification in a clear environment.

REFERENCES

BARCELLOS, J.O.J.; COSTA, E.C.; SILVA, M.D.; SEMMELMANN, C.E.N.; MONTANHOLI, Y.R.; PRATES, Ê.R.; GRECELLÉ, R.; MENDES, R.; WUNSCH, C.; ROSA, J.R.P. **Crescimento de Fêmeas Bovinas de Corte Aplicado aos Sistemas de Cria: Sistemas de Produção em Bovinos de Corte**. (Sistemas de Produção em Bovinos de Corte; Publicação Ocasional, 1). 72p. Universidade Federal do Rio Grande do Sul – UFRGS, Porto Alegre: Departamento de Zootecnia, 2003.

BURKHARDT, J. Transitionfromanestrous in the mares andtheeffectsto artificial lighting.**JournalAgriculture Science**, v.30, p. 64-68, 1947

BRITO, Jerônimo Ávito Gonçalves .Aspectos práticos de um programa de luz para frangos de corte, **Engormix** Jul. 2009. Disponível em: < https://pt.engormix.com/avicultura/artigos/programa-de-luz-frangos-de-corte-t36720.htm . Acesso em: 05 de janeiro de 2022.

CAMPOS, E; J . **Avicultura : Razões, fatos e divergências.** 1ª. ed. Belo Horizonte: Editora FEP-MVZ, 2000. 311 p. ISBN 85-87144-03-0.

COELHO, L. A.; RODRIGUES, P. A.; NONAKA, K. O.; SASA, A.; BALIEIRO, J. C. C.; VICENTE, W. R. R.; CIPOLLA NETO, J.Annual pattern of plasma melatoninandprogesteroneconcentrations in hairandwoolewelambskeptunder natural photoperiodatlower latitudes in thesouthernhemisphere**. Journal of Pineal Research**, v. 41, n. 2, p. 101-107, 2006.

DAELS, P.F. **Management of springtransition**. In: Proceedings of the 8th AAEP Annual Resort Symposium; 2006; Rome, Italy.

DAHL, G. E. Efeito **do fotoperíodo na produtividade e saúde de vacas leiteiras**. Anais do XIV Curso Novos Enfoques na Produção e Reprodução de Bovinos, Uberlândia-MG, p. 367-372, 2010.

DAHL, G.E., T.H. ELSASSER, A.V. CAPUCO, R.A. ERDMAN E R.R. PETERS. 1997. Effects of longdailyphotoperiod on milkyieldandcirculatinginsulin-like growth factor-1 (IGF-1). **Journal Dairy Science**, v.80, p.2784-2789.

GINTHER, O.J., GASTAL, E.L., GASTAL, M.O,BEG, M.A. Seasonalinfluence on equinefollicle dynamics. **Animal Reproduction**, v.1, p.31-44, 2004.

G.J.C. Costa, **Iluminação Econômica: Cálculo e Avaliação** (EDPUCRS, Porto Alegre 2006), v. 5. 4ª ed.

KIM. S.; JUNG. H., MURPHY.B.A.; YOON M. Efficiency of Equilume light mask on theresumption of earlyestrouscyclicityandovulation in Thoroughbred mares. **Journal Animal Science and Technology,** v.64, n.1, p.1-9, 2022. https://doi.org/10.5187/jast.2021.e123.

MAIA, A.L.R.S.; OLIVEIRA, M.E.F. SOUZA-FABJAN, J.M.G.; BALARO, M.F.A.; BRANDÃO, F.Z.; FONSECA, J.F. Distúrbios reprodutivos em cabras leiteiras e impactos potenciais nos sistemas de produção. **Revista Acadêmica de Ciência Animal**, v. 15, n. 2, p. 77-89, 2017.

MOTA, Allan. O que é Arduino e como funciona? **Vida de Silício**, 2017. Disponível em: <https://portal.vidadesilicio.com.br/o-que-e-arduino-e-como-funciona/>. Acesso em: 05 de janeiro de 2022.

NOGUEIRA, Danilo. Sensor de luz TEMT6000 com Arduino. **Auto Core Robótica**, 2020. Disponível em:<https://autocorerobotica.blog.br/sensor-de-luz-temt6000-com-arduino/>. Acesso em: 10 de fevereiro de 2022.

O´BRIEN, C.; DARCY- DUNNE M.R.; MURPHY B. A.Theeffects of extendedphotoperiodandwarmth on hairgrowth in poniesandhorsesatdifferent times of year. 2020.**PLoS ONE,** v.15, n.1: e0227115. https://doi.org/10.1371/journal. pone.0227115

REKSEN, O., A. TVERDAL, K. LANSVERK, E. KOMMISRUD, K. E. BOE, E E. ROPSTAD. 1999. Effects of photointensityandphotoperiod on milkyieldandreproductive performance of Norwegianredcattle. **Journal Dairy Science,** v.82, p.810–816.

SILVA, A. A. F.; GOIS, G. C.; PESSOA, R. M. S.; CAMPOS, F. S.; LIMA, C. A.; **Efeito do fotoperíodo sobre ruminantes,** v.15, 2018. Disponível em https://www.researchgate.net/publication/329360868_Efeito_do_fotoperiodo_sobre_ruminantes . Acesso em: 10 de março de 2022.

ZHANG, L. et al. Effect of monochromatic light stimuliduringembryogenesis on muscular growth, chemicalcomposition, andmeatquality of breastmuscle in male broilers.**Poultry Science**, 2012, v 91, p.1026-1031.