**IGN-Research Award 2021**

**Dr. Beryl Eusemann**

„*The influence of egg production, genetic background, age, an housing system on keel bone damage in laying hens* “

Friedrich-Loeffler-Institut in Celle
and
Freie Universität Berlin
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**Summary**

Keel bone damage (KBD) is one of the most severe animal welfare problems in the egg production industry. The term comprises fractures and deviations of the keel bone, i.e., the prominent ventral part of the sternum in birds. The prevalence of KBD is extremely high: Fractures have been found in up to 97 % and deviations in up to 83 % of laying hens within one flock, respectively. Especially keel bone fractures are likely to cause pain and impair the welfare of affected hens.

While KBD is widely defined as a multifactorial disorder, its etiology is not yet fully understood. The aim of my thesis was to get a better insight into the etiology of KBD. For this purpose, I conducted three different studies together with my colleagues at the FLI in Celle. On the one hand, we established new methods and, on the other hand, we investigated the influence of the endogenous factors egg production, genetics, age, and estradiol-17ß as well as the exogenous factor housing system on the development of KBD.

In the first study, we developed an X-ray method that allows for a longitudinal examination of keel bone fractures and deviations as well as a reliable differentiation of these two symptoms. A particularly new feature of our X-ray image analysis is the objective determination of the severity of deviations. To that aim, the deviated area in the X-ray image is measured and put in relation to the total area of the keel bone. Since this method gives a value for the severity of a deviation that is independent of keel bone size, it is particularly suitable for longitudinal studies and for comparing deviations between different layer lines and age groups.

Furthermore, we investigated the role of genetics, housing system, and age in the etiology of KBD in this study. Five layer lines and two housing systems were compared. The layer lines differed in their phylogenetic background (brown and white layer lines) as well as in their laying performance (high performance: about 320 eggs / year, low performance: about 200

eggs / year). Half of the hens of each layer line were kept in floor housing and the other half in single cages. The keel bone of all animals was regularly radiographed. The two brown layer lines showed more keel bone fractures compared to the three white layer lines while deviations tended to be more severe in the white layer lines. Within the brown layer lines, the high performing line showed more fractures and deviations compared to the low performing line. The prevalence of fractures was higher in floor housing, while within some layer lines, deviations were more severe in cages. Fracture prevalence increased with age of the hens.
The aim of the second study was to develop an animal model with nonegg laying hens which allows for a detailed investigation of the influence of egg production on KBD. To that aim, an implant with the gonadotropin-releasing hormone (GnRH) agonist deslorelin acetate was subcutaneously administered to ten hens shortly after and to ten hens before the onset of lay. In addition, ten hens were kept as control hens for each of the two groups (after / before onset of lay). The implant inhibited egg laying activity in all hens that were treated after the onset of lay and protracted the onset of lay in all hens that were treated before. All hens of this study were also radiographed twice. Egg laying control hens showed significantly more keel bone fractures and more severe keel bone deviations compared to non-egg laying hens within the group that was treated after the onset of lay. In addition, both fracture prevalence and the proportion of deviated area increased with age. As an incidental finding, foot pad dermatitis occurred significantly more frequently in egg laying compared to non-egg laying hens.
The results of the first two studies were used for the third study in which we investigated the role of genetics, egg production, and the gonadal steroid estradiol-17β in the etiology of KBD. Egg production was suppressed in half of the hens each of a high performing and a low performing layer line by administration of a deslorelin acetate implant. In addition, some of the egg laying as well as the non-egg laying hens received an implant with estradiol-17ß. Again, the animals were radiographed at regular intervals. In addition, the X-ray method was extended to assess radiographic density using an aluminum stepwedge for calibration. The risk of keel bone fracture was more than 80 % lower in non-egg laying compared to egg laying hens, while no clear effect of egg production on deviations was found. Radiographic density of the keel bone was higher in non-egg laying compared to egg laying hens at the end of the experimental period. Administration of exogenous estradiol resulted in a moderately increased risk of fracture within egg laying hens, whereas it resulted in a slightly lower risk in non-egg laying hens. The high performing layer line showed a higher risk of fracture than the low performing layer line, while the layer lines did not differ with respect to deviations.
Taken together, we were able to successfully establish both a method to assess keel bone fractures, deviations, and radiographic density in longitudinal studies as well as an animal

model for investigating the relationship between egg production or the early onset of lay and various diseases in laying hens. Furthermore, we found different risk factors for keel bone fractures and deviations indicating that these are two different and independent phenomena and that it is very important to clearly differentiate between them. Both external and internal factors have been found to contribute to the etiology of keel bone fractures and deviations. Part of the keel bone fractures seem to be caused by collisions with housing equipment. However, the very large difference in risk of keel bone fracture and in radiographic density between egg laying and non-egg laying hens clearly indicates that there is a fundamental weakness of the keel bone in laying hens caused by egg production which makes it very susceptible to fractures. Findings between the high and low performing layer lines support this assumption. Thus, breeding is of decisive importance in the prevention of KBD and must give much more im-portance to bone health.

**Take Home Message**

Keel bone fractures and deviations belong to the most severe animal welfare problems in laying hens. In our studies, we were able to show a strong relationship between egg production and keel bone fractures. Furthermore, selection for high laying performance also seems to favor the occurrence of keel bone damage. These results indicate that there is a fundamental weakness of the keel bone in laying hens caused by egg production and high laying performance. The higher radiographic density in non-egg laying compared to egg laying hens supports this assumption. In addition, the phylogenetic background had an influence on keel bone damage, too. My thesis clearly shows that breeding plays a major role in the prevention of keel bone damage. It must give much more importance to bone health in order to counteract this severe animal welfare problem.

**Vita**

Since 2021: Scientist & Animal Welfare Officer
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2020 – 2021: Scientist & Animal Welfare Officer
Freie Universität Berlin, Department of Veterinary Medicine, Institute of Animal Welfare, Animal Behavior and Laboratory Animal Science

2015 – 2018: Doctoral candidate
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**Sources**

Dissertation: https://refubium.fu-berlin.de/handle/fub188/28838
Studie 1: DOI: 10.1371/journal.pone.0194974
Studie 2: DOI: 10.3389/fphys.2018.01846
Studie 3: DOI: 10.3389/fvets.2020.00081