



# Poultry Extension Collaborative newsletter

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



## Keel Bone Fractures in Laying Hens

This newsletter provides an overview of the anatomy of the keel bone, risk factors and welfare implications associated with keel fractures, how to assess keel bone integrity, and management strategies to mitigate keel fractures in laying hens.

### Keel Bone Fractures

- Can cause pain
- Can restrict mobility
- Can affect egg production and quality

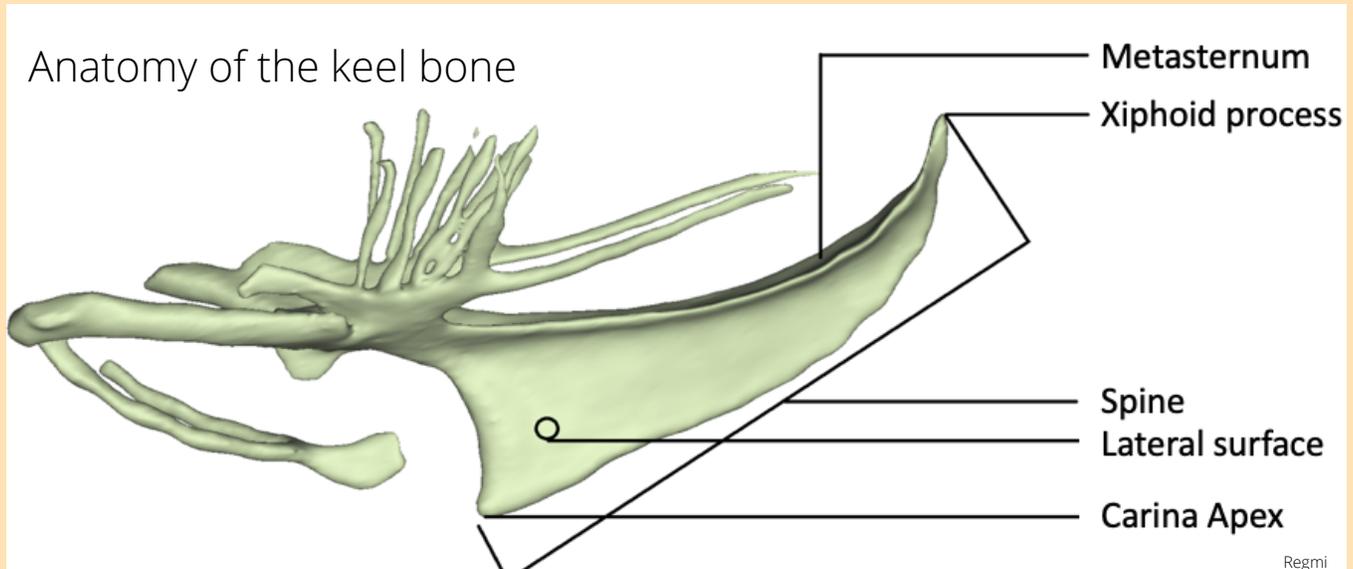
Keel bone fractures and resulting deformations constitute the most pressing challenge for laying hens at present. The extent of the welfare repercussions to hens with fractures can include pain, restriction of mobility and changes in bone mineral dynamics.

Even though the documentation of keel bone deformations and fractures date back to the 1930s, the issue has re-emerged with the change in housing system for laying hens from conventional cages to cage-free systems in recent years. While the rate and severity differ among housing types, keel fractures are prevalent across the majority of housing systems and genetic lines (see figure above for type and severity of keel fractures). Collision with perching structures, slow ossification of the keel compared to other bones, age and stage of production have been identified as major risk factors that could contribute to keel damage.

Understanding the risk factors and employing proper methods of keel bone assessment are imperative to develop robust intervention strategies to tackle these issues.

## What is a keel bone?

The keel extends from the breastbone (sternum) and runs along the midline in head to tail direction. The bone is situated toward the lower surface of the body, provides attachment to major and minor breast muscles and aids in the movement of wings in birds. The anatomical location of the keel bone and a comparative lack of breast muscle mass in laying hens makes the keel a very exposed bone.



## Risk Factors Associated with Keel Fractures

Factors such as housing system, genetics, the position of aerial perches, age, stage of production, and perch material have been associated with keel bone fractures.

**🏠 Housing** - Keel fractures have been observed in both cage and cage-free systems, however, the prevalence can be higher in the latter.

- On average, fracture prevalences of 25-40% have been reported in cages whereas prevalence rate of 60-80% have been observed in cage-free systems.
- Failed landings and subsequent collisions with the structures in cage-free systems could result in keel fractures.
- In conventional cages, birds are more likely to develop osteoporosis which could make the keel vulnerable to fracture even with low impact activity.
- Other risk factors within the housing system include design and placement of perches, space between adjacent rows in the aviaries, and flooring material.



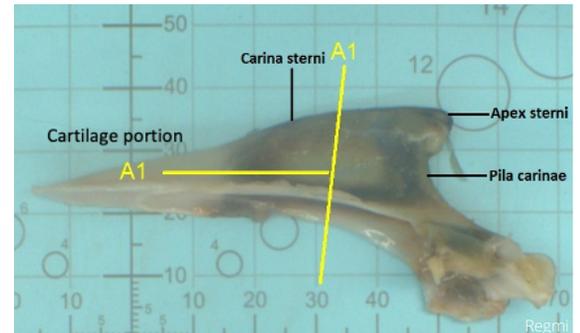
Aerial perches and ramp in an aviary house

 **Genetics** - Modern brown and white genetic lines as well as heritage breeds are known to get keel fractures. Line differences in fracture prevalence are often observed in research studies and could be related to the differences in body mass and bird behavior. For example, brown hens were observed to be less flighty and tend to stay more in the lower sections of the aviary systems whereas white hens preferred to stay in the upper sections.



Heritage and modern layers

 **Age and Stage of Production** - Keel fractures are rarely observed before the onset of egg-laying regardless of housing system and genetic lines. Prevalence rate increases with age and plateaus at around 50 weeks. At this point, the keel bone is mature and egg production has passed its peak. Completion of keel bone mineralization occurs at a slower rate compared to other bones in a chicken. At onset of lay, 8-18% of the total keel length is still cartilaginous; however, the majority of the absorbed calcium from their diet is dedicated towards eggshell formation. Therefore, the immature keel is more vulnerable to fractures than other bones are.



Immature keel bone with cartilaginous and bony areas

## Assessing Keel Fractures

Different methods of keel bone assessment have been used that range from low-cost methods such as palpation and visual assessment to more expensive methods like radiography and ultrasonography.

**Palpation and visual inspection** - Palpation is conducted by running two fingers along the ventral spine of the keel and feeling for bends, indentations, sharp points, and mineral deposits.

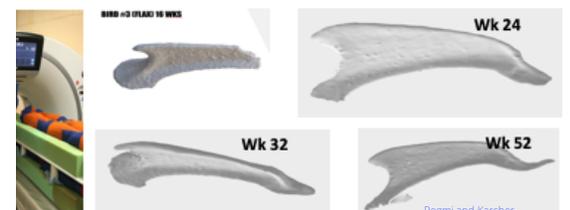
- Palpation is widely used for on-farm [welfare assessments](#).
- Palpation is subjective and can result in error if the assessor is not trained properly.

Visual inspection of excised keels is an objective tool for fracture assessment. However, care should be taken to avoid fractures caused by euthanasia or by post-mortem removal of the keels.

**Radiography** - Computed tomography (CT) and x-ray scans have been used to assess keel bones in research settings. Imaging tools such as radiography and ultrasonography enable better insights into the nature, severity, and location of the fractures. Additionally, bone density and geometry parameters from CT and x-ray can provide information on causes for keel fractures.



Palpation of keel bone for fracture assessment



CT scan of birds to assess keel bone at various ages

## Tips to Reduce Keel Fracture Incidences



Provision of perches and ramps for training

### Optimizing housing design to reduce risks

- Introducing ramps between different tiers in cage-free and aviary systems
- Adjusting perch material and height
  - Wood and rubber perches were found to reduce fracture incidences compared to metal perches.
- Providing perches and ramps during rearing can help to train the birds to navigate the housing system properly

### Nutrition and Management

- Mineral and vitamin supplementation (Calcium, Phosphorus, Vitamin D3)
- Omega-3 fatty acids supplementation
  - Studies have shown omega fatty acids such as fish oil and flax seed can reduce the fracture prevalence
- Bringing hens into lay at a later age may improve some aspects of bone and skeletal health, potentially reducing the risk of keel fractures and deformities.

## Additional Resources

Casey-Trott et al., (2015). Methods for assessment of keel bone damage in poultry. *Poultry Science*. 94: 2339-2350.

Regmi et al., (2016). Comparisons of bone properties and keel deformities between strains and housing systems in end-of-lay hens. *Poultry Science*. 95:2225-2234.

Riber et al., (2018). The influence of keel bone damage on welfare of laying hens. *Frontier in Veterinary Science*. 5:6.

Rufener and Makagon (2020). Keel bone fractures in laying hens: a systematic review of prevalence of age, housing systems, and strains. *Journal of Animal Science*. 98:S36-S51.

Thøfner et al., (2020). Pathological Characterization of keel bone fractures in laying hens does not support external trauma as the underlying cause. *PLoS ONE*. 15:e0229735.