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Stress in poultry: focus on turkeys causes, mechanism, consequences, diagnostics and prevention

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In the modern poultry industry we often encounter situations, when even insignificant changes in the management lead to a major declination from the expected performance, to disease, mortality and naturally– economic losses. This can be partially explained by the tremendous progress achieved in genetics, nutrition, management and disease prevention fields. As a result during a few last decades the slaughter age of broilers, for instance, has been reduced by half, leading to a situation when literally every hour of the flock's presence in the barn can have a tangible impact on the final results. The consequences can vary from minor (fluctuations of the DWG and FCR) to substantial, accompanied by impairment of the flock's veterinary status, increased culling, mortality, meat quality, carcass condemnation and final product grading losses. Unfortunately some farms have such a broad performance variation, which makes it difficult applying any standards to describe the average situation, that it is almost impossible to differentiate which existing or new factors give the major negative input. Others, in case of minor performance decline immediately start looking for new pathogens, which should be isolated, classified and taken under control by extra vaccinations or medication.

We should always remember that most common "potential pathogens" (*E. Coli, Enterococci, Clostridia, Ornitobacterium, Salmonella, Pasteurella, Bordetella, Proteus, Mycoplasma,* etc.) are not necessarily introduced to the farms from outside, but naturally inhabit different niches of the bird's organism, especially on multi-age farms. The problem starts when the balance between the host's defense systems and the microflora is disturbed: bacteria easily proliferate and get access to other non-specific niches, aggravating the problem with secondary infections. Different stressors: overcrowding, starvation, thirst, heat/cold, nutritional disbalance, harsh management, highly virulent viruses and bacteria, protozoa and toxins can serve as "entry openers" through the two major routes (respiratory and intestinal) for such "conditionally pathogenic" microorganisms. If the farmer is careful enough to observe the first signals of a problem, behavioral changes or subtle clinical signs, the situation can be easily reversed via management improvements and the flock –brought back to the track. When the balance is recovered - microflora returns to its primary population size and "niches".

Understanding this simple principle pushes progressive farmers to the necessity of expanding their knowledge about poultry physiology and behavior in relation to the modern management and disease prevention programs. Unfortunately it's widely believed that good or even exemplary results can be achieved only by using modern, sophisticated equipment with fully automated production control. But the reality is often different: the performance in primitive but well managed barns with careful personnel can even overcome the genetic potential of the breeds, whereas many modern, recently built farms demonstrate average to low results.

Why does it happen?- Although good equipment can indeed seriously simplify the work, but the most important daily decisions must always be made by a person, who understands the needs and continuously monitors the status of his flocks. The impact of the environmental factors on the behavior, feed consumption and digestion, growth rate and health of the birds should never be underestimated. In fact we are talking about bird's ecology with its numerous parameters. Everything what poultry contacts with - is its ecology, which directly or indirectly interacts with the flock, causing neutral, positive (stimulating), or negative (distressing) effect. Factors, causing stress in the flock are those "irritants" (stressors) whose impact is above the physiologic adaptability level of the bird's organism. "Stress" term is very popular in many areas of modern medicine and biology. But many poultry keepers do not completely understand the complexity of this process, its etiology, mechanism, manifestations and possible consequences for the poultry, thus, making it difficult to prevent them at an early stage.

Originally the "theory of stress" was formulated in 1936 in Canada by HansSelye (Austrian-Hungarian endocrinologist) and was described as a "General Adaptation syndrome" (GAS). In trials on mice he discovered that any irritating substance ("noxious agents") produced the same symptoms: swelling of the adrenal cortex, atrophy of the thymus, gastric and duodenal ulcers. This, paired with his observation that people with different diseases exhibit similar symptoms, allowed him to develop the theory, where stress is a major cause of disease, due to the fact that chronic stress causes long-term chemical changes involving all metabolic processes. Thus the "triad of Selye" was introduced: any stress reaction develops into 3 stages: alarm, resistance (adaptation, eustress) and exhaustion (distress). Selye's discovery gave a strong impetus to the stress research also in animals and poultry.

Selye distinguished between 2 types of stress: Eustress and Distress. Eustress is an integral part of any living organism's routine adaptation/learning process – achieved under the influence of external/internal factors within the adaptability range of a healthy animal. We successfully use the effect of eustress by vaccinating the birds or heat treating day old chicks for later heat stress resistance increase. On the

contrary, distress–is the pathologic process initiated by an excessive impact of a strong or long lasting irritant, leading to the vicious cycle of hormonal/metabolic changes which the animal eventually is unable to cope with.Every stress reaction is controlled by neuro-endocrine regulatory system which reacts to the stressors by neural (behavior, reflexes) or a more complex hormonal response. Corticosterone is the main hormone associated with stress in poultry. Its concentration in plasma rises under some physiological (egg laying, sexual maturation, flock hierarchy, etc.) and all stressful conditions. Changes in corticosterone level have secondary effects on other hormonal systems, such as the conversion of noradrenaline into adrenaline or the production of thyroid hormones. Elevated corticosterone levels in response to a severe/chronic stress, irrespective to its nature, transform major metabolic processes of the organism into catabolic route with an irreversible effect, ending up with severe consequences: carbohydrates, proteins and lipids break down, growth retardation, immunosuppression and increase of secondary bacterial infection via intestinal (due to reduction of mucus production by goblet cells, damage to the villi, enterocytes, MALT/GALT elements, and tight junctions functionality) and/or respiratory tract.

Genetic predisposition to stress and resistance inheritability differs for birds of meat and layer type and also correlates between different breeds of chickens and turkeys. Turkeys are exceptionally stress-susceptible. Some stressors, which initiate just an alarm/adaptation reaction in chickens, can be acutely lethal for turkeys. Some of the most common causes of stress in poultry can be summarized as shown in Table 1.

From our experience the most frequently and severely affecting stressors for poultry are numerous microclimate related factors, followed by management and nutritional issues. The physiological indicators of stress in poultry are:

a. Different behavioral changes–depending on the type and the strength/duration of the stress
b. Decreased voluntary feed intake (anorexia)
c. Increased/decreased body temperature (depending on the ambient temperature and the age of the bird)
d. Decreased growth and increased muscle degradation
e. Excessive fat deposition in the abdomen (abdominal fat pad)
f. Degradation of meat quality (PSE) at slaughter
g. Drop in laying percentage, egg size and shell quality reduction, increases broody females number, molt
h. Decreased semen quality or stop of semen production in males
i. Impaired growth of cartilage and bone (osteoporosis)
j. Pulmonary hypertension in cold stress/hypoxia and
k. Ascites, heart attack/SDS in high producing broilers, round heart disease in turkeys
l. Increased secondary systemic infections (mostly colisepticemia)
m. Leaky gut and ulcerative enteritis due to the reduction of villus height, number, surface of villi, reduced mucosa production by the Goblet cells
n. Dysbacteriosis and intestinal dysfunction due to the increased gut permeability
o. Atrophy of the thymus, spleen and bursa of Fabricius in young birds
p. Enlargement of the anterior pituitary and adrenal gland
q. Increased levels of plasma corticosterone, leptin and glucagon
r. Changes in the level of plasma metabolites leading to: hyperglycemia, hyperlipidemia, hypercalcemia (e.g. elevated levels of glucose, triglycerides and unsaturated fatty acids, calcium and lactate)
s. Manifold Increased plasma creatine kinase activity – as a result of the direct effect of corticosterone on muscle cell membrane integrity, leading to their break down, and uric acid concentration increase
t. Release of acute-phase proteins-cytokines (monokynes and lymphokynes),specific heat/cold shock proteins
u. Increased adrenaline/epinephrine content in egg yolk of hens
v. Immunosuppression due to the changes in the numbers of circulating leucocytes profile (increase of heterophil/lymphocyte ratio and changes in basophil and eosinophil numbers)
w. Decrease of leucocytes migration activity (LMA)

Stress diagnostics approaches must combine both clinical and postmortem flock/individual birds examination combined with analysis of subclinical metabolic changes expressed in increase/decrease of specific acute phase proteins (C-reactive protein, Alpha-1-acid glycoprotein etc), hormonal shift (corticosterone) and hematological changes (erythrocyte sedimentation rate (ESR), leucogramma, H/L ratio, LMA). The latter proved to be the easiest.

Having said that we must remember that stress is an important part of a living organism's life. Eustress is a necessary element of biological adaptation. But we should carefully control to foreseen and prevent the point when it changes into the stage of distress. Over all, poultry, and particularly turkeys, are continuously under different stressful influences, which sometimes start even before the flock entered the bard (overheating, dehydration during late embryonic development of in the hatcher/transportation). Stresses obviously serve as a starting point for any malfunction in the multiple systems/organs of the bird's organism. Strong or chronic stresses lead to loss of natural resistance, performance, final product quality and even death.

That means that in order to achieve and maintain high economic returns we, as veterinarians or poultry farmers, in addition to searching for new pathogens, vaccines and antibiotics, applying nutritional and management solutions, must reassess the importance of learning, understanding and preventing stress-related conditions in our flocks through better knowledge of the biology, behavior and the natural needs of our "patients"– to allow them staying within the "comfort zone" throughout the whole production cycle.

"Let us remember that it's not the microbe, the poison or the allergen, but our reactions to these agents, that we experience as disease" (Hans Selye, Stress and Disease. Science. November, 1955)

"What doesn't kill - makes me stronger"

Friedrich Wilhelm Nietzsche

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Table 1 Most common causes of stress in poultry

Type of stress	Stress-factors
Climatic	Extreme heat and cold, High humidity
Environmental	Poor brooding conditions by bright/low light, noise, wet litter, inadequate ventilation, high air speed, deterioration of the air quality (high levels of CO/CO2, NH3); type of housing (cages, free range)
Nutritional	Dramatic diet composition change, variation in nutrient content, long or uneven feed distribution, sex separate feeding, starvation, poor pellet/dusty feed, dehydration, ant-nutritional factors (glucans, xylans, galactomannans, tannins, gizzerosine, putrescene etc), fat oxidation, fungal/microbial toxins, toxic/untasty medications
Physiological	Rapid growth/strict nutrients demand, sexual maturity and onset of egg production/ drastic stimulation with feed and light, start of mating
Physical	Pain, damage from catching, immobilization, weighing, grading, debeaking, vaccination, transport
Social	High stocking density, limited feeding/drinking space, as-hatched growing, poor uniformity, pecking order
Psychological	By fear, poor husbandry/harsh caretakers
Pathological	Contaminated premises by built-up litter, early exposure to various infectious agents, clinical/sub-clinical infections due to poor bio-security and sanitation, vaccination/excessive activation of the immune system resulting in an immunological stress, post-vaccinal reactions (reduced feed intake/fever)

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Conflict of interest

Author declares that there is no conflict of interest.

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