SINTEZE

Passive immunity in poultry coccidiosis

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ABSTRACT. Coccidiosis is a protozoosis causing important economic losses in poultry industry throughout the world, either due to mortality or to weight losses. The species belonging to the *Eimeria* genus are host-specific, and the resulting immunity is species-specific. The immune response to coccidiosis is primarily cellularly mediated and secondarily humorally mediated, by means of antibodies. Within the cellular immune response, the CD4^+^ and CD8^+^ cells, and the cytokines they secrete, play an important role. Nevertheless, it seems that in the first days of life, chicks are protected against infection by maternal antibodies, transferred via egg yolk. This type of immune protection is well known in the case of the Gumboro disease. Research over the past 16 years has shown that the immunoglobulin Y (IgY) transferred via the egg yolk to the chicks prevents the appearance of clinical coccidiosis in chicks. The production of specific antibodies in breeders can be stimulated through infections or immunization. It has also been demonstrated that the maternal antibodies that appear as a result of an infection with *Eimeria* spp. (*Eimeria maxima*) offer the chicks partial protection against infection with another species (*Eimeria tenella*), owing to the fact that some eimerian proteins seem to be common to more species.

Keywords: Coccidiosis, Immunity, Passive immunity, Chicks.

Introduction

Coccidiosis is a protozoosis causing important economic losses in the poultry industry throughout the world, either due to mortality or to weight losses, whose clinical manifestation is diarrhoea, which in serious cases is haemorrhagic. *Eimeria tenella, Eimeria acervulina, Eimeria maxima, Eimeria mitis, Eimeria necatrix* and *Eimeria brunetti* are the most frequent of the eimerian species that parasitize hens. Three of them (*E. acervulina, E. tenella and E. maxima*) are frequently found in broilers. The birds are contaminated orally with sporulated oocysts, and the sporozoites are released into the gut and continue the intracellular biological cycle (in enterocytes) going through the schizogenic and gametogenic phases, culminating with the formation of the zygote as a result of fecundation and of the oocyst that will be released into the environment with the faeces. Chicks that survive an initial eimerian infection are resistant to further infections [1], and this resistance is targeted with respect to the species that induced it.

The immune response in coccidiosis is primarily cellular and secondarily humorally mediated. In case of the cellular immune response, the CD4^+^ and CD8^+^ cells, and the cytokines they secrete, play an important role. Nevertheless, it seems that in the first days of life, chicks are protected against infection by maternal antibodies, transferred via egg yolk. This type of immune protection is well known in the case of Gumboro disease.

Innate Immunity

It is well known that protozoan parasites belonging to the *Eimeria* genus exhibit strict host specificity and that the complete life cycle can only be achieved in more than one host under experimental conditions [2]. Thus, Loószová et al. [3] experimentally infected 10-day-old Leghorn chicks with 10^6* Eimeria colchici* oocysts that develop in the pheasant jejunum and caecum. A histological examination revealed the development of the parasite in the epithelial cells of the caecum and small intestine. The number and dimensions of the schizonts, at the caecum, 60 h postinfection, were significantly smaller in comparison with those present in the pheasant.
The mechanism of the host specificity is not very well known, but it seems to include genetic, nutritional, biochemical and immune factors [4], as well as the specificity for a certain type of cell, tissue and organ, which illustrates the antigenic intraspecific and interspecific diversity of the *Eimeria* spp., with implications in the application of some vaccination programmes.

There are receptivity differences within the same species, depending on the age of the animals, but this is not absolute; adult animals rose in conditions that prevented eimerian contact, as well as the immunosuppressed ones, are just as receptive as the young population.

Rhode-Island chicks are more resistant than those belonging to other breeds, and through cross-breeding, they induce a lower coefficient of receptivity [5], while through selections there have been obtained lines of chicks that are more resistant to the infection with *E. tenella* [6].

**Toll-like Receptors and Innate Immunity in Chicken Coccidiosis**

Innate immunity involves sentinel cells such as macrophages, dendritic cells and mast cells that recognize the presence of micro-organisms as well as molecules released by damaged cells, via surface receptors. The most important of the sentinel cell receptors are called Toll-like receptors (TLRs). Once a TLR binds a molecule from an invading micro-organism or molecules produced by damaged tissues, a signal passes into the cell and activates the genes for cytokines. TLRs trigger innate immune defences such as inflammation and also the acquired immune system by secretion of cytokines.

In chickens, TLR1, TLR2, TLR3, TLR4, TLR5, TLR6, TLR10 and TLR15 have been identified [7, 8]. ChTLR1/6/10 mRNAs was expressed at high levels in the spleen and in the kidney, chTLR4 mRNA was highest in tissue with a high number of macrophages or macrophage-like cells, TLR2 type 1 was expressed at moderate levels in the spleen, caecal tonsil and liver samples [7], and mRNA for TLR15 was detected in the spleen, bursa and bone marrow [8]. The chicken gut was strongly positive for all of the chTLR (TLR3++++, TLR1/6/10++++, TLR4, 5++, and TLR7, 2 type 1/2+). Regarding the distribution of TLR in immunological cell subsets (macrophages, heterophils, B cells, CD4⁺, CD8⁺, TCRγδ, TCRαβ, and TCRαβ), different levels of expression were noted. TLR1/6/10, TLR3, TLR4 and TLR5 were detected in all immune cell populations. For chTLR1/6/10, expression was highest in the heterophil and B cell, for TLR2 type 2 expression was highest in B cell and CD8⁺ cell, TLR2 type 1 was expressed in heterophils and TCRαβ⁺ T cell subsets, chTLR3 mRNA gave the highest level in CD8⁺ cells and TCRγδ T cell subsets, chTLR5 was highly represented in heterophils, chTLR4 mRNA was highly represented in macrophages and heterophils, and TLR7 was predominantly in B and T cell subsets [7].

These receptors serve as a receptor for specific antigen molecules. For example, TLR4 binds lipopolysaccharides from the surface of Gram-negative bacteria, TLR1, -2 and -6 recognize peptidoglycans and lipoproteins, TLR5 binds flagellin from bacterial flagella, TLR3 and TLR7 bind RNA viruses, and TLR15 is up-regulated in the caecum of infected chickens with *Salmonella enterica* serovar *Typhimurium* [8].

At this time, there is a significant progress in TLR recognition of the bacteria and viruses, but little is know about the role of the TLR in innate immunity to protozoan parasites. The involvement of TLR in host resistance to *Toxoplasma gondii* infection, an apicomplexan parasite like *Eimeria* spp., was reviewed by Yarovinsky and Sher [9]. It seems that TLR11 in mice is stimulated by a profilinlike ligand recently discovered in the parasite, and regulates the production of IL-12, which is necessary for the protective IFN-g response [10]. Profilins are a class of small actin-binding proteins present only in eukaryotic cells, which have a regulatory role in the polymerization of actin. *T. gondii* profilin shared significant homology only with profilin genes from other apicomplexan protozoa [11].

In *E. acervulina*, *E. tenella*, *E. maxima* and *Eimeria falciformis* sporozoites, an antigen of 19 kDa was detected, localized in the cytoplasm, which was conserved in *Eimeria* spp. [12]. Later, the 19 kDa antigen was detected also in the cytoplasm of *E. tenella* merozoite and the amino acid sequence indicated a conserved domain for the actinregulatory protein profilin [13]. Antigen 3-1E isolated from *E. acervulina* is a very potent stimulator of IL-12 release from dendritic cells.
and it was speculated to be an inducer of protozoan-targeted innate immunity [14]. Moreover, a recombinant protein of this antigen (rEA) stimulated IL-12 and IFN-γ secretion in mice, protecting them against phlebovirus infection, and it was observed that MyD88 is crucial to the immunostimulatory activity induced by rEA in mice. Also, rEA failed to protect hamsters challenged with phlebovirus: the authors suggested that hamsters may lack functional TLR11 [15]. Probably *E. acervulina* 3-1E antigen is a ligand of TLR11. IL-12 is produced mainly by macrophages and B cells, and the major target cells are Th1 cells and NK (natural killer) cells. It is known that in primary *Eimeria* infection, CD4+ cells are elicited.

Also, TLR2 was found to be stimulated by glycosylphosphatidylinositol (GPI) moieties of *Trypanosoma cruzi* and *Plasmodium falciparum*. GPI is abundant in the membranes of tachyzoites in *T. gondii*, *Trypanosoma*, *Leishmania* and *Plasmodium* spp. and in the membrane of sporozoite and merozoite of *E. tenella* [16].

**Acquired Immunity**

The immune response in coccidiosis is complex and different effector mechanisms can be involved, depending on the eimerian species (even in the case of the same host), on the stage of the life cycle and on the factors related to the host, such as the nutritional status and the genetic background of the host. It is generally accepted that the cellular immune response plays an important role in the eimerian infections, the humoral one playing only a secondary part.

In chickens, for example, *E. maxima* is highly immunogenic, while *E. necatrix* induces the same degree of immunity only after doses of infested oocysts that are 4 times larger [17]. Eimerian species located in the large intestine (*Eimeria separata*, *Eimeria falcis*, *Eimeria ferrisi* and *E. tenella*) induce a relatively weak immunity, while the eimerian species located in the small intestine determine a strong immunity. Schito et al. [18] attribute an important role in the local immune defence to the gut-associated lymphoid tissue (GALT), which is better developed and represented in the small intestine than in the large intestine [19], which explains the different degree of immunity induced by the different eimerian species [20].

GALTs

The cellularly mediated immune response implies the activity of the various cellular antigen-specific and non-antigen-specific populations, such as T lymphocytes, NK cells and macrophages. *Eimeria* is an intracellular protozoan parasite and the target tissue is the intestinal epithelium.

GALT is represented by caecal tonsils, Peyer’s patches, Meckel’s diverticulum, bursa of Fabricius and lymphocyte from the lamina propria of the gastrointestinal tract and intraepithelial lymphocyte and plays an important role in immune response in the intestine. In the caecal tonsils, T and B cells are present, and also plasma cells expressing mainly surface immunoglobulin G (IgG) and IgM, and a small number of surface IgA and IgB cells. Peyer’s patches represent the major inductive site for IgA response to antigens and, in mammals, contain B and T cells (most of them are helper cells), macrophages and dendritic cells. The leukocytes located in the gut epithelium are mainly T cells, but also non-T, non-B cells are present in a small percentage. The leukocytes located in the lamina propria are relatively enriched with immunoglobulin- producing B cells. TCRab and CD8 cells are present in both the intraepithelium and the lamina propria, whereas TCRgd cells are present mostly in the epithelium and CD4 cells are located mostly in the lamina propria [26]. In the duodenum and jejunum, TCRgd and TCRab are in similar numbers in the lamina propria and epithelium, whereas in the caecum, there are a large number of TCRgd cells. Also present in the epithelium are NK cells.
Cell-mediated Immune Response in Chicken Cocidiosis

CD4+ cells represent a minor population in the intraepithelial lymphocyte population (IEL) [27] and intervene in the coccidiosis cell-mediated immunity through the secretion of soluble cytokines such as IFN-g [28–30].

Hong et al. [31] noticed that after primary infection with E. maxima of 3-week-old chickens, CD3+, CD4+ and CD8+ cells were significantly increased at days 8, 6 and 7 respectively, whereas CD4+ cells were increased also after the challenged infection at 14 days post-primary infection. It was noted that TCRγδ cells exhibited a biphasic pattern following primary infection, whereas TCRαβ cells displayed a single peak in levels. Because there were no differences between infected and noninfected chickens after secondary infection regarding the CD8+ and TCRγδ cells, the authors concluded that a protective host immune response (cell- or antibody-mediated) had developed subsequent to primary infection.

In the case of E. acervulina, after primary infection in 7-day-old fast-growing broilers, a rapid increase in CD8α+ cells and no increase in CD4+ cells was observed in the duodenum on days 2 and 4 [32]. This was associated with strong IFN-γ and IL-8 responses at day 4 post-infection, in slow-growing and fast-growing lines. In an earlier experiment, the same authors found that this IFN-γ response is absent in animals infected at 1 day of age, but the same strain of broilers infected at 7 days presented the IFN-γ response. Simultaneously with CD8α+ cells, TCRγδ cells increased, from 7 to 14 days post-infection [32–34]. These cells mediate specific cellular immune functions without the requirement for antigen degradation and presentation and thereby are able to directly recognize invading pathogens or damaged cells, and are considered part of innate response [35]. TCRαβ cells are important for development of protective immunity, demonstrated by TCRαβmAb in secondary infection with E. acervulina and E. tenella, when chickens produce more oocysts than controls [25].

It seems that CD4+ cells are not important in controlling primary infection with E. acervulina. Trout and Lillehoj [25] have treated 1-day-old and 1-week-old Hyline SC strain chickens with anti-CD4 monoclonal antibodies (CD4mAb) followed by E. acervulina primary infection, and they have observed that the chickens did not produce more oocysts than controls.

A different finding was observed following primary infection with E. tenella in chickens treated with CD4mAb, which produced more oocysts, suggesting that these cells are important in controlling primary infection with E. tenella [25] and in the induction of the immune response [36]. CD4+ cells in naïve chickens may increase after 2 days, and in immune chickens, the number of CD8+ cells exceeds the number of CD4+, these cells acting as effector cells. Moreover, it was observed that in naïve chickens sporozoites were often located within or next to macrophages, whereas in immune chickens they were within or next to CD3+, CD8+ and TCRαβ cells [36].

The selective elimination of the CD8+ cells with monoclonal antibodies resulted in exacerbation of the disease, illustrated by increased oocysts shedding after E. tenella or E. acervulina infection [25]. A significant increase in CD8+ cells was noted in the IEL following the challenge infections of chicken with E. acervulina [37]. Bessay et al. [38] observed a significant increase of CD4+, CD8+ and TCRγδ cells in the duodenum from day 4 until day 8 post-infection with E. acervulina, correlated with a decrease in CD8+ cells in the blood and spleen between 4 and 6 days post-infection. Immunofluorescence analysis of the duodenum IEL at 10 days following E. acervulina challenge infection in SC chickens revealed that the majority of CD8+ IEL coexpressed TCRαβ [27].

In chickens infected with Eimeria mivati and treated with dexamethasone, the proportion of splenic lymphocytes bearing CD8+, γδ cell receptor (TCR1), class II major histocompatibility or surface IgM antigens was decreased compared with normal chickens [24]. Also, the immunosuppressed chickens eliminated more oocysts following primary and secondary infections, indicating the significance of CD8+ cells in primary, as well as secondary immune responses.
Humorally Mediated Immune Response in Chicken Coccidiosis

Chicks infected with *Eimeria* spp. produce IgM, IgA and IgG antibodies, but their capacity to minimize the pathogenic effects is weak. The experiments on the bursectomized chicks have shown that the role of the antibodies is minor in the case of further infections, the agammaglobulinic chicks being resistant to infection [22, 39]. The sera IgY and bile IgA usually appear 1 week after infection, reaching the maximum level 18–21 days post-infection, persisting for 2 months [40]. Some exceptions have been noted: thus, in the case of the infection with *E. tenella* the high titre of the sera IgM appears 17 days post-infection, and the bile IgA been noted up to 7 days post-infection with *E. tenella* or *E. acervulina*.

Whitmire et al. [41] noticed that the IgG monoclonal antibodies inhibit the penetration of the sporozoites of *Eimeria bovis* into the cells in cultured environments. The phenomenon proceeds similarly in the presence of the IgA or of other immunoglobulins.

Evolution of IgM in Chicken Coccidiosis

Following *E. tenella* infection, the first class of antibodies that appears is of type IgM at 7–14 days post-infection in the caeca, followed by IgA and IgM [42, 43]. After secondary infection, IgM antibodies in the caeca were observed at 3 weeks [44].

In *E. acervulina* primary infection, IgM appears between 6 and 8 days post-infection in the duodenum, followed by a decrease of titre at 21 days post-infection [38, 43].

Evolution of IgA in Chicken Coccidiosis

IgA is predominant in external secretions. In chicken coccidiosis, IgA was observed at a high level at 6–10 days after primary infection with *E. tenella*, and levels remained elevated more than 10 days after challenge infection [45, 46]. Moreover, Rose and Hesketh [47] associated a high level of bile IgA with low parasite number in the intestine in chickens infected with *E. tenella*. The IgA may bind the parasite, thus blocking attachment to the epithelium, by blocking the epithelial receptors directly through conformational changes, or reduction in motility [29, 46]. The bile IgA titre is not correlated with intestinal IgA [29]. Zigterman et al. [48] showed that IgA in chickens infected with *E. tenella* was detected in the caecum, but not in the blood or spleen. Comparable results have obtained by Girard et al. [43] in *E. acervulina* and *E. tenella* infections, when the IgA level was elevated in the duodenum and the caecum at 7 days post-infection.

Evolution of IgG in Chicken Coccidiosis

The IgG+ cells in *E. tenella* infection was observed in the lamina propria of the caecum and in the spleen [49], while the infection with *E. maxima* induces a strong humoral response in chicks [50].

In infection with *E. acervulina* and *E. tenella*, the high level of the IgG in the duodenum and the caecum appears 2 weeks post-infection [43]. The data recorded by Lillehoj and Ruff [40] regarding the infection with *E. acervulina*, *E. maxima* and *E. tenella* support the above mentioned, as they noticed that the coccidian-specific IgG is initiated 1 week post-infection, reaching the maximum titre 8–14 days post-infection, while in the blood it has been detected 2 months post-infection, and Zigterman et al. [48] noted a high level of the IgG in the case of the *E. tenella* infection in the caecum approximately at 10 days post-infection. In vaccinated chicken the titre of the antibodies seems to decrease until 21 days post-vaccination, followed by an increase until 90 days post-vaccination [51].

Maternal Immunity and the Passive Transfer of Immunity

There are three known classes of immunoglobulins in birds: IgM, IgA and IgY. Although IgY is considered to correspond to IgG from mammals, the cDNA that encodes the heavy chains of this immunoglobulin is similar to the one encoding IgE in mammals [52]. IgY is concentrated in the yolk and is thus transferred to chicks.

There are numerous studies demonstrating the role of this immunoglobulin in eimerian immunity. Thus, Wallach et al. [53] immunized laying hens with a gametocyte antigen obtained from *E. maxima* and the chicks subjected to control infection with a homologous strain presented a
significantly smaller level of eliminated oocysts as compared with the chicks descending from non-immunized hens, which indicates the protective role of this immunoglobulin in maternally transmitted immunity. Also, these antibodies offer partial protection against the infection with *E. tenella* and *E. acervulina*, where a 45–63% reduction of the oocyst elimination has been recorded [54]. The magnitude of the protection offered by maternal antibodies is correlated with the existence of appropriate levels of maternal antibodies and depends on the immune status of birds, decreasing with time. The anti-*E. maxima* antibodies of the IgG type at the level of the yolk as well as those from the serum of the chicks have displayed activity as compared with all the stages of the parasit, their level being tightly connected to that from the hens [55]. No antieimerian antibodies of the IgM and IgA type have been detected in the yolk or the white of the egg.

Smith et al. [50] and Wallach et al. [53] studied the possibility of antieimerian protection in chicks through maternal transfer of antibodies. To this purpose, reproductive birds are infected with 20000 *E. maxima* sporulated oocysts, and this is then followed by the production of specific antibodies which are transferred at the vitelline level, the maximum level being recorded 3–4 weeks post-infection. The offspring aged 3 days have been submitted to a control infection with 100 *E. maxima* sporulated oocysts. With the chicks hatching from the eggs collected 3 weeks after infection, there has been a reduction by 90% of the coproeliminations as compared with the witness, while with those hatching from eggs collected 7–8 weeks after infection there has been a reduction of only 47–68%, which suggests a gradual decrease in levels of the specific antibodies [50]. It has been noticed that as a result of the pretreatment of birds with Arlacel A, the antibody concentration has maintained itself at a high level for a longer period of time. Thus, the chicks hatched from eggs collected 8 weeks after infection have displayed a reduction by 80% of the coproeliminations, while those hatched from eggs collected 19 weeks after infection, a reduction by 60%. The sanguinic antibodies concentration and at the level of the yolk was directly linked with the protective level in chicks, measured through the number of eliminated oocysts [50].

These antibodies offer protection against the infection with *E. tenella*. The chicks hatched from eggs collected 28–39 days post-infection from birds infected with *E. maxima* have displayed a reduction of ovocyst coproelimination by 62%, as compared with the control. Through ELISA and Western blot, the IgG type antibodies have displayed a high titre of cross-reactivity to *E. maxima* and *E. tenella* antigens [55]. The serum taken from the birds infected with *E. maxima* reacted specifically with a protein with a molecular weight of 230 kDa, which was later administered intramuscularly in Freund’s adjuvant to birds. The offspring submitted to the control infection displayed a reduction of ovocyst coproelimination by 37% [55]. The second group of researchers immunized the birds with a gametocyte antigen extracted from the *E. maxima* macrogamont, and the offspring have displayed a reduction of the oocysts elimination by 83% as compared with the witness, and their serum mainly reacted with proteins with a molecular mass of 56, 82 and 250 kDa [53, 56, 57]. Later, they suggested the incorporation of these gametocyte antigens in a vaccine to be used to control bird coccidiosis through maternal transfer of antibodies [58]. As a result, birds have been immunized intramuscularly, 2–3 times, the vaccinal antigen being helped with Freund’s adjuvant, the chicks displaying a reduction of ovocyst coproeliminations by 45–63% in the case of the control infection with *E. maxima*, *E. tenella* and *E. acervulina*.

**Immunoprophylaxis of the Coccidiosis in Chickens**

At the present moment, therapy and chemoprevention with a large range of substances – generically named coccidiostatics – play an important part in the defeat and prevention of coccidiosis in the avairy field. There are efforts worldwide to replace chemoprevention with vaccination because of the disadvantages resulting from the use of the drugs.

*Eimeria* vaccines available on the market at present are virulent or attenuated live vaccines normally constituted from more than three eimerian species. Generally speaking, vaccines destined for broiler chicks contain 3–4 eimerian species (Paracox-5, Livaco T and Nobilis COX ATM), while those intended for laying birds contain more than 4–5 species (Paracox-8, Livaco Q, Coccivac D and Immucox II). The
attenuation is obtained through passages on embryonated eggs or chickens, in order to obtain precocious strain. The characteristics of a precocious line are: the reduction of the biological cycle and reproduction, reduction of pathogenicity, maintaining the immunogenic capacity and stability. There is one other subunitary vaccine consisting of a proteic extract of *E. maxima* macrogametes, which offer passive protection to chicks in their first days of life, after which they develop active immunity immediately after the prelevation of oocysts from the litter.

The traditional administration of vaccines in drinking water has been replaced with the spraying method, and in the USA feeder spraying, a method normally used with laying hens. This method is considered to be more efficient because of the fact that it ensures a more even exposure of the chicks to the vaccinal oocysts [59].

The individual oral administration to each chick of the anti-eimerian vaccines allows for a more even exposure of the chicks, but this method is only practical under laboratory conditions and small production units, being impossible to apply in large aviary units. Spraying of the vaccinal suspension and the conjunctival prelevation in the incubator has turned out to be a more practical way. The oocysts pass by the level of the lacrimal duct in the nasal cavity and from here at the intestinal level, via the oropharynx. Thus the individual oral method has not been in use for some time now.

In antiviral vaccinations, spraying rooms are used in incubators that have also been adapted for the anti-eimerian vaccine CocciVac B. This contains a red colorant, so, after administration, approximately 90–95% of the chicks have coloured feathers. The chicks will ingest the vaccinal oocysts through feather pecking. Another vaccine, Nobilis COX ATM, which contains a green colorant, is based on the same principle.

The newest innovation in anti-eimerian vaccine application is under development, and is represented by the introduction of the vaccinal oocysts in the embryonated eggs. The result of the in ovo administration of the *E. maxima* oocysts, in the amniotic sack in the case of the 18-day-old embryos was the presence of the oocysts in the stomach 5 h post-infection, and in the intestine within 72 h [60]. The oocysts probably get to the level of the intestine through the swallowing reflex. After hatching, oocysts have been eliminated, which suggests that the oocysts administered have completed the biological cycle. It is not known whether the release of the sporozoites happens prior to or after hatching. The in ovo administration of vaccines has turned out to be efficient and safe in the field as well [61].

**Experimental and Practical Aspects regarding Passive Immunoprophylaxis in the Coccidiosis of Broiler Chicks**

Most researchers agree that T lymphocytes play a major part in anti-eimerian immunity, while B lymphocytes have a rather minor role. This is based on the fact that organisms with deficiency of T lymphocytes present a weak immune response to the parasite, while bursectomized organisms are capable of controlling the development of the parasite. There is evidence showing that the humorally mediated immune response is highly protective. Thus, serum taken from chicks that have undergone *E. maxima* infection, inoculated in 1-day-old chicks, sometimes blocks the development of the parasite by almost 100%. The protective capacity of the serum is tightly connected to the concentration of anti-*E. maxima* Y-specific immunoglobulin. It has also been demonstrated that the gammavitellinic fractions of the yolk of birds infected with *E. maxima* injected subcutaneously to receptive chicks offer them protection against infections with *E. maxima* [62].

Based on the research of Rose between 1970 and 1980 regarding the maternal transfer of antibodies, in hens infected experimentally with *E. maxima*, Smith and Wallach (1989–1997) identified in *E. maxima* macrogametocytes the existence of some glycoproteins with high immunogenic potential, which offer anti-eimerian protection to both laying hens and to their offspring. Moreover, these antigens offer partial protection against the natural infections with *E. acervulina* and *E. tenella*. As a result of the positive experimental outcome, a subunitary vaccine has been created, which contains these gametocyte glycoproteins (56 and 82 kDa), named CoxAbic.
Research has been carried out on the efficiency of this vaccine under experimental conditions, as well as in the field. In the first case, hybrid Hybro G birds were vaccinated and, later, field experiments on Cobb 500 were carried out. The dynamics of the evolution of the concentration of serum antibodies has been observed in laying birds after vaccination, and the protective efficiency offered by the specific antibodies transmitted through the vitelline from parents to their offspring has been studied.

In Hybro G antevaccinal, the eimerian population was chiefly represented by *E. maxima* (90.09%), other species being weakly represented (*E. tenella* – 6.3%, *E. acervulina* – 1.8% and *E. mitis* – 1.8%), while the predominant species after vaccination was *E. mitis* (64.12%), followed by *E. acervulina* (34.35%) and *E. tenella* (1.52%), but there was no *E. maxima* [63]. The level of specific antibodies postvaccination was higher in the vaccinated group (1.1+0.312–1.576+ 0.366 UDO, the ratio S/P 0.978+0.318–1.454+0.384), as compared with control group (0.724+0.318–1.576+ 0.366 UDO, the ratio S/P 0.704+0.312–1.928+0.317) respectively. In UDO, the ratio S/P 0.978+0.312–1.454+0.384), as compared with control group (0.724+0.318–1.576+ 0.366 UDO, the ratio S/P 0.704+0.312–1.928+0.317) respectively. In Poland, similar results have been obtained, that is to say values of the S/P of 0.81 in the vaccinated group with CoxAbic and 0.73 in the control group [64]. Contrary to these results, in hybrid Cobb 500, lower values have been recorded, the medium being of 0.409+0.185 UDO in the CoxAbic group and of 0.320+0.257 UDO in the control one [65].

Experimental infections have been carried out on the offspring and the immunoprophylactic value has been assessed by the assessment of the lesion score and the number of oocysts eliminated. In Hybro G antevaccinal, the eimerian population was chiefly represented by *E. maxima* (90.09%), other species being weakly represented (*E. tenella* – 6.3%, *E. acervulina* – 1.8% and *E. mitis* – 1.8%), while the predominant species after vaccination was *E. mitis* (64.12%), followed by *E. acervulina* (34.35%) and *E. tenella* (1.52%), but there was no *E. maxima* [63]. The level of specific antibodies postvaccination was higher in the vaccinated group (1.1+0.312–1.576+ 0.366 UDO, the ratio S/P 0.978+0.318–1.454+0.384), as compared with control group (0.724+0.318–1.576+ 0.366 UDO, the ratio S/P 0.704+0.318–0.928+0.317) respectively. In Poland, similar results have been obtained, that is to say values of the S/P of 0.81 in the vaccinated group with CoxAbic and 0.73 in the control group [64]. Contrary to these results, in hybrid Cobb 500, lower values have been recorded, the medium being of 0.409+0.185 UDO in the CoxAbic group and of 0.320+0.257 UDO in the control one [65].

Experimental infections have been carried out on the offspring and the immunoprophylactic value has been assessed by the assessment of the weight gain, of the ratio of food conversion, the lesion score and the number of oocysts eliminated. The average oocysts per gram (OPG) eliminated in the CoxAbic groups was 1.15x10^4/g faeces in conventional chicks. The average oocysts per gram (OPG) eliminated in the CoxAbic groups was 1.15x10^4/g faeces in conventional chicks. However, the weight gain and the food conversion ratio, with which, for 1 kg spor, 2.135 kg fodder/kg was needed [65].

**SUMMARY**

**Imunitatea pasivă în eimerioza puilor**

Eimerioza este o protozooză care cauzează pierderi economice importante în industria avicolă în întreaga lume, fie datorită mortalității, fie pierderilor în greutate. Speciile care aparțin genuului *Eimeria* sunt specifice de gazdă și imunitatea rezultată este specifică de specie. Răspunsul imun la eimerioză este în primul rând mediat celular și secundar mediat umoral, prin intermediul anticorpilor. În cadrul răspunsului imun cellular, celulele CD4+ și CD8+, împreună cu citokinele pe care acestea le secretă, joacă un rol important. Totuși, se pare că în primele zile de viață puii sunt protejeți împotriva infecției prin anticorpi maternali, transferați prin gălbenușul de ou. Acest tip de protecție imună este bine cunoscută în cazul bolii Gumboro. Cercetările din ultimii
16 ani au arătat că imunoglobulina Y (IgY) transferată prin gălbenușul de ou la pui previne apariția eimeriozei clinice. Producția de anticorpi specifici în crescătorii poate fi stimulată prin infecții sau imunizare. De asemenea, s-a demonstrat că anticorpi materni care apar ca urmare a infecției cu *Eimeria* spp. (*Eimeria maxima*) oferă puilor o protecție parțială împotriva infecției cu alte specii (*Eimeria tenella*), datorită faptului că unele proteine eimeriene par să fie comune mai multor specii.

**References**


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