

## ***The Development of the Immune System in Foals (Equus Caballus)***

*Passive immunity, the microbial colonization of the digestive tract  
and factors affecting this development*



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A neonate foal (*Equus caballus*) is equipped with a complete functioning innate, first line of defense immune system (for example the skin and mucous barrier, phagocytic cells and a complement system). Also immature lymphocytes of the specific immune system are already present.

### **Passive transferred immunity**

Due to the complex built up of the placenta (epitheliochorial) of the mare a foal does not receive maternal immunoglobulins, thus specific immunity, from the mare during gestation. This makes the neonates system so called “agammaglobulinemic“, until the point when the foal starts ingesting the maternal colostrum. The foals’ immune system until it ingested colostrum is called naïve, since it does not contain maternally transferred memory of encountered pathogens. The maternal colostrum is known to be very rich in immunoglobulins (the mare transfers all immunoglobulins: IgG, IgA, IgM and IgE to the foal, but especially IgG is found in very high concentrations in the maternal colostrum) (Wagner et al., 2006). This makes it incredibly necessary for the foal to drink the colostrum and acquire passive adaptive immunity as quick as possible. The process of acquiring maternal specific immunity is also called passive transfer of immunity. During the first hours of a new born foal the gut is so called still “open”, this means that the microbial colonization did not take place yet and the uptake of nutrients and also immunoglobulins takes place in a poorly defined pinocytotic process. Already after about 12 hours after birth the gut begins to “close” (Brandtzaeg et al. 2003). This means that also the maternal nutrients and antibodies can be absorbed less efficient, which stresses the importance of quick ingestion.

Foals which successfully ingested the colostrum during the first hours of life normally have IgG levels of 2,400 mg IgG/dl, however the levels of immunoglobulins in the colostrum strongly depend on the general health status of the mare. If the colostrum is not ingested (in time) this is called failure of passive transfer (FPT). Levels of IgG of below 400mg/dl at 24 hours after foaling are defined as FPT (Sellon, 2006). If this failure happens the foal runs great danger of serious infections, although the risk of infections of course depends on the environment as well.

This having said makes clear that the ingestion of the colostrum makes it necessary for the foal to acquire specific immunity to be able to withstand the presence of pathogens in its environment in case the innate immune system is not sufficient and to gain time to develop further immunity.

The passively transferred immunoglobulins have been shown to decrease rather quickly, after three weeks having already decreased by 50% and after four months the maternal antibodies are rarely detectable (Frape, 2004). This means that the foal is maternally protected to certain pathogens during the first quarter of the first year of life, during this time the foal thus needs to acquire active specific immunity.

### **Development of the immune system in relation to microbial colonization**

The digestive tract is one of the few organs being under constant exposure to pathogens from the outer world. Therefore a strong barrier needs to be developed during the time where the foal is still protected by maternal immunity and will play a crucial role in the horses’ immune system in later stages of its life.

With ingestion of milk, the digestive tract increases in length and diameter and with that increases in density and height of villi and differentiation of enterocytes. This development increases the efficiency of nutritional uptake (Ousey et al., 1995) and builds the base of microbial colonization in the intestines.

During gestation the foals’ digestive tract is kept sterile until birth were the newborn comes into contact with bacteria from the mothers’ vagina, feces and saliva. It has been found that lactobacilli are most

dominant in the digestive tract of horses, which start to develop quickly from birth on (Eadie et al., 1970). Also other bacteria mainly ingested via suckling are staphylococci, streptococci, corynebacteria, propionibacteria and bifidobacteria (Mackie et al., 1999). Besides that, it is commonly observed that foals often start eating feces of the mare to ingest even more of the beneficial bacteria to establish microbial colonization. The development of probiotic, beneficial bacteria in the foal's gut is, besides the development of a strong mucous layer, one direct protection mechanism against the growth and spreading of harmful pathogens. A constant strive for balance between beneficial and potential harmful pathogens starts to ensure long term health. This balance however, can easily be interrupted by external factors, which will be discussed more in detail.

The microbial colonization is not only necessary for metabolic processes, such as fermentation and nutrient production, but it is said that the intestine related immune system makes up about 80% of the overall immune system. As already mentioned does a healthy digestive system contain millions of bacteria both beneficial as well as potential pathogens. Such a constant presence of pathogens and thus antigens can be seen as a "trainer" for the neonates' immune system. It has been found that lymphocytes are highly active in the digestive system, where they can both take over the role of antigen presenting cells, antibody processing plasma cells and antigen destroying cells. The bacteria stimulate the 'gut associated lymphoid tissue (GALT), which is highly present in a complex network of lymph nodes and vessels to produce and 'educate' lymphocytes to the specific antigens (Nikles, 1991). This micro flora being ingested mainly by food thus enables the system to constantly produce antibodies (especially IgA) and to train both the innate as well as the adaptive immune system. This constant production of lymphocytes and antibodies is not only restricted to the digestive tract, but spreads through the lymphoid tissues and the bloodstream through the whole body. This interplay between beneficial and harmful bacteria and the constant training of the immune system through this micro flora points out the importance of a proper and healthy microbial colonization in the very beginning of the foals life.

### **Factors affecting the development of the foals' immune system**

Often improper foal management can already build the basis of a suboptimal development and functioning of the immune system. Factors such as putting them into a confined stable from the very beginning on, starting to give them concentrated feed from early age on and weaning them abruptly at too young age can have such an impact. Stabling a horse for long periods of the day means, besides an increased risk of developing (chronic) stress (Visser et al, 2008) that the foal, since it will lie down a lot, is under high pressure of inhaling/ingesting pathogens developing in bedding, such as bacteria. Relative warm temperatures, moisture and feces and urine are a highly favorable for pathogenic development. Inhaling large amounts of such pathogens causes high infection risk and with that possible inflammation, which has a direct result on the immune system. A continuous fight against such invasive pathogens in high concentrations means that the immune system eventually might not be able to act as efficiently to other pathogens in the body. It has been recognized that horses having enough place to roam freely will avoid eating grass near feces and urine places, thus not spending time in pathogenic pressure areas (Kiley-Worthington, 2007). They instinctly avoid the constant pathogenic and parasitic pressure at such places, which is not at all given when being stalled. Only under certain circumstances they specifically will search for feces to ingest beneficial bacteria to support the micro flora and with this also the immune system. Factors such as this high pressure of pathogens, stress and improper feeding (high in soluble

carbohydrates) will result in a disruption of the micro flora balance and an immune system not being able to perform on high levels ending up in potential long term consequences of the foals' health.

### **Conclusion**

Neonate foals under the right circumstances when ingesting maternal colostrum in time are equipped with a rather well functioning immune system, both innate as well as passively adapted. Through this the foal is able to develop own specific immunity during the first months of life and especially to develop a micro flora in the digestive tract which will help the immune system to encounter potential pathogens and respond to them correspondingly. However, in nowadays horse management several factors such as stabling, feeding and quick and sudden weaning result in both physical and well as mental stress and in a disturbance of the microbial balance and may let the immune system develop and function improperly.

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