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ARDUINO SYSTEM AND MODULES AS A MODEL FOR DEVELOPING EQUIPMENT USED IN LIVESTOCK FARMING

(*Sistema arduíno e módulos como modelo para desenvolvimento de equipamentos utilizados na pecuária*)

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RESUMO

Novas tecnologias têm o potencial de gerar benefícios ao agronegócio através da união entre os cenários produtivos e científicos. Sendo que na pecuária 4.0 a constante coleta e análise da dados feitos por sensores e programas permite aos responsáveis avaliarem informações relacionadas tanto aos animais quanto ao ambiente. O presente experimento teve como objetivo fazer uso do sistema Arduíno e seus módulos para desenvolver equipamentos que possam ser usados na pecuária visando tornar mais acessível aos produtores ruais o novo modelo de produção "Pecuária 4.0". Fazendo-se uso de um Arduíno UNO e dos módulos Ethernet Shield W5100, sensor de fluxo de água, DHT11, termômetro a prova da água (Ds18b20), sensor LDR e um cartão micro SD de 2 Gb, os dados referentes ao fotoperíodo, temperatura ambiente, umidade relativa do ar, consumo de água e temperatura da água foram coletados durante um período de teste de 24 horas e armazenados pelo sistema no cartão micro SD em um arquivo no formato "txt". As informações armazenadas no arquivo foram transferidas para o aplicativo LibreOffice Calc 7.1, onde foram processadas e analisadas. Percebendo-se que os animais consumiram água em bandos e em períodos específicos do dia, com maiores temperaturas ambientais e umidade relativa do ar mais baixas, apresentando assim picos de consumo em determinados momentos.

Palavras Chaves: Tecnologia, pecuária 4.0, zootecnia de precisão, comportamento animal, bioclima.

ABSTRACT

New technologies have the potential to generate benefits to agribusiness through cooperation between productive and scientific scenarios. In livestock 4.0, the constant collection and analysis of data made by sensors and programs allows those responsible to evaluate information related to both animals and the environment. The present experiment aimed at making use of the Arduino system and its modules to develop equipment that can be used in livestock to make the new production model "Livestock 4.0" more accessible to rural producers. Making use of an Arduino UNO and Ethernet Shield W5100 modules, water flow sensor, DHT11 (Digital Humidity and Temperature Sensor), water-proof thermometer (Ds18b20), LDR (Light Dependent Resistor) sensor and a 2 Gb micro SD card, data for photoperiod, room temperature, relative humidity, water consumption and water temperature were collected during a 24-hour test period and stored by the system on the micro SD card in a file in the format " txt". The information stored in the file was transferred to the LibreOffice Calc 7.1 application, where it was processed and analyzed. It was perceived that the animals consumed water in groups and at specific periods of the day, with higher environmental temperatures and lower relative humidity, thus presenting peaks of consumption at certain times.

***Keywords**: Technology, livestock 4.0, precision animal science, animal behavior.*

INTRODUCTION

Development in digital technology has generated benefits for agribusiness, among these: precision animal science. Incorporating the productive and scientific scenario, which

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constantly goes through a dynamic process of updates, enables one to manage production, product quality and expand both. Driven by the alimentary behavior of the world's population, through the increased consumption of meat and the preference for sustainable production patterns, which require new technologies and techniques, ease of communication and the exchange of information, even if those responsible are in distant areas. In addition, the development of digital technology works by facilitating the development of production models and business, through better management, with awareness, identifications of problems or needs, and faster decision-making, along with innovations (BRAUN *et al*., 2018; CASTRO JÚNIOR *et al*., 2021; KLEPACKI, 2020; SABONARO *et al*., 2022; SOBROSA NETO *et al*., 2018).

In “livestock 4.0 “, equipment with sensors, mathematical methods and integrated intelligence act to provide information to those responsible for production, through the communication that occurs between the components and the evaluation of environmental data, machinery and animal data, with great precision. These data, such as feeding behavior, water consumption, temperature environment, relative humidity, soil moisture, proper operation of equipment, facilities and other made through image processing in real time. These infractions may be sent wirelessly to a responsible primary node for uploading the information to an "internet of things" platform. These processes can act in conjunction with other digital processes of rural properties, such as the integration of network or cloud systems and the automatic control of other equipment involved in the processes (BRAUN *et al*., 2018; CASTRO JÚNIOR *et al*., 2021; KLEPACKI, 2020; FELIPE *et al*., 2022).

Arduino was created at the IVRAE Institute, which decided to open it to the public (considered to be an open-source platform) and in addition also allows the public to propose suggestions for the evolution of the project. “Arduinos “are different types of programmable circuit boards, which can be used to allow interface sensors and modules to communicate with each other, in addition to controlling all operations. These generate the possibility of creating different projects for several areas of activity. This technology makes it also possible to make use of internet connections or local connections with other devices such as Smartphones, tablets, desktop computers, other equipment such as household appliances, work environments, among others (JAMES *et al*., 2022; VITAL-CARRILLO, 2022).

Welfare in animal production today is essential to achieve a sustainable production system, and currently the production systems of cattle have a wide variation in forms of management and within this the way to offer and evaluate water consumption for animals, the latter of which needs to have knowledge about the individualities of the animals to propose better management, because one of the factors that influence the consumption of water by animals is the type of diet that they receive, and can be described as an example of beef cattle consumption that consume between 20 and 80 litres of water per animal per day and milk cattle that can be consume 20 to 150 liters of water per animal per day. In assessing these aspects, it is extremely importance that in pasture production schemes the distribution of water to animals be carried out effectively, avoiding their energy expenditure to seek water, so it is necessary that farms have a good water infrastructure to maximise productivity (SOBROSA NETO *et al*., 2018; STRAWS *et al*., 2021; PALHARES *et al*., 2019; PALHARES *et al*., 2021; WILLIAMS *et al*., 2019).

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Williams *et al*., (2019) conducted a study in Australia to assess the potential of the use of radio frequency identification data readers to assess the number of visits and the attempt between them to the drinking fountains by cattle, as well as evaluating aspects obtained from official weather stations located at or near each site of the experiment (temperature, humidity, wind speed, cloud cover, sun exposure and precipitation). Since their results showed that the majority of cattle visits to water points occurred during the day (between 06:00 and 19:00) and in 48 hours from a previous visit. The differences seemed to reflect seasonal conditions and availability of water at each site of analysis, according to the evaluation periods, temperature, humidity and cloud cover. Finally, the author still determines that the data in this evaluation model makes it possible to identify animals that do not visit the water points, also gives a better understanding of the conditions of the pasture, improve decision making by ranchers and inform recommendations for the optimal number and distribution of water points.

The present experiment aimed to make use of the Arduino system and its modules to develop equipment that can be used in livestock farming and make the new production model "Livestock 4.0" more accessible to the rural livestock farmer.

MATERIALS AND METHODS

Prototype test site

The prototype test was carried out at Colina Verde farm, located in the municipality of Nova Tebas, Paraná, Brazil. Coordinates 24°34'11.7"S 51°52'56.8"W. During the period from 13:30 from 05/02/2022 to 13:30 of 06/02/2022, totaling 24 hours. During the evaluation period, the climate was interspersed between rainy and cloudy. Using an old concrete drinking fountain that had the flow rate controlled by a water box buoy, protected by a structure so that the animals would not remove it (Fig. 01), 11 animals had access to the drinking fountain, of these two were adults of the equine species and nine adults and young of the bovine species. On site there was electrical power available to connect the only necessary installation of an outlet near the water fountain.

(**Source:** Prepared by the authors, 2022)

Figure 01: Installation of the prototype in the water fountain.

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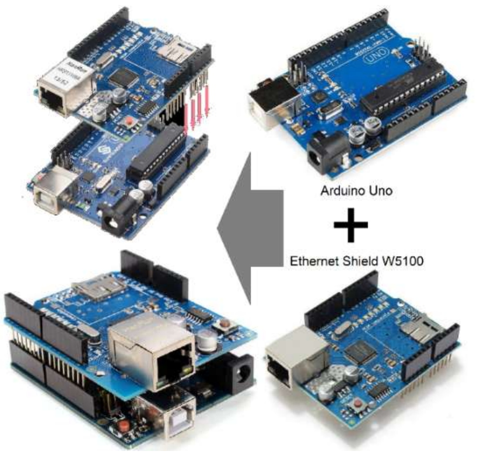
Used equipment

- 1 Arduino UNO
- 1 Ethernet Shield W5100 (HanRun HR911105A)
- 1 water flow sensor (SAIER Model: SEN-HZ21WA)
- 1 DHT11 digital humidity and temperature sensor
- 1 Waterproof thermometer DS18B20
- 3 resistors of 10K ohms
- 1 LDR sensor (Light Dependent Resistor)
- 1 two gigabyte Micro SD card (SanDisk, class 4)
- 1 source nine volts of two amperes Wires and connectors to make connections
- Liquid insulator (used under the boards, some circuits that should not be exposed and joining wires)
- Insulating tape (in provisional wire joints)

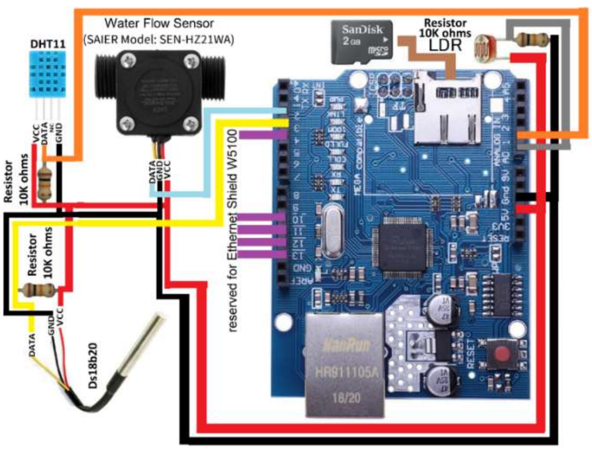
Connections and use of pins

The diagram of links between the components is shown in Fgs. 02 and 03:



(**Source:** Prepared by the authors, 2022)

Figure 02: Connection scheme between Arduino UNO and Ethernet Shield.



(**Source:** Prepared by the authors, 2022)

Figure 03: Connections and use of pins.

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Programming

The programming was made using the Arduino IDE program and the libraries available for the modules. The sketch used 24430 bytes (75%) of storage space for programs of up to 32256 bytes. Global variables used 1340 bytes (65%) of dynamic memory, leaving 708 bytes for local variables of up to 2048 bytes. Although some programming codes of the network functions are present, we chose not to make use of the sending of data via the network at the time, not being programmed this function, because the network of computers and internet of the property was not yet installed until the given of the tests done for this stage of the project, being used the IP protocol only to identify the prototype. Thus, the collected data were saved in a file in the format "txt" on the micro-SD card, for further evaluation, which was made in the LibreOffice Calc 7.1 program.

Statistical Analysis

It was decided to use the descriptive statistical analysis model in order to describe the observed data related to environmental aspects, the physiological needs of the animals and the interaction between the two.

The observed data were ambient temperature in degrees Celsius (°C), relative humidity, both measured by the DHT11 module, water temperature in degrees Celsius (°C), measured by the DS18B20 module and water consumption peaks in liters (L), measured through the water flow sensor module (SAIER Model: SEN-HZ21WA). Due to the meteorological characteristics of the day of the evaluation were cloudy with intermittent rains and little variation in sunlight intensity, it was decided not to use the data obtained by the LDR module.

The values collected in the 24-hour period (starting at 13:30 on 02/05/2022 and ending at 13:30 on 02/06/2022) were converted into graphic images to facilitate their evaluations and comparisons for further discussions, presented in this study and consider whether the prototype worked correctly or not. A cost analysis of the assembly of the prototype was also evaluated in the present study, establishing the possibility of price variation of products, purchased in retail stores, based on the variations of the Dollar in the acquisition period (occurred during the year 2021).

RESULTS AND DISCUSSION

The functioning of the prototype during its test in a 24-hour period, proved satisfactory, and it was necessary to correct a few errors that occurred in the recording of water temperature during the evaluation. The error was the recording of a temperature of -127 °C in less than 10 moments, and these records were eliminated for evaluation.

After releasing the data from the "txt" file, saved in the micro-SD, in the LibreOffice Calc 7.1 program, it can be observed that the variations in water temperature accompanied the variations in ambient temperature. It was noticed that the peaks of water consumption by the animals occurred at times when the ambient temperature was higher and the relative humidity was lower, possibly in times of absence of precipitation (Fig. 04).

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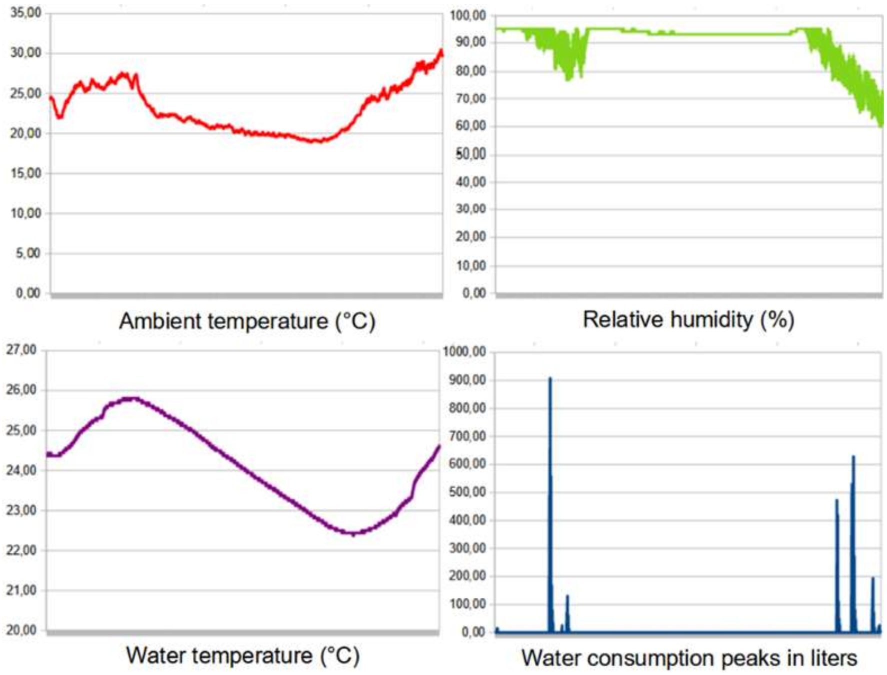

(**Source:** Prepared by the authors, 2022)

Figure 04: Graphical analysis of ambient temperature in degrees Celsius (°C), relative humidity in percentage (%), water temperature in degrees Celsius (°C) and water consumption peaks in liters during the 24hour test period of the equipment.

When analyzing the description of Almeida *et al*. (2020) in which when the need for animals to activate thermoregulatory functions, to decrease body temperature, such as increased sweating, respiratory water loss (which increases by evaporation of the skin at air temperatures above 20 °C), the animals tend to drink a greater amount of water, to re-create sweat and breathing losses and promote body cooling. In times of high humidity large water consumptions may not have occurred for two reasons, because precipitation contributed to the heat loss of animals with the environment or according to Piovesan and Oliveira (2020) the loss of water by evaporation in these moments to be slow or null. It is also observed that the peaks of water consumption by animals express their behavior of living in herds, because it has the characteristic of going to consume water in groups and in large volumes at once.

In addition, Pedro *et al*. (2021) mention that cattle are considered less sensitive to lack of water when compared to non-ruminants, due to the ability to use the liquid reserves present in pre-stomachs in times of rapid scarcity.

The variations in water temperature followed the variations in the temperature of the environment, but these variations in water temperature do not seem to have influenced the consumption of the animals, possibly because it is at temperatures between 26 and 22 °C. Many authors describe the ideal water temperature for cattle with differing values, as examples we have Almeida *et al*. (2020) which describes that the ideal temperature is between 18 and 22 °C; Wilks *et al.* (1990) reported that in their research the preference of water temperature by cattle was close to 27 °C when compared to that offered at 10 °C.

When evaluating the photoperiods (divided into day or night), there was no significant water consumption by the animals at night and the relative humidity of the air remained above

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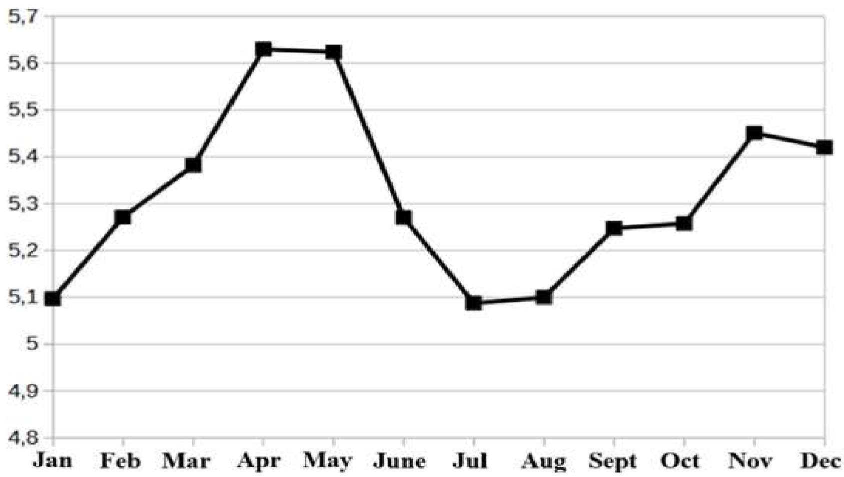
90% (95% to 93%), the ambient temperature in the early evening was 22.9 °C and at the end of 19 °C and the water in the early evening was 25.7 °C and at the end of 22.8 °C. The water consumption by the animals occurred all in the photo periods considered as day, and the greatest variations in relative humidity of the air occurred in the diurnal periods.

For the assembly of the prototype, approximately R$ 212.00 was spent in 2021 (the expenditure on electrical insulation, wires and the protective box was not counted), with the components purchased at retail, with an average of the dollar price for 2021 of R$ 5.32 (Fig. 05).



(**Source:** Adapted from São Paulo Bar Association, 2022)

Figure 05: Analysis of the price of the dollar in Reais during the year 2021.

This fact is that most rural producers have financial access to low-cost components, where according to Cunha and Putti (2020) that support of technologies has been limited due to factors such as the economic situation and the available infrastructure. Because its production is low cost and the structure it needs for installation is just a simple drinking fountain with a buoy for flow control and an energy source.

CONCLUSIONS

It was concluded that the prototype presented good functioning and covers of identifying the temperature of the environment (°C), relative humidity (%), water temperature (°C), peaks of water consumption in liters and whether it was night or daytime environment according to the intensity of light. This is also useful to evaluate the behavior of animals in relation to water consumption.

It was observed that the peaks of water consumption by the animals were in the hottest times and with lower percentages of relative humidity, at times recorded by the equipment as daytime periods.

The variations in water temperature followed the variations in environmental temperature but these variations in water temperature seem not to have influenced the consumption of the animals, possibly because it is at temperatures between 26 and 22 °C.

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