Tracking and monitoring of individual chickens housed in groups using passive radiofrequency identification

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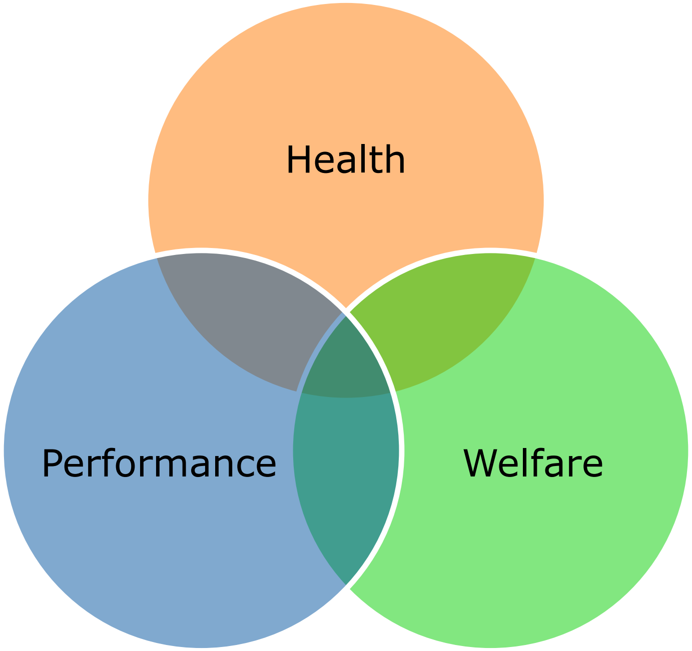
Why monitor in groups?



✓ Individual information

✓ For breeders: relation to performance in groups

✕ Monitoring difficult → video analyses

- Homogeneous appearance (Dawkins et al., 2012)
- Time-consuming, error prone (Catarinucci et al., 2014; Howerton et al., 2012)

Overview of the project

Automatically collect data on health, welfare and performance of individual animals that are kept in groups, using sensor technologies

Activity in poultry

- Gait problems
- Disease

General locomotor activity (+)

- Feed consumption ↑
- Energy expenditure ↑
- Bone strength and density ↑
- Bending and twisting of bones ↓
- Litter quality ↑
- Use of the free range area ↑

Based on Kjaer (2017)

Sensor technologies

Requirements

- Individual level
- Multiple animals
- Fast processing of data
- Determine:
  - **Activity**
  - Location
  - Proximity

Possible systems

- **Radiofrequency identification**
  - Passive
  - Ultra-wideband
- Video tracking
- Accelerometers
- …

→ **Combinations**

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Radiofrequency identification systems

- Wireless communication systems using radiofrequency fields (Debouzy & Perrin, 2012)
  - Tags – attached to animal
  - Antennas and readers

(Finkenzeller, 2010)

Different RFID systems

- Different systems can be distinguished based on:
  - Memory type of tags (Ilie-Zudor et al., 2006)
  - Reader type (Ilie-Zudor et al., 2006)
  - Communication method & range (Finkenzeller, 2010)
    - Linked to operating frequency
  - Operating frequency (Finkenzeller, 2010)
  - Power supply (Ilie-Zudor et al., 2006)

FOCUS

Power supply of the tags

Active

With battery - continuous exact location determination

Passive

No battery - registered when an antenna is passed

(Ilie-Zudor et al., 2006)

Operating frequency

- Three basic operating frequency classes
  - Low frequency (LF): ± 134.2 kHz
  - High frequency (HF): ± 13.56 MHz
  - Ultra-high frequency (UHF): 866-868 MHz (EU)

- Additional:
  - Microwave: >3 GHz (Finkerzeller, 2010) ~ 2.45 GHz
  - Ultra-wideband (UWB): low-power signals on a range of frequencies (Weis, 2007)

What type to use?

Low frequency (P)	One tag **X** No interference of water and metals 0-80 cm
High frequency (A/P)	Multiple tags Low interference of water and metals ✓ 10 cm – 1 m
Ultra-high frequency (A/P)	Multiple tags Strong interference of water and metals **X** Up to 12 m
Microwave (**A**/P) **X**	Multiple tags Can interfere with WiFi, water, metals **X** Up to 12 m or higher
Ultra-wideband (A) **X**	Multiple tags No interference of water and metals Long reading range

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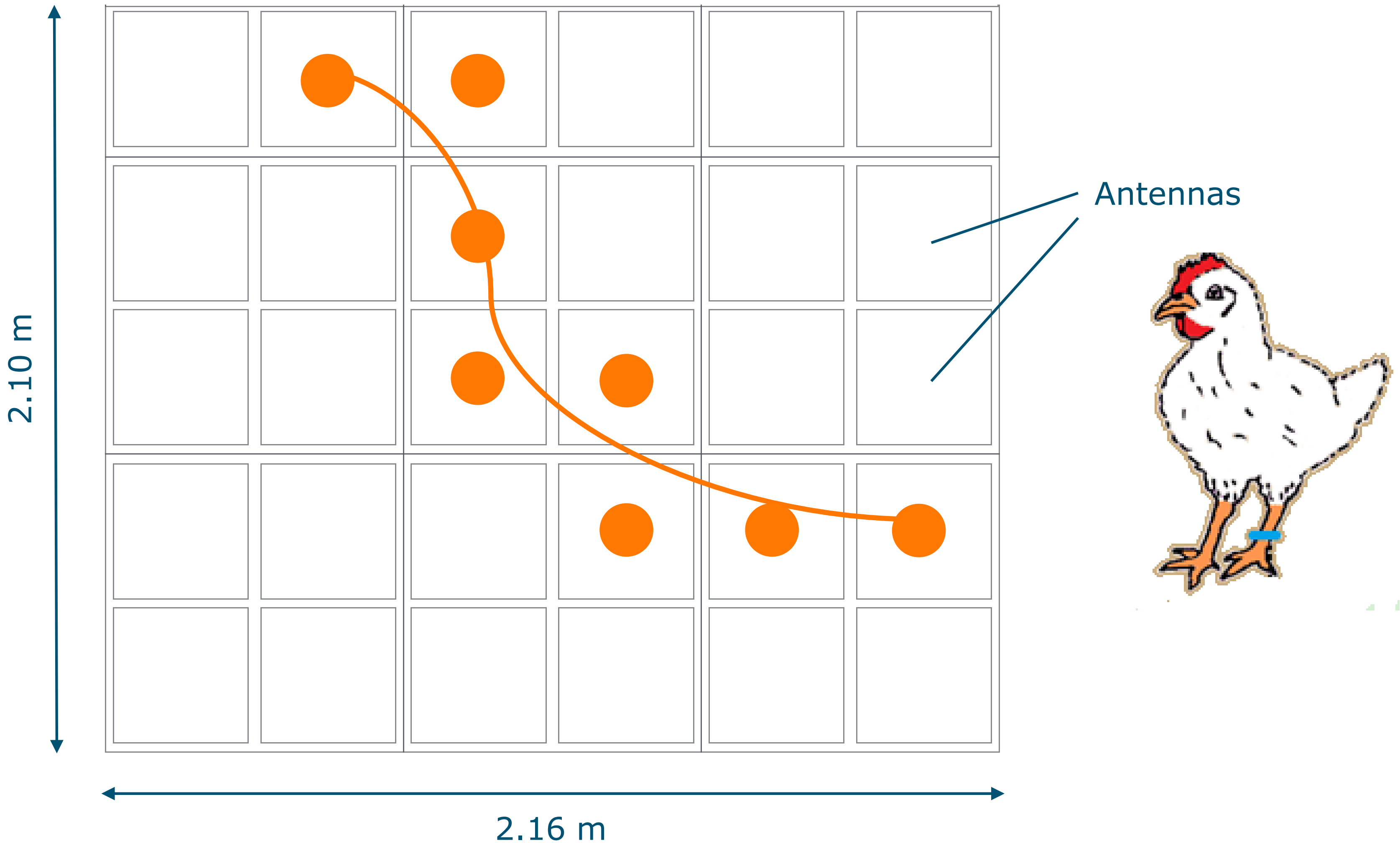
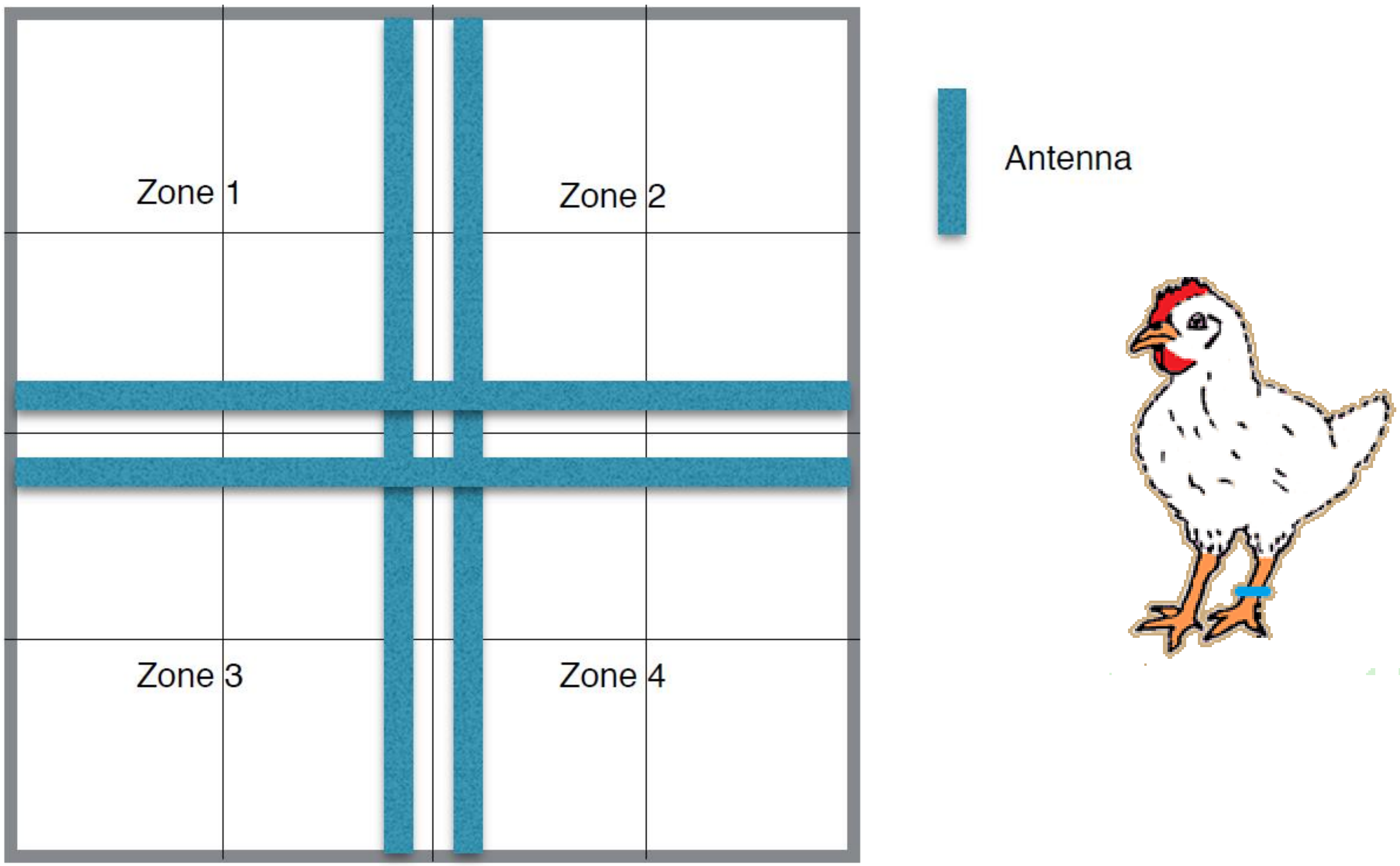
(Weis, 2007; Finkenzeller, 2010; Ruiz-Garcia & Lunadei, 2011; Brown-Brandl et al., 2017)

Passive HF RFID



Passive HF RFID – larger scale



Output

RFID system

Time	Animal ID	Antenna number
00:01	42	8
00:47	42	9
00:53	42	14
03:41	42	9

Video observation

- EthoVision
- The Observer XT

Other tracking methods

- UWB tracking

→ Assess agreement between the methods

Validation

- **Sensitivity** $= \frac{TP}{P}$
  - Likelihood that a present animal is detected

- **Specificity** $= \frac{TN}{N}$
  - Likelihood that a not present animal is not detected

TP = number of true positives (both video and tracking system find positives)
P = number of positives (video identifies positives)
TN = number of true negatives (both video and tracking system find negatives)
N = number of negatives (video identifies negatives)

(Maselyne et al., 2014)

Validation

Aim: 90%

- **Sensitivity** $= \frac{TP}{P} = \frac{9}{10}$
  - Likelihood that a present animal is detected

- **Specificity** $= \frac{TN}{N} = \frac{9}{10}$
  - Likelihood that a not present animal is not detected

TP = number of true positives (both video and tracking system find positives)
P = number of positives (video identifies positives)
TN = number of true negatives (both video and tracking system find negatives)
N = number of negatives (video identifies negatives)

(Maselyne et al., 2014)

Validation

- **Accuracy** $= \frac{TP+TN}{P+N}$
  - Likelihood that an animal's status is correctly identified by the system
- **Precision** $= \frac{TP}{TP+N-TN}$
  - Likelihood that a detected animal is actually present

TP = number of true positives (both video and tracking system find positives)
P = number of positives (video identifies positives)
TN = number of true negatives (both video and tracking system find negatives)
N = number of negatives (video identifies negatives)

(Maselyne et al., 2014)

Validation

- **Accuracy** $= \frac{TP+TN}{P+N} = \frac{9+9}{10+10} = \frac{18}{20}$ → **90%**
  - Likelihood that an animal's status is correctly identified by the system

- **Precision** $= \frac{TP}{TP+N-TN} = \frac{9}{9+10-9} = \frac{9}{10}$ → **90%**
  - Likelihood that a detected animal is actually present

TP = number of true positives (both video and tracking system find positives)
P = number of positives (video identifies positives)
TN = number of true negatives (both video and tracking system find negatives)
N = number of negatives (video identifies negatives)

(Maselyne et al., 2014)

Validation

- Desired values depend on the goal and traits to be measured
    - E.g. for early warning system

TP = number of true positives (both video and tracking system find positives)
P = number of positives (video identifies positives)
TN = number of true negatives (both video and tracking system find negatives)
N = number of negatives (video identifies negatives)

(Maselyne et al., 2014)

Topics: overview

- Activity differences between different genetic lines or treatments
  - E.g. High feather pecking vs Low feather pecking lines
  - Estimating genetic parameters for activity
  - ...
- Correlations between activity and gait score

Topic: Gait

- Lameness common in broilers and turkeys (Kestin et al., 1992; Martrenchar et al., 1999)
  - Problem for welfare (SCAHAW, 2000)
  - Affects performance and economic output (Weeks et al., 2002)
- Links between activity and gait in poultry (Aydin et al., 2013; Van Hertem et al., 2017)

Can we automatically score gait when GLA is monitored?

Topic: Gait

HF RFID tracking results

Manual gait scoring
(Garner et al., 2002)

→ *Study correlations*

Novel, automated method of gait scoring

+ Continuous measurements
+ Non-invasive

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Relevance

- Improved understanding of animals
- Health and welfare monitoring
  - Early identification of disease → prevent welfare impairments and save costs (Hammer et al., 2017)
- Precision phenotyping in breeding programmes

Breeding healthy animals that perform well in group housed systems

Discussion points

- What other sensors could we use?
    - Combinations of sensors?
- Proximity: social interactions
- Machine learning

Thank you

Project: Tracking and monitoring of individual animals kept in groups

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Funded by Breed4Food

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References

Aydin, A., Pluk, A., Leroy, T., Berckmans, D. & Bahr, C. (2013). Automatic identification of activity and spatial use of broiler chickens with different gait scores. *Transactions of the ASABE, 56*(3), 1123–1132. https://doi.org/10.13031/trans.56.9987

Brown-Brandl, T.M., Maselyne, J., Adrion, F., Kapun, A., Hessel, E.F., Saeys, W., Van Nuffel, A. and Gallmann, E. (2017) Comparing three different passive RFID systems for behaviour monitoring in grow-finish pigs. Berckmans, D. & Keita, A. (Eds) Precision Livestock Farming ’17. *Papers presented at the 8th European Conference on Precision Livestock Farming*.

Catarinucci, L., Colella, R., Mainetti, L., Patrono, L., Pieretti, S., Secco, A., & Sergi, I. (2014). An animal tracking system for behavior analysis using radio frequency identification. *Lab Animal, 43*(9), 321–327. https://doi.org/10.1038/laban.547

Dawkins, M. S., Cain, R., & Roberts, S. J. (2012). Optical flow, flock behaviour and chicken welfare. *Animal Behaviour, 84*(1), 219–223. https://doi.org/10.1016/j.anbehav.2012.04.036

Debouzy, J.-C. & Perrin, A. (2012). RFID. In: Perrin, A., & Souques, M. (Eds.). (2013). Electromagnetic Fields, Environment and Health. *Springer Science & Business Media*. Chapter 7, pp. 81-87.

Finkenzeller, K. (2010). RFID handbook: fundamentals and applications in contactless smart cards, radio frequency identification and near-field communication. *John Wiley & Sons*.

Garner, J. P., Falcone, C., Wakenell, P., Martin, M. & Mench, J. A. (2002). Reliability and validity of a modified gait scoring system and its use in assessing tibial dyschondroplasia in broilers. *British Poultry Science, 43*(3), 355–363. https://doi.org/10.1080/00071660120103620

Hammer, N., Pfeifer, M., Staiger, M., Adrion, F., Gallmann, E., & Jungbluth, T. (2017). Cost-benefit analysis of an UHF-RFID system for animal identification, simultaneous detection and hotspot monitoring of fattening pigs and dairy cows. *Landtechnik, 72*(3), 130–155. https://doi.org/10.15150/lt.2017.3160

Howerton, C. L., Garner, J. P., & Mench, J. A. (2012). A system utilizing radio frequency identification (RFID) technology to monitor individual rodent behavior in complex social settings. *Journal of Neuroscience Methods, 209*(1), 74–78. https://doi.org/10.1016/j.jneumeth.2012.06.001

Ilie-Zudor, E., Kemeny, Z., Egri, P., & Monostori, L. (2006). The RFID technology and its current applications. *Proceedings of the Modern Information Technology in the Innovation Processes of the Industrial Enterprises*, 29-36.

Kestin, S., Knowles, T., Tinch, A. & Gregory, N. (1992). Prevalence of leg weakness in broiler chickens and its relationship with genotype. *Veterinary Record, 131*(9), 190-194. https://doi.org/10.1136/vr.131.9.190

References

Kjaer, J. B. (2017). Divergent selection on home pen locomotor activity in a chicken model: Selection program, genetic parameters and direct response on activity and body weight. *PLoS ONE, 12*(8), 1–11. https://doi.org/10.1371/journal.pone.0182103

Martrenchar, A., Huonnic, D., Cotte, J. P., Boilletot, E. & Morisse, J. P. (1999). Influence of stocking density on behavioural, health and productivity traits of turkeys in large flocks. *British Poultry Science, 40*(3), 323–331. https://doi.org/10.1080/00071669987403

Maselyne, J., Saeys, W., De Ketelaere, B., Mertens, K., Vangeyte, J., Hessel, E. F., Millet, S. & Van Nuffel, A. (2014). Validation of a High Frequency Radio Frequency Identification (HF RFID) system for registering feeding patterns of growing-finishing pigs. *Computers and Electronics in Agriculture, 102*, 10-18.

Ruiz-Garcia, L. & Lunadei, L. (2011). The role of RFID in agriculture: Applications, limitations and challenges. *Computers and Electronics in Agriculture*, 79, 42-50.

Scientific Committee on Animal Health and Animal Welfare. (2000). The Welfare of chickens kept for meat production (broilers). European Union Commission, 1–149.

Van Hertem, T., Norton, T., Berckmans, D. & Vranken, E. (2017). The relation between impaired gait and automated monitoring of broiler flock activity levels. *Proceedings of the 7th International Conference on the Assessment of Animal Welfare at Farm and Group Level*, 7, pp. 114.

Weeks, C., Knowles, T., Gordon, R., Kerr, A., Peyton, S. & Tilbrook, N. (2002). New method for objectively assessing lameness in broiler chickens. *Veterinary Record, 151*(25), 762–764. https://doi.org/10.1136/vr.151.25.762

Weis, S. A. (2007). RFID (radio frequency identification): Principles and applications. *System, 2*(3).

Discussion points

- What (minimum) validation values should we adhere to?
- How to apply this in large groups?
  - What information can we still obtain?
  - How to implement this in commercial situations?