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Poultry Extension Collaborative newsletter

A collaboration between Purdue University, University of Maryland, University of Georgia and Virginia Tech

Technology to monitor poultry welfare: wearables and implantables

The poultry husbandry landscape in the United States is rapidly evolving in response to public concern related to animal welfare. As the production systems become complex and the flock sizes increase, conventional welfare assessment methods can be inadequate. Technology can help us in that regard by reliably measuring behavioral and physiological indicators of welfare. In the recent years we have experienced a tremendous growth in the use of environmental and on-body sensors to monitor health and behavior of humans and pet animals. Early reports indicate that these technologies can also be useful in acquiring information on livestock and poultry welfare and health. From feeding to breeding and from compliance to flock management, technology will continue to drive all aspects of poultry production.

The use of sensing tools to continuously monitor poultry is premised on the findings that dynamic changes in bird behavior and physiology could provide clues to their welfare status. A variety of environmental, locomotion, vision, acoustic, and health related technologies are being considered in poultry production. These sensors can reliably collect behavior and physiological information and can act as farmer's eyes and ears when human resources and accesses are limited. In this review, we will look at wearable and implantable sensors that are bringing paradigm shifts in the way poultry welfare is monitored.

WEARABLES AND IMPLANTABLES

- What are they?
- How are they used to monitor welfare?
- Advantages and disadvantages
- Affordability and future applications

Star-Oddi (Regmi)

Fig 1: Implantable heart rate and temperature sensor


VERT (Regmi)

Fig 2: Wearable tri-axial accelerometer

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What are wearable and implantable sensors?

Wearable and implantable sensors are often biosensors that can be applied to animals either non-invasively or with minimal tissue invasion. Ideally, these sensors have small component size, extended power, and robust connectivity. There are various types of wearable and implantable sensors such as accelerometers, radio-frequency identification (RFID) system, temperature capsules, microphones, heart and respiration rate sensors that have been used in chickens to monitor physiology and behavior. These sensors have been used primarily in research settings. However, technological advances have rapidly reduced sensor size and increased power and connectivity in recent years, holding great potential to be widely used in commercial production systems.

Commonly used wearable and implantable sensors in poultry

Radio-Frequency Identification (RFID)

RFID systems consists transponders (RFID tags with unique identifiers), antennae, and a receiver with a decoder to interpret the data. Often passive RFID tags with unlimited lifespan are used in agriculture. RFID has been successfully used previously for monitoring feeding/drinking behavior, environmental preferences including range use in laying hens. RFID-based tracking systems have also been used to analyze spatiotemporal distribution of hens in cage-free systems. The RFID chips are often encapsulated into a plastic or a metal ring that are attached onto the birds as leg bands. In an experimental set up recently used to monitor laying hen behavior, successful detection rates ranged between 85.8 ± 8.0% and 91.0 ± 2.6% (mean ± std dev.). With further improvement in detection range and accuracy, time-series data on resource-use patterns of chickens can be used in optimizing the housing design, understanding the social dynamics within the flock, and detecting critical control points for stressful events in the production environment.

Fig 3: Laying hen wearing a leg band with embedded RFID chip

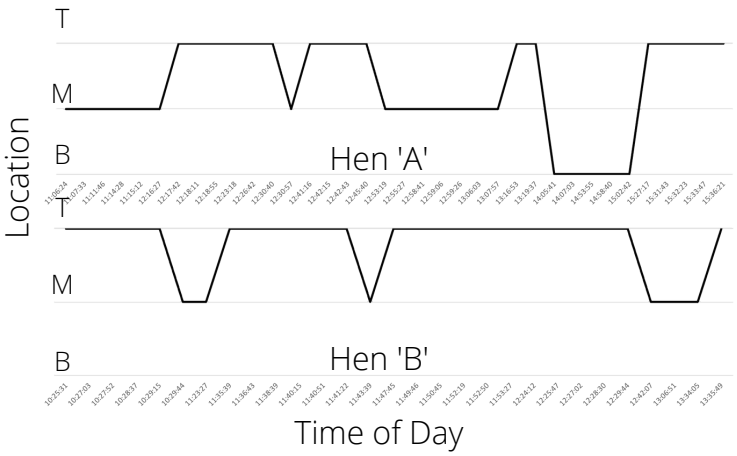

Fig 4: Movement pattern of two hens between different zones (B - Bottom tier, M - Middle tier, T - Top tier) in a cage-free aviary throughout a day

Accelerometers

Accelerometers provide the direction and magnitude of acceleration of an animal. Often, triaxial accelerometers are used in poultry to measure dynamic body acceleration in X-, Y-, and Z-axes simultaneously. Some units also incorporate an altimeter to specifically measure jumps or movements in a vertical direction. The sensitivity of an accelerometer is defined by the frequency of measurement and the threshold acceleration employed. In poultry research, acceleration as low as 0.1 G has been measured at a frequency of 100 to 1000 Hz. The wireless accelerometers can be attached to a bird using wearable structure such as a vest or a jacket. It can also be implanted under the skin if longer-term data collection is desired. Accelerometers have been used to monitor activity level in broilers and layers, gait analysis in turkeys and broilers, behavior monitoring during ectoparasite infestation in laying hens and to quantify different behaviors. Once the raw data from the accelerometer are manually/visually tagged for specific behaviors, machine learning algorithms can be trained and developed for automated behavioral analysis.

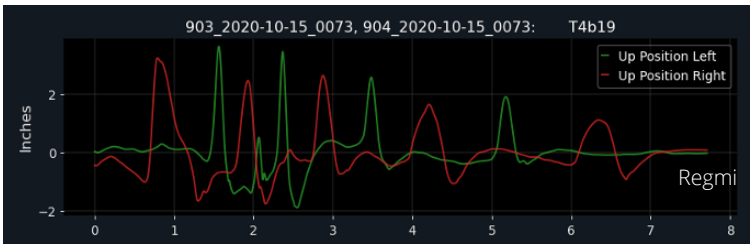

Fig 5: Gait analysis using accelerometer in turkeys

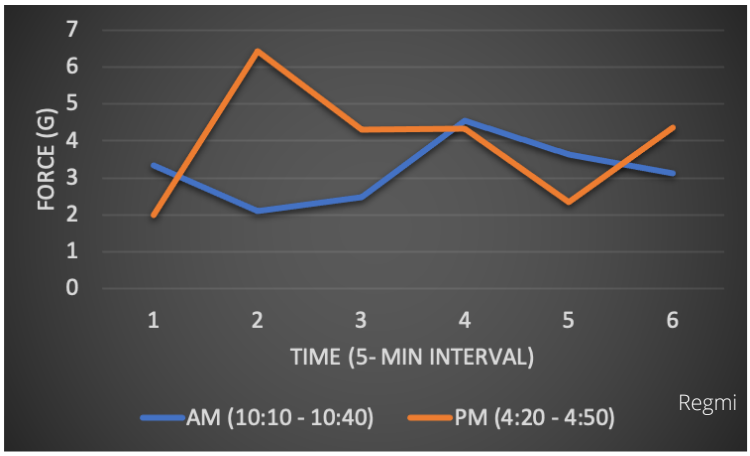

Fig 6: Energy-use in laying hens during AM and PM measured using an accelerometer

Pixabay

The Fitbit that you use to track steps uses accelerometer technology

Physiological Sensors

These are often implantable micro-sensors that uses electric, magnetic or photonic signals to measure vital signals such as heart rate, respiration rate, and body temperature. Parameters mentioned above are crucial in understanding the underlying mechanisms of stress, disease, and welfare. Heart rate and core body temperatures can predict feeding, drinking, thermal stress, and even affective states of the bird. Newer products are available commercially that enable real-time monitoring of above mentioned physiological parameters.

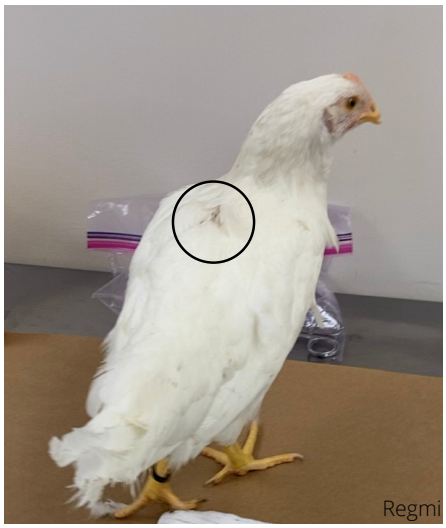

Fig 5: Chicken with a heart rate and temperature sensor implanted on the back (black circle) 7d post implantation

Advantages and disadvantages of wearable and implantable sensors

Advantages

RFID
- Cheaper and can be employed in large number of birds
- Non-invasive and the signal reader can collect data from the tags for months without interruption

Accelerometer
- Captures finest movement and postural data
- Non-invasive and easy to use

Physiological sensors
- Collects physiological data in an uninterrupted manner
- Minimally invasive
- Could be useful in early disease diagnosis

Disadvantages

RFID
- Metal structures can cause signal interference
- Multiple antennas should be used within a housing system to get proper data

Accelerometer
- Limited battery life
- Costly and often requires many receivers if real-time data is sought from multiple accelerometers
- Birds need to be acclimated to the sensor before data acquisition

Physiological sensors
- Limited battery life
- Costly and often requires post-euthanasia removal of sensor to collect the data

Things to consider...

- Sensor size in proportion to bird size
  - Poultry species are smaller in comparison to other livestock and require sensors smaller in size as well. However, there is a potential trade-off between sensor size and its battery power

- Habituation
  - Birds can react by altering their behavior when the sensor is first attached to them. A habituation exercise is necessary before useful data can be collected from the sensors. For example, chicken often require 48 hours to get comfortable to wearing a vest with an accelerometer
  - For implantable sensors, tissue healing at the site of implantation should be considered

- Use of sensors should be carefully monitored for any negative effects on bird health and welfare

- Wireless wearable and implantable sensors require internet capabilities in the poultry house along with electrical infrastructures

Summary

- Wearable and implantable sensors enable fine-grained monitoring of poultry behavior and physiology

- At present, implanting sensors in large number of birds in commercial settings is not feasible because of higher cost and technological limitations

- With advances in Internet-of-things (animals), fusion of data and data analytics from multiple sensors is possible for comprehensive assessment of poultry welfare

- The sensors, however, can be employed in a subset of the population to increase the capability of the image/video based sensors that are currently used

- Implantable sensors, such as the heart rate monitors, can also provide an insight into the emotional state of the bird

Resources

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