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THE CONTROL OF NEWCASTLE DISEASE BY VACCINATION - A REVIEW

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SUMMARY: Newcastle disease is a very important viral disease of poultry. Two main control measures are available, namely slaughter combined with quarantine and routine vaccination. Most countries of the world resort to vaccination as a control of Newcastle disease. Types of vaccine virus, routes of administration and vaccination programmes employed varies from country to country depending on the requirements and local conditions of each country.

Key words: Newcastle disease, control, vaccination, review

INTRODUCTION

Newcastle disease (ND) was first recognized in 1926. Since then, it has become one of the most important poultry diseases, causing severe losses to poultry farmers. With the introduction of various control measures in the early 1950s, ND appeared to be under control. However, from the early 1970s, virulent ND reappeared in most continents, spreading very rapidly. This was attributed mainly to the movement of wild birds and to a rapid expansion in the population of pet birds, particularly parrots and other psittacine species (Hanson, 1974).

According to Lancaster (1981a), the control of ND within a country depends on a number of factors:

1. The virulence and diffusibility of the field virus
2. The density of the poultry population and the management practices
3. The fact that in the tropics, a number of poultry diseases are more virulent and more difficult to combat
4. Policies of government and industry regarding the control measures to be implemented
5. The types of ND vaccines available within the country
6. The laboratory facilities available for monitoring the control programmes and conducting research studies
7. The need for poultry farmers to be provided with information on the correct use of ND vaccines and isolation measures

In order to control ND, many countries prevent or control the importation of live birds, both domestic and wild, poultry carcasses and table eggs, which may be infected or contaminated with Newcastle disease virus (NDV). Some countries subject frozen imported poultry carcasses to laboratory examination before these are released for consumption (Lancaster, 1981a).

Allan (1978) discussed such control measures and divided them into six categories:

1. National legislation restricting the movement of poultry, poultry products, pathogenic materials and trade in captive wild birds
2. National control measures on infected farms including the slaughter of birds infected with some or all types of disease, including ND
3. National control measures aimed at establishing and maintaining hygienically run farms
4. Diagnosis of disease and information on disease status in different localities
5. Programmes of vaccination for ND and associated infections such as infectious bursal disease
6. The production, storage and distribution of effective vaccines which are suitable for the locality and type of poultry industry.

In summary, the two main control measures available are slaughter combined with quarantine, and routine vaccination. The choice between these measures depends on the economic situation of the country, the importance of the poultry industry, the prevalence of virulent ND and the system of poultry production in the country. Biosecurity measures at farm level would also help to prevent the entry of NDV into the farm as well as prevent the spread of infection. NDV has been shown to be capable of dissemination over long distances by wind (Smith, 1964) and pet birds especially those belonging to the psittacine family (Dawson, 1973). This mode of spread would be difficult to control, and thus, the most logical measures in many areas will still be to vaccinate all susceptible chickens.

In developed countries, such as Scotland, Scandinavia, Denmark, Northern Ireland (Allan and Stuart, 1974), Southern California (Sharman and Lamont, 1974) and Canada (Lancaster, 1974), control measures of the first type have been conducted with satisfactory results. However, in some countries, for example in Asia, the disease spreads rapidly and as virulent NDV is endemic, slaughter methods are ineffective. In any case, quarantine and slaughter measures are hard to put into practice, and it would be beyond the financial capabilities of these countries to pay the necessary compensation. Therefore these countries, and indeed most countries of the world, resort to the control of ND by vaccination (Biggs, 1982; Lancaster, 1981b). The aim of vaccination is to protect birds not only from death but also from loss of production caused by virulent strains of NDV.

FACTORS INFLUENCING VACCINATION

A variety of vaccines and vaccination programmes has been introduced or developed in different countries according to local requirements. Most vaccination programmes are designed to provide protection from the first week of life, with follow-up vaccinations to protect the older birds. It is up to farmers to choose the most efficient and suitable vaccines and vaccination programmes for their farms.

The success of any vaccination programme depends ultimately on the immune response of the host to the vaccine. This, in turn, depends on many factors:

1. Types of vaccine and vaccine virus
2. Dose of vaccine virus
3. Routes of administration
4. Host
5. Environment

TYPES OF VACCINE AND VACCINE VIRUS

The quality of vaccine is important in that it should contain a strain of virus which will offer maximum protection and optimum potency. Several ND vaccines are available commer-

cially and have been used in many parts of the world; they are of two main types: live and inactivated ND vaccines.

Live ND Vaccines

The live vaccines consist of avirulent, lentogenic and mesogenic strains. The most widely studied avirulent strains of NDV are the Irish strain, Ulster, and one of the Australian strains, V4 which is commercially available. The lentogenic strains commonly used are the F, B1 and La Sota strains, while the mesogenic strains are the Mukteswar strain (Haddow and Idnani, 1946), the Hertfordshire or Herts (H) strain (Iyer and Dobson, 1940), the Komarov or Haifa strain (Komarov and Goldsmit, 1946) and the Roakin strain (Beaudette *et al.*, 1949).

The characteristics of all these virus strains have been described by several workers and summarised by Alexander (1988) and Lomniczi (1975) (Table 1). However, vaccines having the same designation but coming from different manufacturers can vary in their characteristics. This is because they have had different passage histories since isolation.

TABLE 1

Characteristics of strains of Newcastle disease virus

Strain	ICPI	IVPI	MDT	Ha	I	k
Ulster	0.00	0.0	>150	22	60	0.22
V4	0.00	0.0	>150	20	60	0.23
F	0.25	0.0	119	3	2	2.08
B1	0.20	0.0	120	–	< 2	–
La Sota	0.40	0.0	103	2	< 2	2.08
Komarov	1.40	0.0	69	–	–	–
H	1.18	0.0	48	4	30	1.16
Roakin	1.45	0.0	68	–	–	–
Mukteswar	1.40	0.0	46	–	–	–
Hert's 33	1.90	2.6	48	5	45	0.86

Source: Allan *et al.*, 1978 – ICPI, IVPI, MDT values for H strain; Alexander, 1988 – ICPI, IVPI, MDT values for other strains; Lomniczi, 1975 – Ha, I, k values.

Key:
- ICPI – intracerebral pathogenicity index
- IVPI – intravenous pathogenicity index
- MDT – mean death time in hours
- Ha – time of 2 log2 decrease in haemagglutination (minutes) at 56°C
- I – time of 2 log10 decrease in infectivity (minutes) at 56°C
- k – rate constant of thermostability at 56°C
- – – not recorded

a) The Avirulent Strain

V4 Strain : V4 strain was isolated in Australia in 1966 (Simmons, 1967). It possesses heat stable haemagglutinin and infectivity (Lomniczi, 1975; Kim and Spradbrow, 1978a; Westbury, 1978), and spreads readily from infected to contact chickens (Spradbrow, 1987). A number of vaccine studies using this strain has been carried out by several workers (Spradbrow 1987). Of special interest has been the possibility of using this strain as a vaccine to protect Australian birds against any exotic NDV that might be introduced into the country. A company in Austrália has already produced V4 vaccine for export to other countries while

maintaining a stock for use in the event of an outbreak of virulent ND. V4 strain has now been used in the preparation of food pellet vaccine (Aini *et al.*, 1990a; 1990b).

b) The Lentogenic Strains

(i) F Strain : The F strain of lentogenic NDV was first introduced by Asplin (1952). It was isolated from a mild outbreak of ND in England and closely resembles the B1 strain in many of its properties (Anon., 1971). It has been found suitable for the vaccination of chickens of all age groups. This vaccine is most effective when administered to birds individually. Strain F has been used as an intranasal vaccine for both broilers and layers. Mild respiratory signs have appeared in a variable proportion of inoculated chickens but no nervous or intestinal signs have been seen (Asplin, 1952). F strain has the lowest virulence of all the lentogenic vaccine strains in common use (Allan *et al.*, 1978).

(ii) B1 Strain : The characteristics of the B1 or Blacksburg strain were first described by Hitchner and Johnson (1948) who suggested its use as a vaccine. It has been found slightly more effective and more virulent than the F strain and is often administered as a mass vaccine by the drinking water or spray methods. Initial studies showed that it could be used in birds of all ages from day-old to birds in full production. Since then it has been used extensively in different parts of the world. Lancaster (1966) summarized reports on intranasal, conjunctival and drinking water administration of B1 vaccines. He concluded that it caused mild respiratory signs or no clinical signs in chickens.

(iii) La Sota Strain : The La Sota strain was isolated by Beaudette (1946) and introduced as a commercial vaccine in 1952 (Hitchner, 1964). This strain is considered to be more pathogenic than the F and B1 strains. It often causes post-vaccination respiratory signs (Allan *et al.*, 1978), and acts synergistically with *Escherichia coli* or *Mycoplasma* to cause respiratory signs (Gross, 1961). However, it can be of use in flocks which are mycoplasma free, and as a booster vaccine in flocks that have been given B1 or F at an earlier age. The serological response elicited by the La Sota strain has been found to be higher than that from the F or B1 strains (Winterfield and Seadle, 1957). La Sota vaccine has been effective when administered by the aerosol route (Renaut and Zygraich, 1979; Villegas *et al.*, 1976). Ibrahim *et al.* (1983), compared the efficacy of spray vaccination using F, B1 and La Sota vaccines. They concluded that all three strains stimulated satisfactory antibody responses up to nine weeks after vaccination and that the vaccines protected chickens against virulent NDV.

c) The Mesogenic Strains

(i) Mukteswar Strain : The Mukteswar strain originated from the passage of virulent virus in chick embryos (Haddow and Idnani, 1946). It is the most invasive of the mesogenic strains and therefore provides the greatest and most durable immunity (Asplin, 1952; Allan *et al.*, 1978). However, it can only be used in growing birds that have been vaccinated with one or more doses of lentogenic virus vaccines. Adverse reactions leading to respiratory distress, loss of weight or drop in egg production can be observed if this vaccine is used in partially immune chickens. In areas where velogenic NDV is endemic, such as in Southeast Asia, the Mukteswar strain is widely used as a booster vaccine and has been found to be effective in preventing velogenic, viscerotropic Newcastle disease VVND (Allan *et al.*, 1978). Ibrahim et al. (1980) found that chickens revaccinated with freeze-dried Mukteswar strain vaccine at six-weeks-old, after vaccination with F strain at three weeks-old, resisted challenge up to 20 weeks of age.

(ii) Hertfordshire Strain : The Hertfordshire (H) strain is less pathogenic than the Mukteswar strain. It was adapted from virulent virus (Hert's 33) by serial passage through embryonated chicken eggs. This strain is also recommended as a booster vaccination for chickens over eight weeks of age and which have been immunized at an earlier age with lentogenic vaccine. The method of vaccination is usually by the subcutaneous or intramuscular routes. The Hertfordshire strain is not suitable for oral vaccination because there is no or very little spread between birds (Allan *et al.*, 1978).

(iii) Komarov Strain : The Komarov strain was obtained by serial intracerebral passage of virulent virus through ducklings (Komarov and Goldsmit, 1946). It is less pathogenic than the Mukteswar strain. It has been reported to provide adequate immunity against ND and is used as a booster vaccine.

(iv) Roakin Strain : The Roakin strain was isolated as naturally occurring mesogenic strain. It has been used mostly in the United States (Allan *et al.*, 1978) especially in the immunization of turkeys which do not respond well to any lentogenic virus strains. This strain is recommended for use only as a booster vaccine.

Inactivated ND Vaccines

The inactivated vaccines were the first to be studied (Beaudette, 1943). They are produced by the inactivation of infected allantoic fluid using formalin or betapropiolactone. Killed vaccines, when administered by the parenteral route, will induce protective immunity in a large majority of chickens and if widely used, will increase the threshold of resistance and reduce the likelihood of spread of disease to other flocks. If disease does occur in vaccinated flocks, it may be expected to be of reduced severity and short duration.

Beach (1944) reported on the use of inactivated vaccine for the control of ND in California. Although inactivated vaccines protected chickens against paralysis, mortality and drop in egg production, they did not protect the respiratory systems. However, an advantage of the inactivated vaccines is that they are more stable than the live vaccines. Since the virus is inactivated, it is no longer capable of initiating infection or spreading the disease. These vaccines are also safe for use in flocks with intercurrent respiratory infections, in which live vaccines could cause excessive reaction. The inactivated vaccines are also useful in preventing drop in egg production in layers.

A number of workers have described the effect of inactivated ND vaccines (Box and Furminger, 1975; Eidson *et al.*, 1980; Hofstad, 1968; Philips, 1973; Winterfield *et al.*, 1980). Most workers have found that a live vaccine must be given before an inactivated vaccine in order to induce good antibody response. Philips (1973) and Robertson *et al.* (1978) found that under field conditions, inactivated vaccine, when given after a primary dose or doses of live vaccine, induced a satisfactory antibody response. However, inactivated vaccine preparations cannot be applied successfully on a mass, automated basis and thus are not as economical and practical to apply as live virus vaccines. The production of inactivated vaccine is also more expensive than live vaccine as it requires more antigen and the addition of adjuvants in order to increase the immune response. The adjuvants commonly used are oil-in-water emulsions, liquid paraffin and an emulsifier, or aluminium hydroxide gel (Lancaster, 1966; Allan *et al.*, 1978). The efficacy of the inactivated oil-emulsion ND vaccines depends on their formulation, the emulsifier contents, aqueous-to-oil ratios and antigen concentrations.

DOSE OF VACCINE VIRUS

A satisfactory immune response is dependent on an adequate virus titre in live vaccines. A minimum dose is specified by control authorities in many countries. Winterfield and Seadale (1957) suggested the need for minimum titre of $10^{4.5}$ to $10^{5.0}$ fifty percent embryo infective doses (EID_{50}) per ml of drinking water for the B1 strain, and a similar regime was

suggested for the F strain (Winterfield *et al.*, 1957), whereas protection was obtained with a dose of $10^{3.4}$ EID_{50} per ml for the La Sota strain. However, doses commonly employed by other workers are $10^{6.0}$ EID_{50} per bird (Schalkoort and Spradbrow, 1980), or $10^{7.0}$ EID_{50} (Turner *et al.*, 1977; Samberg *et al.*, 1977). A dose of between $10^{5.6}$ to $10^{7.5}$ EID_{50} of strain V4 by the orotracheal, oronasal, intranasal, conjunctival or intramuscular routes appears to be adequate to induce a serological response in susceptible chickens (Turner *et al.*, 1977; Kim *et al.*, 1978b).

Immunity induced by vaccine is also dependent upon the number of vaccinations given. Revacinnation of chickens at appropriate intervals not only produces a rapid and high antibody response but also results in uniform immunity. Programmes using the above vaccines vary between countries, or even among farms within a country. In some countries, vaccination is compulsory, while in others, the programme is actively encouraged or the costs of the vaccine are subsidized (Lancaster, 1964). ND vaccines which are prepared, handled and administered correctly should stimulate a substantial degree of immunity in a large proportion of healthy fowls (Hanson, 1978a).

ROUTE OF ADMINISTRATION

ND vaccines are usually administered parenterally by the intramuscular route, by non-parenteral routes such as the intraocular or intranasal, or by drinking water, sprays or aerosols. Other non-parenteral methods have also been reported in experimental situations. These include the use of vaccines incorporated into food pellets (Hanson, 1982; Aini *et al.*, 1990a; 1990b), or dust (Markham *et al.*, 1955; Kraft and Baumer, 1975) and delivery of vaccine directly to the crop or intestine (Cheville *et al.*, 1972; Shuaib *et al.*, 1985; Samuel, 1987; Spradbrow *et al.*, 1988).

Several workers have shown that the immune response in the individual chicken depends largely on the method of administration of the vaccine (Lancaster, 1981a).

Parenteral Route of Administration

a) Intramuscular Route

This is the best method of giving an accurate dose of vaccine to each individual chicken. However, chickens have to be handled individually, thus stressing the chickens and increasing the cost of labour. This method is also not practical for indigenous chickens that are kept on a free range system. The live Mukteswar strain is commonly administered by the intramuscular route (Chew and Liow, 1974), as are inactivated vaccines (Philips, 1973; Robertson *et al.*, 1978).

Intramuscular inoculation of antigen induced the production of humoral antibodies only (Beard and Brugh, 1975).

b) Subcutaneous Route

This route of vaccination is sometimes used for inactivated vaccines (Giambrone and Clay, 1986).

Non-parenteral Route of Administration

a) Intranasal or Intraocular Conjunctival Drop

These routes of vaccination can be used for live lentogenic vaccines which include the B1, F and La Sota strains. These methods usually result in little or no post vaccination reactions; this has been observed with the B1 strain (Hitchner and Johnson, 1948; Lancaster, 1966) and

the F strain (Lancaster, 1966; Allan *et al.*, 1978; Ibrahim *et al.*, 1983). Australian lentogenic strains, V4 (Simmons, 1967) and CT (Turner and Kovesdy, 1974), are also capable of producing immunity against virulent virus when administered either intranasally or intraocularly (Turner *et al.*, 1977).

Birds immunised by respiratory exposure can produce both local and systemic antibody (Beard and Brugh, 1975). The acinous mucous cells in the respiratory tract act as target when the virus is introduced via the respiratory tract. The virus disseminates to other organs, such as the liver, spleen, kidney and brain (Cheville and Beard, 1972). For intraocular vaccination, the virus gain access to local aggregates of lymphoid tissue in the eye (Harderian gland) resulting in antibody production (Albini *et al.*, 1974).

Beard and Easterday (1967) evaluated the effects of the route of vaccination on (i) humoral antibody, (ii) resistance to infection, and (iii) the development of disease following challenge. They found that intranasal and intraocular administration were less effective than the aerosol route. The main advantage of the intranasal or intraocular methods of vaccination is that they usually result in antibody responses four times greater than those obtained by drinking water vaccination (Lancaster, 1981a). These are also practical methods of vaccination for day-old chicks that must be handled as they are taken from the incubator, although maternally derived antibodies can be a problem at this age. However, the disadvantage of using these routes of vaccination is that the chickens to be vaccinated need to be handled individually.

b) Drinking Water Route

In countries where ND is enzootic, mass application of ND vaccine by drinking water or aerosol is most commonly practised, as less time and labour are required than for individual administration (Allan, 1971; Hanson, 1978b). The F and B1 strains of NDV are commonly used for drinking water vaccination. Drinking water vaccination is also practised in farms that have large flocks of birds, especially in battery systems, where individual vaccination is impractical. However, the quality of the water in which oral vaccine is suspended may limit the infectivity of the virus (Gentry and Braune, 1972). Water sources in some regions may contain alkali, iron or copper, and water may be contaminated with disinfectants, residues or certain metal ions, and these are rapidly viricidal. The addition of 1 part of powdered skim milk to 400 parts water has been effective in protecting the vaccine virus in drinking water (Gentry and Braune, 1972).

The other major disadvantage of drinking water vaccination is lack of uniformity in dosage, which may result in ineffective immune responses in some birds (Allan *et al.*, 1978). Drinking water vaccination is also not suitable for large commercial farms where automatic drinkers and pressure tanks are used. The water tank needs to be emptied, then filled with clean water before the vaccine virus is added.

In drinking water vaccination, the virus not only pass into the gullet and the digestive tract, but also have contact with the nasal epithelium, and through droplets formed in the process of drinking, also reach into the deeper passages of the respiratory tract.

c) Spray or Aerosol Route

This type of vaccination involves the application of live lentogenic virus either in the form of a spray with droplet size ranging from 10 to 100 microns, or in the form of an aerosol with droplet size from less than 1 up to 50 microns. One advantage of spray and aerosol vaccination is the relative ease and rapidity of application. In general, aerosol vaccination can be effectively used in closed houses and gives the most reliable immune response, compared to other routes (Gough and Alexander, 1973). However, this method is impractical in tropical countries which have open chicken houses.

There are other constraints of the spray or aerosol routes of vaccination. According to Markham *et al.* (1955), the effectiveness of aerosol application is determined by the interplay of two factors: particle size and virus concentration. With spray vaccination, as the particle size is greater, many may fall away from the birds leaving few particles to reach the upper respiratory tract, and none may reach the lungs. Aerosol vaccination results in fine particles that may tend to dry up before reaching the birds, and thus not all the virus particles reach the target cells. However, these fine particles are deposited in deep pulmonary spaces reaching the target cells, thus giving a faster immune response (Allan *et al.*, 1978). Beard and Easterday (1967) speculated that the resistance of the respiratory tract conferred by aerosol vaccination might be due to production of local antibody by lymphoid cell aggregates in nasal mucosa.

Determination of the dose received per bird is constrained by the difficulty in deciding on the virus concentration, the period of spraying and the aerosol particle size. The calculated dose of vaccine virus given per bird is usually $10^{6.0}$ EID_{50} (Lancaster, 1981a) or $10^{7.0}$ (Samberg *et al.*, 1977), but the amount received by the bird may be influenced by the type of diluent used (Yadin and Orthel, 1978). The environmental circumstances such as the ambient temperature will also affect the response (Allan *et al.*, 1978), and there are occasional vaccine reactions (Hanson, 1978b). Flocks infected with *Mycoplasma gallisepticum* are susceptible to respiratory reactions following aerosol vaccination (Allan *et al.*, 1978). Allan and Borland, (1979), found that La Sota strains were more damaging to the respiratory tract than the B1 strains. This may be associated with a better immune response to the La Sota strains.

The other disadvantage of aerosol vaccination is the hazard that it may pose to the person administering the vaccine. There is the need for protective clothing and air filters to avoid inhaling the virus particles. Adequate electrical outlets are also necessary in large sheds to ensure that the whole area can be covered.

d) Dust Vaccination

Dust vaccine is prepared by lyophilizing a mixture of vaccine virus and defatted milk powder dissolved in distilled water. The dry preparation is pulverised in a mortar and vaccination is carried out by powdering the dry vaccine preparation onto normal chicken feed which is then fed to the chickens. This type of vaccination has not received extensive studies. Markham *et al.* (1955) described the first dust vaccination; their study was followed by that of Price *et al.* (1955) and Dardiri *et al.* (1961). Later, Lancaster (1966), reported on early studies using live B1 virus in a dust method. He found that there were reactions after vaccination which became more severe in chicks exposed to *E. coli* or *Mycoplasma*. Kraft and Baumer (1975) repeated the work of Markham, using a dry preparation of B1 strain mixed with the normal dry feed mash. They found that dust vaccine against ND produces similar titres in four to five week–old specific pathogen free (SPF) chickens as does drinking water vaccine. This method may be of advantage in places where water supply systems are unsuitable.

e) Pellet Vaccine

Hanson (1982) reported work on a pellet vaccine using the V4 strain. The virus was mixed into a sugar–protein paste and dried to make a pellet that could be eaten by chickens. Chickens fed with this vaccine were protected when challenged with a highly virulent NDV. Recently Aini *et al.* (1990a; 1990b) reported development of a food pellet vaccine using V4–UPM virus and successful trials were conducted with vaccine incorporated onto food pellets or grains. The chickens could be fed with the food pellet vaccine, removing the necessity of handling the birds for vaccination. Further work is in progress to improve the vaccine and produce it commercially.

f) Intracrop Vaccination

This method of vaccination has only been described at an experimental level, as part of the studies on oral vaccination and the pathogenesis of NDV in the intestinal tract (Shuaib *et al.*, 1985; Samuel, 1987; Spradbrow e*t al.*, 1988). It is not practical for routine vaccination. The studies also show that sites of infection for V4 virus seem to include the crop (Samuel, 1987).

g) Intratracheal Vaccination

Eidson *et al.* (1976) vaccinated groups of day–old chicks with varying levels of maternal antibody against ND, using B1 strain in a device which simultaneously debeaks the chick and emits a fine spray of vaccine into its trachea. Chicks with low to moderate levels of maternal antibody attained a satisfactory antibody response, but chicks with extremely high levels of maternal antibody had a minimal antibody response.

CONDITION OF THE HOST

The host and its condition at the time of vaccination are two very important factors to be considered in any vaccination programme. Firstly, the chickens to be vaccinated should be healthy; and secondly, the age of chickens at the time of vaccination has to be considered. The age of chickens has at least two distinct effects on the immune response. The immune mechanism of chickens is not fully developed until about 10 weeks of age (Chu and Rizk, 1975). Very often chicks are vaccinated between day–old and three weeks of age, during which they are not immunologically mature and are not capable of responding fully to a vaccine. The presence of the maternal antibody may also affect the response of chicks to vaccination and the severity of reaction to vaccination. Too early vaccination may result in neutralisation of the administered virus by maternal antibodies, thereby reducing or eliminating the potential of the vaccine. Chicks with maternal immunity from vaccinated hens showed little response to ND vaccine given at one day–old (Chu and Rizk, 1975). The possibility of the chicks that received early vaccination developing memory cells, such that there will be an amnestic response when a second vaccination is given, has not been investigated.

Vaccination of maternally immune chickens, by the intranasal route or through drinking water at one day old, failed to induce any stimulation of haemagglutination inhibition (HI) antibody irrespective of whether 1×10^7 EID_{50} or 5×10^7 EID_{50} doses were given (Ibrahim *et al.*, 1982). Another problem with the maternal antibody is that the titres of the chicks are not uniform. Thus only a percentage of the individuals in a flock is susceptible to vaccination and gives a satisfactory immune response. Therefore vaccination of chicks from immune hens should be delayed to about three weeks of age so that the maternal antibody in the majority of chicks drops to a level which will no longer inhibit the response of the chicks to the vaccine (Chu and Rizk, 1975).

Immunosuppressive diseases such as infectious bursal disease, Marek's disease, lymphoid leukosis and reticuloendotheliosis can result in a markedly adverse effect on the ability of the birds to respond to ND vaccine (Faragher *et al.*, 1974; Beard, 1978; Sharma, 1978). The intensity of immunosuppression is proportional to the severity of the disease process. From this aspect, the time of the first vaccination is also important. Infectious bursal disease virus can cause irreversible damage to the lymphoid tissue of the bursa of Fabricius. Vaccinating chicks against ND at one day–old can avoid the immunosuppressive effect of infectious bursal disease on ND vaccination (Meulemans *et al.*, 1977). Though in general, vaccination of chicks with maternal antibody should not be done at day–old, in situations of high risk of infection by immunosuppressive diseases, such vaccination is indicated. Thus the time of the first vaccination depends on the immune status of the chicks, as well as on the risk of immunosuppressive diseases.

The presence of other infectious diseases such as infectious bronchitis and coccidiosis also plays a role in the host's response to vaccination. Concurrent diseases will result in a depressed immune response to vaccination.

Stress has an important effect on the immune response. Heat, cold and population density stress can immunosuppress the animals. Spalatin and Hanson (1974) demonstrated that food and water deprivation for 12 hours before exposure to a challenge virus reduced the survival time, and increased the mortality of chickens. On the other hand, if the deprivation preceded vaccination, it appeared to prime the physiological system of the chickens and produce a more effective response to an avirulent virus. The severity of social stress and changes in environmental temperatures can also affect the immune response of chickens (Sinha *et al.*, 1957). Chickens that are lower down in the pecking order tend to get less food, and this lowers the body's resistance. Extremely low or high ambient temperatures stress the chickens, thus decreasing their immune response to vaccination.

ENVIRONMENT

The environment also plays a role in the choice of vaccine and route of vaccination adopted. The concentration and distribution of virulent NDV in an area is an important factor to be considered. In areas like Southeast Asia, where virulent NDV is endemic, routine vaccination and a strongly protective vaccine is required. Thus, the Mukteswar strain is commonly used as a booster vaccine in these areas and it is usually administered intramuscularly.

CONCLUSION

Most countries of the world resort to vaccination as a method of control for Newcastle disease. The types of vaccine virus, routes of administration and vaccination programmes, vary from country to country. Types of management will also decide the suitability of the route of vaccination. Some vaccines are only suitable for well organised farms. Mass vaccination by aerosol or spray is only suitable for chickens kept in an enclosed and well covered house. Drinking water vaccination can only be used in areas where water supply is clean and the water does not contain substances that have detrimental effects on the virus. Intraocular, intranasal and intramuscular routes of administration are applicable to chickens that are reared in sheds or cages, and can be easily and quickly caught for individual vaccination.

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RINGKASAN

PENGAWALAN PENYAKIT NEWCASTLE SECARA PEMVAKSINAN – SATU PANDANGAN

Penyakit Newcastle adalah satu penyakit virus yang penting bagi ayam. Dua cara pengawalan utama yang terdapat bagi penyakit ini ialah penyembelihan berserta kurantin dan pemvaksinan yang rutin. Kebanyakan negara di dunia ini menggunakan pemvaksinan sebagai cara pengawalan bagi penyakit Newcastle. Jenis vaksin virus, cara penyampaian dan program pemvaksinan yang diikuti adalah berbeza dari satu negara ke negara yang lain bergantung kepada keperluan dan keadaan setempat bagi setiap negara.