

## Editorial

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## Feed Efficiency: A Key Production Trait and A Global Challenge

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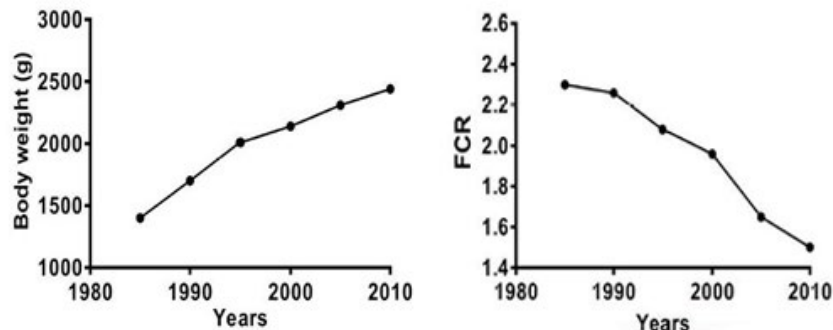
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Animal agriculture is facing substantial challenges from a steep projected increase in global demand for high quality animal protein and the need to adapt to higher temperature due to climate change. Indeed, with predictions that the world human population will increase to between 9 and 10 billion, United Nations Food and Agriculture Organization (FAO) estimates that by 2050 there will be increased demand for meat and egg protein by 73% and dairy products by 58% over 2011 levels.<sup>1</sup> Meeting the expected growth in global demand for high quality animal protein will be very strenuous, especially under environmental temperature constraints due to climate change and increased feed cost.

Large, abrupt, and widespread extreme heat waves have occurred repeatedly in the past<sup>2</sup> and resulted in estimated total annual economic loss to the US livestock production industry of \$1.69 to 2.36 billion.<sup>3</sup> More intense and frequent heat waves are predicted to increase for the next century.<sup>4</sup> Thus, there is a critical need for extensive applied and basic research efforts to improve animal adaptability and tolerance to high ambient temperature and to maximize their productivity. Our research is devoted, using top-down/bottom-up approaches and multidisciplinary area ranging from integrative physiology and genetics to molecular and cellular biology, to understanding the molecular mechanisms that regulate energy homeostasis and feed efficiency in avian species as well as the basis of their response to environmental stress.

Although it is moderately heritable, Feed Efficiency (FE) that defines the animal's ability to convert feed into body weight, is a trait of vital importance for maintaining sustainable agriculture. Two parameters are widely used to assess FE in chickens and in livestock: 1) Feed Conversion Ratio (FCR) that is defined as the amount of feed consumed per unit of weight gain<sup>5</sup> and 2) Residual feed consumption or intake (RFC or RFI) which is the variation between animal's actual and expected feed intake based on the estimated requirement for maintenance and growth/production.<sup>6</sup> Genetic selection based on these parameters has made spectacular progress in meat production traits. For instance, as seen in Figure 1, under optimal husbandry conditions, body weight and breast yield have dramatically increased however FCR decreased. The selection methods however have been applied without knowledge of the fundamental molecular mechanism changes that might be induced by the selection. Associated with these successes (increased muscle yield and high growth rate) there have been a number of undesirable changes in modern chickens such as muscle disorders (muscle myopathy, white striping), heart failure syndrome, ascites, lameness and fat deposition. Thus, a deep molecular and mechanistic understanding of traits of breeding interest may help to avoid the above mentioned unfavourable consequences.

Our group has developed several avian (chicken and quail) genetic populations designed to attack specific (patho) physiological and environmental challenges facing the modern poultry industry. As the regulation of energy homeostasis (energy intake and expenditure) and the stress response are coupled physiological processes,<sup>8</sup> we have unique experimental models including quails that were divergently selected for high or low feed efficiency and for sensitivity or resistance to stress.<sup>9</sup> As the hypothalamus, which contains the satiety and hunger centers, plays a crucial role in the regulation of body energy balance,<sup>10</sup> we determined the feeding-



**Figure 1:** Time trends increase of economically important broiler traits (body weight, FCR, and breast yield). The graph is presented based on the data published by Siegel PB.<sup>7</sup>

related hypothalamic neuropeptide profile in two chicken lines divergently selected for low ( $R^-$ ) or high residual feed consumption ( $R^+$ ). For the same body weight and egg production, the  $R^+$  chickens consume 40% more feed than their counterparts  $R^-$  lines.<sup>11</sup> We identified several feeding-related hypothalamic key genes that are differentially expressed between the two lines that might explain the difference in feed intake.<sup>12</sup> We also identified avian mitochondrial uncoupling protein and found that it was highly expressed in the muscle of  $R^+$  compared to  $R^-$  chicken suggesting that the  $R^+$  chickens dissipate energy as heat and they are thereby inefficient.<sup>13</sup> Our previous studies have also revealed a link between mitochondrial bioenergetics and dynamics and FE in broiler chickens. Low FE birds exhibited lower mitochondrial electron transport chain coupling and higher hydrogen peroxide compared to high FE counterparts.<sup>14</sup> Interestingly, we recently found that the orexigenic peptide, orexin, was highly expressed in chicken muscle and orexin treatment altered mitochondrial biogenesis, bioenergetics and dynamics (fission and fusion) in avian muscle cells,<sup>15</sup> however the role of orexin in high and low feed efficiency warrants further studies.

With the new cutting edge techniques involving genomics, proteomics, transcriptomics, mobilomics, microbiomics and metabolomics we will have the potential to identify molecular signatures for feed efficiency and to solve the intervening puzzle between nutrients, genes, environment and performances. A personalized nutrition approach based on identification, selection and optimization of nutrients fine-tuned with animal genetic profiles and animal's capability to withstand environmental stress will improve performances, health and wellness.

## CONFLICTS OF INTEREST

The authors have declared that no conflicts of interest exist.

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