Eine objektive Methode, um die Auswirkungen von Brustbeinfrakturen zu verstehen und Lösungen zu erarbeiten, die ihr Auftreten und Schweregrad verringern (Project 2.15.05)

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Key words:
Laying hens, Keel bone damage, pain, animal welfare, productivity

Aim of the study
Keel (breast) bone fractures (KBF) in laying hens currently represent one of the greatest welfare problems to laying hen production systems. The conducted work sought to demonstrate the link between KBF and welfare (Objective A) and determine the role that locomotion plays in causing fractures (Objective B) while providing alternatives that can be built into aviary systems and reduce fractures sustainably. Objective A was conducted over two experiments, where production (Experiment A1) and mobility (Experiment A2) of hens with and without fractures was quantified. Objective B was pursued using hens trained to jump between a platform and perch at different positions.

Material and methods
For Experiments A1 and A2, the same rearing and laying arrangement was followed. At 18 WOA, hens were moved to 10 (Experiment A1) or 6 (Experiment A2) identical, side-by-side, pens in a layer barn on the same site. Each pen contained 225 hens of which 15 were of one hybrid (i.e., color) and served as focal hens. Beginning at 23 weeks of age, and then subsequently at 10 time points until 63 weeks of age, focal birds were collected and assessed for fracture by radiography on site. Additionally, in Experiment A1, focal birds were given a capsule containing fat soluble dye that was absorbed by the yolk of the developing oocytes allowing eggs laid by focal hens to be linked to that hen and her fracture status. In Experiment A2, individual mobility of hens were recorded using an infrared tracking system. Infrared emitters were installed on the vertical grid panels dividing the pens into five pre-defined zones: litter, lower tier, nest box tier, top tier, and wintergarden. Infrared receivers, mounted on the leg bands of focal hens, recorded the zone-specific signal sent out by the emitters with a frequency of 1 Hz along with date and time of each zone change. Collected mobility data was then related to the individual hen's fracture status.

Experiment B used 80 Nick Chick (white) and 80 Brown Nick (brown) hens reared in one pen of a barn with 600 hens (300 Nick Chick, 300 Brown Nick) and then transferred to an experimental barn and randomly assigned to eight identical pens (n = 20 birds per pen; 4 pens with Nick Chick and 4 pens with Brown Nick hens). From 20 weeks of age, focal hens (40 Brown Nick, 40 Nick Chick hens) were trained over a seven-week period for a custom jumping test using three variables of moving: direction (upward vs. downward), angle (flat: 30 ° for upward, 15 ° for downward jumps vs. steep: 60 ° for upward, 30 ° for downward jumps), and distance (50 cm vs. 100 cm). For jump tests, high resolution video recordings of behaviour before, during, and after were made as well as acceleration readings at the animal's keel.

Results and significance
Experiment A1 found individual egg laying performance was linked to an interaction of age and KBF severity ($p = 0.005$). For example, at 37 WOA, egg laying performance was similar irrespective of KBF severity (estimated means of performance: 95.5 % with severity 0.0 vs. performance of 96.2 % with severity 10.0). At later time points, increasing KBF severity was associated with a pronounced decrease in laying performance where extremely severe KBF associated with a decline in performance of 15.6 % over time (estimated means: 96.2 % at 37 WOA to 80.6 % at 61 WOA). Individual laying performance was also linked to an interaction of age and healing activity ($p = 0.02$). Immediately after peak of lay (37 WOA), hens with fresh KBF had a lower estimated laying performance than hens with healing or inactive KBF. Performance was similar irrespective of healing activity during mid-lay (45 to 49 WOA), though from approximately 57 WOA, hens with fresh or healing KBF showed a higher performance than hens with inactive KBF.

Experiment A2 found no effect of KBF severity or fracture gap on the total number of zones crossed per day in LB or LSL hens. In assessments of duration in particular zones, for LB hens, duration in the litter decreased with increasing KBF severity ($p < 0.0001$). Lohmann brown hens without fractures spent 276.1 min per day in the litter, whereas LB

hens with the highest KBF severity spent 66.3 min per day in this zone. A similar pattern emerged regarding the duration of stay in the lower tier ($p = 0.0011$) where less time was spent in this zone with increasing fracture severity (186.6 min per day in hens with the lowest KBF severity 0.0 to 83.1 the most severe KBF). Whereas the duration of stay in the litter and in the lower tier decreased with increasing KBF severity, the opposite pattern was observed regarding the duration of stay in the top tier. Hens without fractures spent 163.8 min per day on the top tier, whereas hens with the most severe fractures spent 372.4 min per day on the top tier ($p = 0.0005$).

Experiment B found hens had greater impact forces in steep, longer paths when moving downwards ($p < 0.05$). Hen also required greater a time duration to regain balance during these paths as well ($p < 0.05$)

Our results indicate that keel fractures have dramatic effects on hen productivity (A1) and mobility (A2) suggesting that the lesions are a source of compromised welfare. When the behaviour and biomechanical forces at the keel were assessed in controlled flights (B), we found that specific types of flights, characterized by steep angles over short distances, were more difficult to navigate. In conclusion, our data suggests keel fractures are an important consideration for welfare and movement pathways angles more than 45° should be avoided in aviary designs.

Publications, posters and presentations

Rufener, C., Stratmann, A., and M.J. Toscano. Perch positioning affects locomotion of laying hens and forces experienced at the keel bone. *In prep, submission expected Nov 2018.*

Rufener, C., Abreu, Y., Asher, L., Berezowski, J., Maxmiano Sousa, F., Stratmann, A., Würbel, H., and M.J. Toscano. Keel bone fractures are linked with individual mobility of laying hens housed in aviary systems. *Submitted to Applied Animal Behaviour Science*

Rentsch, A.K., Rufener, C.B., Spadavechia, C., Stratmann, A. and Toscano, M.J. Keel Bone Fractures affect laying hen behaviour in a non-cage system. *Submitted to Applied Animal Behaviour Science.*

Rufener, C., Stratmann, A., Würbel, H., Baur, S. and M.J. Toscano. Keel bone fractures affect egg laying performance but not egg quality in laying hens. *Accepted to Poultry Science*

Rufener, C.B., Berezowski, J., Maximiano Sousa, F., Abreu, Y., Asher, L. and Toscano, M.J. Finding hens in a haystack: Consistency of movement patterns within and across individual laying hens maintained in large groups. *Accepted to Scientific Reports.* 8(1): 12303. Available at: https://www.nature.com/articles/s41598-018-29962-x.pdf

Rufener, C. Baur, S., Stratmann, A., and M.J. Toscano. A Reliable Method to Assess Keel Bone Fractures in Laying Hens From Radiographs Using a Tagged Visual Analogue Scale. Frontiers in Veterinary Science 5:124. doi: 10.3389/fvets.2018.00124. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5999807/

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***Project** 2.15.05*

***Project duration** June 2015 – August 2018*