# PhenoLab: automatic recording of location, activity and proximity in group-housed laying hens

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## Abstract

With the transition to larger group housing systems in farm animals, it is becoming increasingly important to be able to automatically record the performance of individual animals housed in groups. This is especially important to record damaging behaviours, such as feather pecking in laying hens, or related traits. With traditional methods, such as live and video observations this is difficult and time consuming. Recent developments in sensor technology offer new possibilities for automatic tracking of behaviour of individuals. The aim of the PhenoLab project is to develop methods for automatic recording of location, activity and proximity in group-housed laying hens. Hundred thirty one laying hens from three feather pecking selection lines (high and low feather pecking (n = 45 and 41) and an unselected control line (n = 45)) were tracked using two different tracking systems: video-tracking using EthoVision and ultra-wideband tracking using TrackLab. Birds were tracked in three different situations: individually in a barren test-room (individual novel environment test), in a group in a barren test-room (group novel environment test) and in a group in a room offering four different functional areas (preference test). Preliminary results indicated that distance moved using TrackLab yielded up to 96% accuracy, when compared to video-tracking using EthoVision. For the group tests, ultra-wideband tracking seems the better option, as this method is better able to distinguish between individuals compared with video-tracking, as it relies on individual tags. Previously found line differences in activity, with the high feather pecking line showing higher activity levels than both other lines, were confirmed by the ultra-wideband tracking system. Furthermore, ultra-wideband tracking provides valuable information on the behaviour of specific individuals within a group, allowing us to investigate differences in activity patterns between feather peckers, victims and neutrals.

**Keywords**: Animal behaviour, Laying hen, Tracking, Ultra-wide band, Sensors, Activity

## Introduction

Since the European ban on battery cage housing for laying hens in 2012, the percentage of laying hens kept in non-cage systems is increasing in the EU. Also in the United States, the laying hen industry is changing from cage to non-cage systems, in response to societal pressures. On the one hand, the change to non-cage systems is positive for laying hen welfare, as hens have more space and can perform more natural behaviours in these systems. On the other hand, the large flock size in non-cage systems poses a risk for outbreaks of feather pecking and cannibalism (Rodenburg et al., 2005). Feather pecking (FP), the pecking and plucking feathers of conspecifics, occurs regularly in large flocks, and can cause feather damage and increased mortality rates (Lambton et al., 2010; Gilani et al., 2013; de Haas et al., 2014). Identifying individuals that perform FP, i.e. feather peckers, is extremely difficult in large groups and relies on traditional behavioural observations. It may be more realistic to identify feather peckers by measuring related characteristics, such as activity level (Kjaer, 2009), but even that may be difficult and time consuming using traditional observation methods. Recent developments in sensor technology offer new possibilities for automatic tracking of behaviour of individuals (Banerjee et al., 2014; Nakarmi et al., 2014; Rodenburg and Naguib, 2014; Zaninelli et al., 2016). To develop methodology for automatic tracking of individual laying hens, the PhenoLab project was initiated. The aim of the PhenoLab project was to develop methods for automatic recording of location, activity and proximity in group-housed laying hens. Ultra-wideband tracking using TrackLab and video-tracking using EthoVision were used to explore differences between three lines divergently selected on feather pecking (unselected control, high and low feather pecking lines) and between phenotypes within lines (feather peckers, neutrals and victims).

## Material and Methods

*Animals and housing*

Hundred thirty one adult laying hens from three feather pecking selection lines (high (HFP, n=45) and low feather pecking (LFP, n=41) and an unselected control line (control, n = 45)) were used for this experiment. They were kept in 2 $m^2$ floor pens in groups of maximum eight birds per pen, with ad libitum feed and water. These feather pecking lines have previously been found to differ in activity levels, with the high feather pecking line showing signs of hyperactivity (Kjaer, 2009). This difference in activity indicates that individuals with a

tendency to develop FP might be detected on the basis of their activity levels, potentially prior to the development of FP. Apart from the comparison of the three lines, we also assessed differences in activity of birds characterized as feather pecker, neutral or victim. Data here represents preliminary data of activity of birds based on one batch of 131 animals.

*Tracking in the PhenoLab test-room*

For testing, birds were transferred to the PhenoLab test-room and tracked using two different tracking systems: video-tracking using EthoVision (Noldus, Wageningen, The Netherlands) and ultra-wideband tracking using TrackLab (Noldus, Wageningen, The Netherlands). Birds were tracked in three different situations: individually in a barren test-room (individual novel environment test), in a group in a barren test-room (group novel environment test) and in a group in a room offering four different functional areas (preference test with 1) perches, 2) feed and water, 3) litter and 4) feathers). The ultra-wideband tracking system consists of active tags that are placed on the birds. The location of each bird is calculated based on triangulation between four beacons, based on time of arrival and angle of arrival of the signal. A test-room (Figure 1, left panel: 7*6m) at the research facility of the Wageningen University (The Netherlands) was equipped with four Ubisense beacons (Figure 1, middle panel). An active sending tag of Ubisense containing a 12V battery (3.5 * 3.5 cm, ± 29 grams) was used for tracking (Figure 1, right panel). Battery life was approximately five weeks when continuously active. Tags were placed in a backpack on an adult White Leghorn laying hen. Sampling rate was set to twice per second in Ubisense. During and after tracking TrackLab provided the following data, per sample point; x, y, z location, x-y distance (cm), x-y speed (m/s), acceleration (cm/$s^2$), x-y heading (degree), x-y turning angle (degree), and x-y angular velocity (degree/$s^2$). These data were further processed by TrackLab to provide a statistical overview per track. For validation of the ultra-wideband tracking method, we compared data of TrackLab with video-tracking using EthoVision (Noldus, Wageningen, The Netherlands). Data was collected on 24 hens which were tested individually for five minutes in a barren test-room and compared between systems, based on distance moved. Eight non-moving, eight highly moving and eight randomly chosen birds were selected.


Figure 1. Test-room at Wageningen University (left panel), TrackLab beacon (middle panel), Active sending tag (right panel).

*Three different behavioural tests*

First, an individual test was conducted in the barren test-room. Hens were placed in the middle of the test-room in darkness. This procedure was needed to assure that all hens started at the same position and tracking started directly after the light was switched on. TrackLab and EthoVision were linked to start exactly at the same time point by one command. For five minutes video and ultra-wide band tracking took place. Distance moved of the HFP, LFP and control lines were compared at an individual level. Second, a group test was performed in the barren test-room. Hens were taken per pen and placed in the middle of the test-room and individual hens were tracked using TrackLab for 15 minutes. Distance moved was compared at an individual level. Finally, hens were tested in a group test with four functional areas. Hens were taken per pen and placed in the middle of the test-room. This test was conducted in the morning and in the afternoon for all groups to assess and correct for potential time effects. The test-room was divided in four equal zones, with each zone offering a different feature 1) wood shavings, 2) feathers, 3) feed and water or 4) a perch). Time spent and distance moved in each zone was recorded using TrackLab. After exactly 3.5 hours programs were terminated. Time spent in different zones was compared between HFP, LFP and control lines.

## Results and discussion

*Individual ultra-wideband tracking vs. video-tracking*

Data on distance moved was initially not comparable between TrackLab and EthoVision due to a large overestimation of distance moved in TrackLab, caused by outliers and small detection errors when tags were not moving. Corrections were applied to the TrackLab data to exclude outliers by 1) outlier removal of data points having an acceleration over 10m/s$^2$, 2) maximum smoothing of 29 sample points and 3) virtually cutting of 125cm of each corner of the test-room (x and y), where fluctuations in tracking were recorded due to wall reflections. After correction, distance moved using TrackLab yielded up to 96% accuracy of

all 24 tracks, when compared to video-tracking using EthoVision. The same correction of TrackLab data was used when analysing the group tests.

*Differences in activity between lines and phenotypes*
Distance moved was compared for all three tests using the TrackLab data. Distance moved was higher for HFP than for LFP and control birds in the individual test (Figure 2, left panel). In the group tests, birds characterised as feather peckers had a higher distance moved in the group test than victims (Figure 2, right panel). The finding that birds from the HFP were more active is consistent with previous studies using the same lines (Kjaer, 2009; de Haas et al., 2010). Kjaer (2009) actually suggested that hyperactive birds are more at risk to develop feather pecking. Our data on the phenotypes support that idea, as also birds characterised as feather peckers were more active than victims.

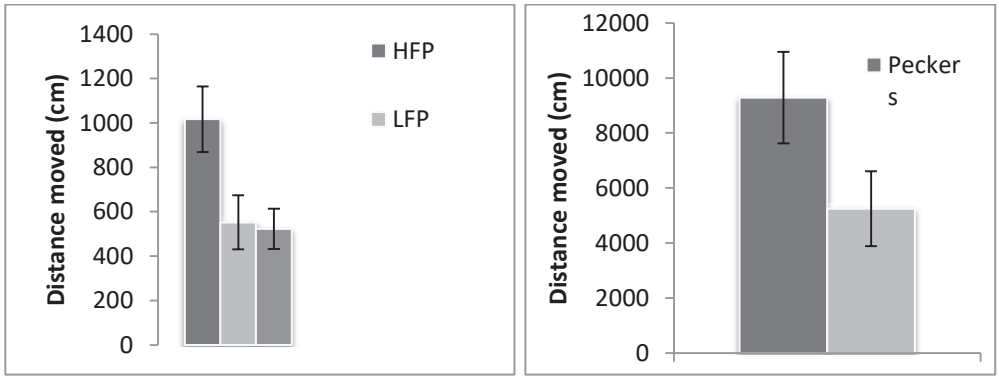


Figure 2. Distance moved in the individual test in birds from the HFP, LFP and control line (left panel) and the group test in the birds characterised as peckers or victims (right panel).

When the lines were compared regarding the use of the four different functional areas, we found that HFP birds spent more time in the foraging zone than LFP and CON birds (Figure 3). This result also corresponds with previous findings: when offered novel foraging opportunities in a foraging maze, HFP birds were faster to explore these opportunities and pecked more at the foraging materials offered (de Haas et al., 2010). This underlines the strong relationship between foraging behaviour and feather pecking. Contrary to our expectations, HFP birds did not spent much time in the feather zone. This could be because the loose back feathers offered may not have been attractive enough for feather pecking or feather eating (Harlander-Matauschek and Feise, 2009).

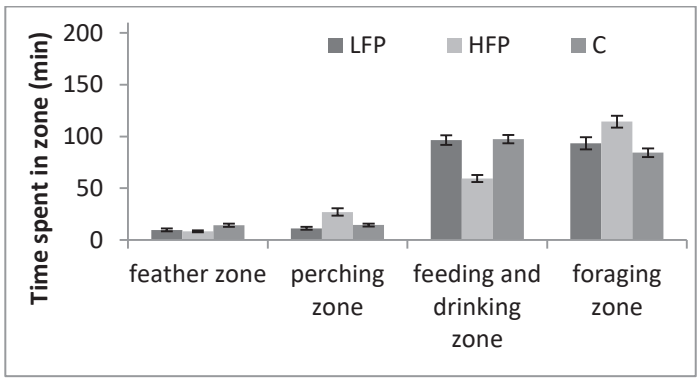


Figure 3. Time spent in the feather zone, perching zone, feeding and drinking zone and foraging zone for birds from the LFP, HFP and Control lines.

## Conclusions

The aim of the PhenoLab project was to develop methods for automatic recording of location, activity and proximity in group-housed laying hens. By comparing the ultra-wideband data collected with TrackLab to the video-tracking data collected with EthoVision, we were able to calibrate the TrackLab system and reach a 96% accuracy compared with the video track. The group tests show that the TrackLab system can be used to track individual laying hens in groups. We were able to confirm previously found line differences in activity and use of space between the HFP, LFP and control line. Moreover, using the TrackLab system we were able to analyse differences between individuals within the same group, allowing us to focus on space use of individual birds with different phenotypes. This revealed that, similar to the line differences, birds characterised as feather peckers were more active. Future work will focus on proximity analysis and combination with other sensing methods (RFID, video-tracking).

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