Vaccines and vaccination programs

Acknowledgement

We would like to acknowledge the committee of National Egyptian Guidelines for Veterinary Medical Interventions, Egyptian Health Council for adapting this guideline.

Executive Chief of the Egyptian Health Council:

Prof. Dr. Mohamed Mustafa Lotief.

Head of the Committee:

Prof. Dr. Ahmed M Byomi

The Rapporteur of the Committee:

Prof. Dr. Mohamed Mohamedy Ghanem.

Scientific Group Members:

Prof. Dr. Nabil Abd Elgaber, Prof. Dr. Ashraf Ali Eldesoky Shamaa, Prof. Dr. Amany Abbass, Prof. Dr. Dalia Mansour, Dr. Essam Elmarakby, Dr. Mohamed Elsharkawi

Editor: Prof. Dr. Dalia Mansour, Dr. Essam Elmarakby.

Abbreviations:

(AIV ,AI flu, influenza, fowl plague)	Avian influenza
ND	Newcastle disease virus
ILT	Infectious laryngotracheitis
Wet pox	Fowl pox
IB	Infectious bronchitis
MD	Marek's Disease virus
I.coryza,	Infectious Coryza
CRD	Mycoplasma,
F cholera	Pasteurella multocida
EDS	Egg drop syndrome

Scope:

The guidelines for the evaluation the most suitable vaccine and design effective vaccination programs to prevent and control contagious poultry diseases.

The target audience:

The guideline is intended for all veterinarians who are intended to diagnose, treat, and control Poultry Diseases.

Aim:

Design and implementation of effective vaccination programs to prevent diseases that usually affect broiler farms and should be based on disease prevalence and infectious pressure in the area, the farm conditions, and the correct choice of the type of vaccine.

The most commonly used vaccines:

Vaccines consist of attenuated microorganisms or their particles that are designed to activate the immune system and create a memory in the event of an outbreak.

1. **Newcastle Disease**: It is a disease caused by a paramyxovirus that is very contagious and causes high mortality rates in poultry. Vaccination of poultry against Newcastle Disease is essential to prevent outbreaks in poultry farms.
2. **Avian Influenza** (Bird Flu): A viral disease that in some cases can affect both poultry and humans (zoonosis). Vaccines reduce the spread of the virus among poultry, thereby reducing the risk of transmission to humans.
3. **Marek's disease**: A viral disease caused by a type 2 herpes virus that primarily affects chicks and causes tumors and neurological disorders.
4. **Avian cholera**: Caused by a bacterium of the genus Pasteurella, which can cause significant morbidity and mortality.
5. **Avian Infectious Bronchitis (IB)**: This is a viral disease caused by a highly contagious coronavirus that affects the respiratory tract of poultry. This virus can reduce egg production and degrade eggshell quality.
6. **Gumboro disease (infectious bursitis)**: This is a viral disease caused by a birnavirus that affects the immune system of young poultry, causing damage to the bursa of Fabricius and weakening immunity. Vaccination is essential to prevent the spread of this disease and to protect young poultry.

Vaccination failure

Vaccine failure takes place when birds **is not properly protected** after receiving a vaccine and, therefore, contracts the disease anyway. Vaccine efficacy can be evaluated through ELISA tests that quantify **antibody production levels** in blood serum. Many variables can reduce vaccines' efficacy and can be related to the environment, the management practices, the bird or the vaccine.

The most important causes are:

- Related to the vaccine: inadequate storage conditions or application methods can cause vaccine failures. Also, choosing a vaccine strain different from the field's without cross-immunity or a type of vaccine that is not the proper one. Manufacturer and professionals' indications must always be considered to design an effective vaccination program.
- Maternal immunity: in young chickens, maternal antibodies may interfere with the replication of live vaccines and reduce their efficacy. To prevent it, the breeder vaccination program should be considered when designing broilers vaccination program'.
- Immunosuppression: it can be caused by many factors that are frequent in intensive production systems. It may appear due to productive stress, since selection for highly production breeds causes an overstraining of the organs and the immune system, making animals weaker; management, environmental and nutritional factors; and immunosuppressive diseases.

Innovation in poultry vaccination:

Innovations in poultry vaccination have led to significant improvements in farm performance, as evidenced by reduced morbidity, reduced mortality, increased production rates and improved animal welfare.

- **Vector vaccines**: These use attenuated or genetically modified viruses that carry a gene from another pathogen to induce the immune response, without the need to use the original microorganism. This has improved the safety and efficacy of vaccines.
- **Recombinant vaccines**: these use proteins or genes from the pathogen to stimulate the immune response and are specific.
- **Subunit vaccines**: These use specific fragments, called antigenic subunits, from either viruses or bacteria that are recognized by the immune system. They are very safe and economical to develop.
- **DNA/RNA vaccines**: Specific fragments of the genetic material (DNA or RNA) of the pathogen can be used to stimulate the immune response in poultry. These vaccines are stable, safe and can be rapidly produced.
- **Nanostructures in vaccines**: The incorporation of nanostructures into vaccines allows for the controlled release of antigens, improving the efficacy of the immune response and the duration of protection.

In ovo vaccination

Embryonic chickens have a functioning immune system by 16 to 18 days incubation. Vaccination of embryonic chicks in ovo is a highly effective method of vaccinating large numbers of birds in a very short time. Automatic egg injection machines have been widely adopted. Injection through the eggshell is performed at 18.5 days when eggs are routinely transferred to hatching trays to avoid turning in the setter compartment of the incubator.

In ovo vaccination requires specialized equipment, great accuracy, and a very high degree of hygiene because once opened to the environment by a needle puncture, eggs are susceptible to bacterial or fungal invasion. With appropriate hygienic precautions, the method is highly satisfactory. It is predominantly used for Marek's disease vaccines containing the CVI 988/Rispens strain of virus. It may also be used for control of infectious bursal disease in addition to fowl pox, and avian influenza.

Antibacterial vaccines

Although viral diseases are of greater overall significance, antibacterial vaccines are also essential.

Pasteurellosis: Fowl cholera is caused by *Pasteurella multocida,* an acute fatal septicemia in chickens and turkeys. *P. multocida* vaccines include bacterins adjuvanted with aluminum hydroxide or oil emulsions, or they may contain attenuated live organisms. Multivalent Pasteurella vaccines usually contain the commonest serotypes 1, 3, and 4. The inactivated vaccines are usually given by injection. The attenuated live vaccines (M9 or PM-1 strains) may be given by the wing web or in drinking water. Protection develops in about two weeks.

Mycoplasmosis: These diseases are caused by several pathogenic Mycoplasmas. The most important are *Mycoplasma gallisepticum* (MG) and *Mycoplasma synoviae* (MS*)*. MG causes chronic respiratory disease, whereas MS causes respiratory disease or synovitis. It is generally best to maintain mycoplasma-free flocks, but inactivated, attenuated live and fowlpox-vectored vaccines are available for use in countries where vaccination is permitted.

A fowl pox recombinant MG vaccine is also available. It is administered in the wing web. The use of the attenuated vaccines has been characterized as controlled exposure by giving a mild infection at an age when little damage occurs. Pullets are generally vaccinated between 12 to 16 weeks of age. One dose is sufficient to make the birds permanent carriers

Infectious coryza: This is an acute respiratory disease of chickens caused by *Avibacterium paragallinarum.* It is characterized by nasal discharge, sneezing, conjunctivitis, diarrhea, and facial swelling. Affected hens show a significant drop in egg production. Coryza may be complicated by the simultaneous presence of many other bacteria in addition to infectious bronchitis virus. There are three serovars of *A. paragallinarum* (A, B, and C).

Colibacillosis: Colibacillosis is caused by avian pathogenic *Escherichia coli*. This commonly starts as a respiratory infection and eventually leads to colisepticemia, sickness, deaths, and carcass condemnation. Colibacillosis is a leading cause of economic loss in the poultry industry.

Salmonellosis: Salmonellae present the poultry farmer with two potential problems. One is the fact that they may kill large numbers of birds. The other is that they may cause human food poisoning caused by the contamination of eggs and poultry meat with *Salmonella enterica* serotype Enteritidis. This is of major concern to the poultry industry for both legal and financial reasons. Young chickens may be infected by both vertical and horizontal transfer and they probably acquire the infection soon after hatching.

Antiviral vaccines:

Marek's disease virus (MDV) belongs to herpesviruses causes a lymphoproliferative, immunosuppressive and neuropathic disease that affects the nerves, viscera, muscle, and skin of chickens. Chickens may become persistently infected without showing any clinical signs. There are three species of MDV. Marek's disease is primarily controlled by vaccination either in ovo at day 18, or by subcutaneous injection at day of hatch. The need for vaccination against MDV has a significant economic impact on the poultry industry.

Bivalent vaccines containing serotypes 1 and 3 or trivalent vaccines containing serotypes 1, 2, and 3 are used. These vaccines contain live virus and although they prevent tumor production they do not generate sterilizing immunity. Vaccinated chickens still get infected and can shed virulent field virus.

Several different modified live virus vaccines are available to control Marek's disease. Turkey herpesvirus (HVT or MDV-3) is an avirulent virus that can effectively protect chickens against MDV.

Newcastle Disease is a serious respiratory disease caused by virulent strains of avian paramyxovirus serotype 1 of the genus *Avulavirus*. All strains of the virus (NDV) are contained in a single serotype, but they are divided into two classes, class I and class II. Class II is then divided into 16 genotypes.

Class 1 viruses are primarily found in wild birds because NDV can infect many different avian species.

Class II NDVs vary greatly in their virulence for chickens. They are classified as velogenic—rapidly lethal; mesogenic—intermediate; and lentogenic—relatively low virulence, based on their lethality for chick embryos. For example, class II, genotype II strains are so lentogenic that some, such as Hitchner B1 and LaSota, can be used in modified live vaccines.

Inactivated vaccines are given by the intramuscular or subcutaneous routes. They are often given to layers or breeders to provide persistent high antibody levels that can be transferred to their chicks.

Modified live lentogenic or mesogenic strains are used in MLV-NDV vaccines. The live vaccines are usually grown in embryonated chicken eggs or in tissue culture. The mesogenic vaccines cause mild disease so they are generally used in countries where Newcastle disease is endemic. In countries largely free of ND only lentogenic strains are permitted. These live vaccines are given in drinking water, by coarse sprayer, or by intranasal or intraocular administration. A lentogenic strain is also available for in ovo use.

Recombinant vectored NDV vaccines using turkey herpesvirus or fowlpox vectors incorporating the hemagglutinin gene or the F gene, or both, are also available. Some of these may be appropriate for in ovo vaccination. NDV itself may also be used as a vector for other vaccines such as those against IBD or avian influenza.

Infectious bursal disease Also called Gumboro disease, the causal agent of IBD is an avibirnavirus. It infects multiple bird species, but causes clinical disease only in chickens less than 10 weeks of age. The virus destroys B cells within the Bursa of Fabricius resulting in bursal atrophy and subsequent suppression of the antibody responses. This immunodeficiency will result in a poor response to other vaccines and overwhelming secondary infections. There are two serotypes of IBDV but severe bursal disease is only associated with serotype 1. All commercial vaccines are directed against this serotype. There are no reports of clinical disease caused by serotype 2. As with all RNA viruses, IBDV is rapidly evolving and as a result there is much variation in antigenicity and virulence, features that complicate vaccine development.

Many different types of IBD vaccine are available, both monovalent and in combinations. These include live attenuated vaccines, inactivated oil-adjuvanted vaccines, live recombinant vaccines, or even immune-complex vaccines. Because this disease affects very young chicks it is important to exploit maternal immunity by vaccinating hens.

The inactivated vaccines are water-in-oil adjuvanted products. They are mainly used to induce long-term immunity in breeding stock. They are best used in birds at 16 to 20 weeks that have been primed by live vaccines at 8 weeks of age.

The viral structural protein 2 (VP2) is the major protective antigen in IBVD.

Modified live vaccines have been attenuated by serial passage in tissue culture or eggs. Depending on their degree of attenuation, live attenuated IBDV vaccines may be classified as mild, intermediate, or invasive based on their ability to replicate and cause bursal lesions. This also reflects their ability to overcome maternal immunity. Mild vaccines are used to prime broiler breeders before boosting with an inactivated vaccine. If chicks have maternally-derived antibodies, then vaccination should be delayed until this has waned. The mild vaccines show poor efficacy in the presence of maternal antibodies or against very virulent strains of IBDV. The intermediate or hot strains are more immunogenic but may induce bursal lesions. The vaccine is usually given in a spray or in drinking water.

Infectious bronchitis is an economically significant respiratory disease of chickens that also causes nephritis, decreased egg production, poor growth, and high morbidity. It is caused by a *gammacorona* virus, avian infectious bronchitis virus (IBV). The combination of high morbidity, and loss of performance, together with secondary bacterial infections can lead to unsustainable losses. As a result, almost all commercial poultry are vaccinated against this virus.

Inactivated vaccines may be used alone or in combination with modified live virus (MLV) vaccines in layer/breeder flocks to induce maternal immunity and thus protect chicks from an early age.

Modified live IBV vaccines containing three common serotypes are administered in the drinking water, or by coarse spray, and given at day one or within the first week. Some short-lived broilers receive only this single dose. For longer-lived broilers, a second dose is generally given two to three weeks later. Long-lived broiler breeders and layers receive multiple vaccine doses at two, four, and six weeks. Revaccination after that depends upon the local threat assessment.

Infectious laryngotracheitis An economically important respiratory disease caused by herpesvirus 1, ILT affects chickens, peafowl, pheasants, and partridges. The principle lesion is tracheitis and the disease can vary in severity from lethal asphyxiation to very mild or subclinical infection. As with other herpesviruses, infected birds may become healthy carriers. The disease is usually prevented by the use of either live attenuated vaccines or recombinant vectored vaccines.

As a result of residual virulence in modified live vaccines, efforts have been made to generate safer vaccines by developing viral vectored vaccines. They are also administered by subcutaneous vaccination to one-day-old chicks or in ovo.

Avian reoviruses belong to the genus Orthoreoviruses in the *Reoviridae* family. They cause arthritis/tenosynovitis, proventriculitis, a runting-stunting syndrome, and "blue-wing disease" in broilers. Because these diseases affect very young birds, reovirus vaccines are often administered to breeding hens to stimulate maternal immunity and protect the newly hatched chicks. Both inactivated and modified live vaccines are available.

The inactivated oil-emulsion adjuvanted vaccines may contain multiple strains and different pathotypes. They are used in replacement and breeder hens and are often used in combination with NDV, Marek's or bronchitis vaccines.

Avian influenza vaccination against HPAI is actively discouraged or banned because it interferes with the detection of infected flocks. Vaccination alone is not a solution to the problem of HPAI, or H5/H7, low pathogenic avian influenza (LPAI) viruses because it raises the possibility that these strains could become endemic in avian populations..

Vaccination may be used in control programs for both HPAI and LPAI. The recent emergence of pandemic influenza A strains such as H7N9 and H5N1, reveals the tremendous challenges to our current influenza control strategies.

Fowl pox is caused by an Avipoxvirus, a large, complex DNA virus. They are transmitted through aerosols or by biting insects. It is a slowly spreading infection characterized by proliferative skin lesions (dry pox) on unfeathered skin, or by diphtheritic lesions in the mucosa of the mouth, esophagus, larynx, or trachea (wet pox). The latter can result in asphyxiation of young chicks. In general mortality is low but may reach 50% in stressed flocks. Modified live fowlpox or pigeon poxvirus vaccines attenuated in cell culture or embryonated eggs are available. They may be given as monovalent vaccines or in combinations. Most are administered into the wing web after maternal immunity has waned. Some are administered subcutaneously to one-day-old chicks and there is also an in ovo recombinant vectored vaccine available that expresses ILT antigens. They may be used in situations where the disease is endemic because the infection spreads relatively slowly and may be administered in the face of an outbreak. They have also been used in pigeons, turkeys, and quail, in addition to chickens.

Avian encephalomyelitis: The cause of epidemic tremor, avian encephalomyelitis virus is a picornavirus that affects the central nervous system. In young chickens it induces paralysis, ataxia, and muscular dystrophy. In older chickens, infection is usually subclinical but causes a decline in egg production and hatchability. Several modified live vaccines are available. Some may be combined with fowl pox. Most

are administered by wing web vaccination using a double needle applicator. Breeder chickens are vaccinated at 10 to 16 weeks of age, at least 4 weeks before start of lay. The site of inoculation should be examined for "take" at 7 to 10 days postvaccination. A positive take is indicated by a swelling or scab at the site of inoculation. If given to laying flocks this vaccine can cause a serious drop in egg production.

Egg drop syndrome (EDS) is caused by an adenovirus infection in laying hens. It is characterized by production of soft-shelled and shell-less eggs and also a 10% to 40% drop in egg production. An inactivated vaccine containing EDS'76 virus strain BC14 in a water-in-oil emulsion may be available. It should be administered intramuscularly to layers and breeders no later than 4 weeks before the expected onset of lay.

Antiparasite vaccines

Infection with Eimeria coccidia induces a strong, species-specific protective immunity. As a result, several live coccidial vaccines are used in commercial poultry. These vaccines typically contain live sporulated oocysts from multiple Eimeria species and strains. Some consist of virulent, drug-sensitive organisms administered repeatedly in very low doses of oocysts (trickle infection). Some of these organisms have been attenuated by repeated passage through eggs, but this only works well for *Eimeria tenella*

Maternal immunity

Newly hatched birds emerge from the sterile environment of the egg. Serum immunoglobulins are actively transported from the hen's serum to the yolk while the egg is still in the ovary. During egg production about 30% of the hen's immunoglobulin (IgY) will transfer from her plasma to the yolk. IgY in the fluid phase of egg yolk is therefore found at levels equal to or greater than those in hen serum. As the fertilized ovum passes down the oviduct, IgM and IgA from oviduct secretions are acquired with the albumin. As the chick embryo develops in ovo, it absorbs the yolk IgY, which then appears in its circulation. At the same time, the IgM and IgA from the albumin diffuse into the amniotic fluid and are swallowed by the embryo. Thus when a chick hatches, it possesses IgY in its serum, and IgM and IgA in its intestine. The newly hatched chick does not absorb all its yolk sac antibodies until about 24 hours after hatching. These maternal antibodies effectively prevent successful vaccination until they disappear between **10 and 20 days after hatching**. Newly hatched chicks begin to make their own IgA at day three in the bursa, and day seven in the gut and lung. Interestingly, maternal IgA persists for at least seven days because it appears to be retained by the intestinal mucus. The presence of maternal antibodies may neutralize live vaccine strains and

day of age vaccination is not therefore ideal. That is why in ovo vaccination is employed.

Vaccination Program for Broilers

Viral disease	Age	Route	Vaccine
Marek's disease	**1 day**	**SC**	**Turkey herpesvirus and SB-1 or Rispens strain for high-challenge areas**
Newcastle disease	**1 day** **14–21 days**	**Coarse spray** **water**	**Hitchner B1** **LaSota or colon30**
Infectious bronchitis	**14–21 days**	**Coarse spray**	**Massachusetts**
Infectious bursal disease	**1 day** **14–21 days**	 **Water**	**Intermediate**

Vaccination Program for Commercial Layers

Viral /bacterial disease	Age	Route	Vaccine
Marek's disease	1 day	SC	Turkey herpesvirus and SB-1 or Rispens strain for high-challenge areas
Newcastle disease/ Infectious bronchitis	1 day 14 –21 days 5 wk 8–10 wk 12–14 wk 16–18 wk (Every 60–90days or 18 wk	Coarse spray Parenteral	Hitchner B1 LaSota or colon30 Massachusetts inactivated
Infectious bursal disease	1 day 14–21 days	 Water	Intermediate
Encephalomyelitis	10–12 wk	Wing web	Live, chick-embryo origin
Fowl pox	10–12 wk	Wing web	Modified live
Laryngotracheitis	10–12 wk	Intraocular	Modified live
Mycoplasma gallisepticum	10-12 wk	Intraocular or spray	Mild live strain

Vaccination Program for Commercial Ducklings

Viral/bacterial	Age	Route	Vaccine
Riemerella anatipestifer	**1 day**	Aerosol	Live vaccine[a]
	10-14 day	Drinking water	
	3 wk	SC	Bacterin[b]

A) live, avirulent vaccine consisting of the three major serotypes (1, 2, and 5) of *R anatipestifer*

b) A formalin-inactivated cell suspension of the three major serotypes (1, 2, and 5) of *R anatipestifer* is recommended for preventive immunization on farms where the disease is endemic or epidemic.

Ducklings should not be vaccinated within 21 days of slaughter

Vaccination Program for Duck Breeders

Viral/bacterial	Age	Route	Vaccine
Riemerella anatipestifer	**1 day**	Aerosol	Live vaccine[a]
	10-14 day	Drinking water	
	3 wk	SC	Bacterin[b]
Duck viral hepatitis	4 wk	SC	Live vaccine[c] (Type 1)
Duck viral enteritis	4 wk	SC	Live vaccine
Riemerella anatipestifer	10 and 20 wk[d]	SC	Bacterin[b]

a) A live, avirulent vaccine consisting of the three major serotypes (1, 2, and 5) of *R anatipestifer*.
(b)A formalin-inactivated cell suspension of the three major serotypes (1, 2, and 5) of *R anatipestifer*. Bacterins and killed virus vaccines are administered subcutaneously in the neck.
(c) A modified live virus vaccine of embryo origin

Vaccination Program for Turkeys

Age	Market Turkeys	Breeder Hens	Breeder Toms
2–3 wk 15wk 18wk	ND; B1-B1 or LaSota, DW or spray	ND, B1-B1, or LaSota; DW or spray	ND; B1-B1, or LaSota, DW or spray
4 wk	Hemorrhagic enteritis; DW	Hemorrhagic enteritis; DW	Hemorrhagic enteritis; DW
6 wk 12 wk 18wk-24 wk	Fowl cholera;DW (live) or SC (inactivated) N/A	Fowl cholera;DW (live) or SC (inactivated)	Fowl cholera;DW (live) or SC (inactivated)
9–10 wk 21wk	ND; LaSota, DW or spray N/A	ND; LaSota, DW or spray	ND; LaSota, DW or spray
26 wk	N/A	Erysipelas; DW (live) or SC (inactivated) Pox; WW ND; SC (inactivated)	Erysipelas; DW (live) or SC (inactivated) Pox; WW ND; SC (inactivated)
28 wk	N/A	Fowl cholera; DW (live) or SC (inactivated) Encephalomyelitis; DW	Fowl cholera; DW (live) or SC (inactivated) Encephalomyelitis; DW

(a) Recommendations are for production areas where the diseases listed are common. In addition, other vaccinations may be advisable if previous experience indicates a prevalence of certain diseases in the area.

These may include turkey bordetellosis eye drop vaccine at 1 day old and in water or

spray at 14 days old, or bacterin; paramyxovirus 3 and influenza A (prevalent hemagglutinin) at 26–28 and 40 weeks old; erysipelas—live or killed products might be required for market turkeys, and repeated vaccinations might be required for breeders; and salmonellosis bacterins at 24 and 28 weeks old. DW, drinking water; ND, Newcastle disease; WW, wing web stab.

(b)Recommended age at vaccination is an approximation.

(c)Spray vaccines against Newcastle disease should not be administered to birds suffering from respiratory disease; in such cases and at that age, the mild B1-B1 strain vaccine can be administered in water. The timing of vaccination depends on maternal antibody levels.

(d) Live fowl cholera vaccines should be used only in healthy flocks..

Vaccination Program for pigeon

Pigeon pox vaccine

the vaccine must be administered to healthy receptive birds held in proper environment under good management. In addition, the response may be modified by the age of the birds and their immune status.

Wing-Web Administration

Age of vaccination 6 and 18 week of age

1. Vaccine is applied to the web of the wing. Use the fork applicator.
2. A dose of 0.01 ml should be administered to each bird by dipping the applicator in the vaccine mixture, allowing the applicator grooves to fill with liquid, and stabbing the webbed portion of the wing from beneath. Avoid feathered areas of the web.
3. At about 7 to 10 days after vaccination, a few birds should be examined for takes. A good take reaction, indicating that a satisfactory vaccination job was done, shows swelling in the skin at the point of vaccination with scab formation. The scabs will fall off about 2 to 3 weeks following vaccination.

paramyxovirus in pigeons typically has a clinical picture with neurological symptoms and that is highly contagious., causing immense damage to pigeon flocks in infected areas.

Neurological symptoms are the most common. The pigeons' heads tremble, they twist their necks in a funny way, sometimes so much that the top of their heads points to the ground. Their movements are disordered,. Those with such severe symptoms cannot possibly consume their feed, but consumption of water and food

can be a problem even for those with milder symptoms. The illness can also be accompanied by lameness, with one or both of the pigeon's wings drooping, and there can also be weakness in the legs.
The other typical symptom is large amounts of **watery "diarrhoea"**, sometimes released almost continuously, which makes the floor of the cage look as if it had been hosed down. The large amount of liquid is released from the kidneys under attack by the virus: the damaged kidney tissues are not capable of performing their function of making urine concentrated, and so it becomes abnormally watery and plentiful.
Only healthy pigeons in healthy flocks should be vaccinated. It is important to vaccinate all the pigeons in a loft to optimise loft protection. Young pigeons are often given the first vaccine dose at 4 weeks of age and the second vaccine dose 4 weeks later. An annual booster vaccination is highly recommended.

References:

- A. F. M. F. Islam, C. W. Wong, S. W. Walkden-Brown, I. G. Colditz, K. E. Arzey, and P. J. Groves, "Immunosuppressive effects of Marek's disease virus (MDV) and herpesvirus of turkeys (HVT) in broiler chickens and the protective effect of HVT vaccination against MDV challenge," Avian Pathol., vol. 31, no. 5, pp. 449–461, 2002.
- C. Pejkovski, F. G. Davelaar, and B. Kouwenhoven, "Immunosuppressive effect of infectious bursal disease virus on vaccination against infectious bronchitis," Avian Pathol., vol. 8, no. 1, pp. 95–106, 1979.
- Poultry Health Today, "Controlling infectious bronchitis in broilers starts with breeder vaccination," 2020. [Online]. Available: https://www.thepoultrysite.com/articles/controlling-infectious-bronchitis-in-broilers-starts-with-breeder-vaccination.
- J. Borrell, "Uso de pronutrientes de origen natural en veterinaria," RACVE (Real Acad. Ciencias Vet. España), 2005.
- J. Borrell, C. Domenech, N. Martin, and A. Tesouro, "Pronutrients use in poultry nutrition (S11-0224)," in XXV World's Poultry Congress, 2016, p. 97.
- D. Díez, C. Domenech, J. P. Orpí, and A. Tesouro, "Use of Alquernat Immuplus (botanical product) to improve the efficacy of vaccination against hemorrhagic enteritis in turkeys," in Poultry Sicence Association 108th Annual Meeting Abstracts, 2019, p. 241.
- https://www.msdvetmanual.com/multimedia/table/vaccination-program-for-duck-breeders.

- https://pigeondoctors.com/paramyxovirus/