From Structure to Welfare: Understanding Muscle Function in Living Animals

Every animal movement, from standing and walking to working, grazing, or producing food, depends on muscle function. Muscles are not only engines that generate force; they are biological structures shaped by evolution to meet the demands of specific environments. From a biomechanical perspective, muscles exemplify the fundamental biological principle of structure and function: anatomical design constrains movement possibilities, whereas functional demands shape how muscles adapt over time. Therefore, understanding muscle function provides a powerful way to connect fundamental biology with questions of animal health, performance, productivity, and welfare.

In living animals, movement is never the result of muscle activation alone. Muscle function emerges from the integration of multiple physiological systems that interact with the environment. An animal's movement depends on its coordination, adaptability, and individual capacity. Subtle changes in muscle activation and movement patterns can signal ageing, fatigue, training effects, or early functional problems, often long before obvious clinical signs appear. Studying muscle function *in vivo* allows us to better understand how animals respond to physical challenges in production systems, sports, and managed environments.

One of the major challenges in animal science is bridging the gap between the detailed laboratory knowledge of musculoskeletal function and how animals actually move and behave in complex, real-world settings. Recent advances in non-invasive biomechanical and physiological monitoring have made it possible to observe muscle function during natural locomotion and everyday activities. These developments are also central to precision livestock farming, where objective measurements of movement and muscle-related function can support the early detection of health problems, provide insight into functional capacity and comfort, and contribute to animal-centered management that promotes health, welfare, and overall well-being in production systems.

In this lecture, I will explore muscle function as a unifying biological concept that connects structure, physiology, animal production and welfare. Using examples from studies on living animals, I will demonstrate how biomechanical principles and monitoring technologies can be combined to understand functional capacity, adaptation, and resilience. I will also look ahead at how such integrative approaches can support precision livestock farming and help animals cope with increasing environmental variability, changing workloads, and a changing climate, contributing to sustainable, health-promoting, and welfare-oriented animal systems in the future.