



## Research Paper

Infectious Bronchitis Virus in Broiler Chickens:  
Seroprevalence and Associated Risk FactorsOmar Salhi<sup>1</sup>, Chafik Redha Messai<sup>2</sup>, Mustapha Nabi<sup>1</sup>, Nassim Ouchene<sup>1,3\*</sup>, Nadjat Amina Khelifi Touhami<sup>1,3</sup>

1. Institute of Veterinary Sciences, Saad Dahlab University of Blida, Ouled Yaïch, Algeria.

2. Laboratory of Research Health and Animal Production, High National Veterinary School, Algiers, Algeria.

3. Normal High School of Technological Teaching, Skikda University, Skikda, Algeria.



**How to cite this article** Salhi O, Messai ChR, Nabi M, Ouchene N, Touhami NAKh. Infectious Bronchitis Virus in Broiler Chickens: Seroprevalence and Associated Risk Factors. *Archives of Razi Institute Journal*. 2025; 80(6):1507-1514. <https://doi.org/10.32598/ARL80.6.3501>

**doi** <https://doi.org/10.32598/ARL80.6.3501>

## Article info:

Received: 21 May 2025

Accepted: 26 Jun 2025

Published: 01 Nov 2025

## Keywords:

Broiler chicken, Infectious  
Bronchitis Virus, Risk Factors,  
Seroprevalence

## ABSTRACT

**Introduction:** Infectious bronchitis virus (IBV) is one of the most important viral diseases, causing considerable economic losses in the poultry industry worldwide. The present study was conducted in Algeria to investigate the seroprevalence, associated risk factors, clinical signs, and lesions of IBV disease in broiler chicken.

**Materials & Methods:** The study was conducted in 63 chicken farms, where three IBV vaccination protocols were used in the first protocol: A single H120 dose was administered to the chicks at 7 days of age, in the second protocol: H120 at 3 days with an MA5 booster at 14 days, and in the third protocol: H120 at 3 days with MA5 and 4/91 boosters at 14 and 35 days, respectively. A total of 2142 sera were collected and analyzed using the enzyme-linked immunosorbent assay (ELISA) test.

**Results:** IBV was detected in 77.77% of broiler farms. The most common clinical signs observed were wheezing, sneezing, coughing, nasal discharge in the respiratory form, aqueous diarrhea, and dehydration in the nephropathogenic form. Lesions included tracheitis, fibrin deposition in the respiratory form, hemorrhagic nephritis, uric acid deposition at the renal, visceral, and articular level in the nephropathogenic form. Antibody titers were higher in winter compared with autumn and spring ( $P<0.01$ ). Antibody titers were also higher in chickens aged  $>30$  days, in farms with a high density, poor hygiene level, and under the first vaccination protocol, compared with chickens aged  $\leq 30$  days ( $P<0.01$ ), farms with a low density ( $P<0.001$ ), farms with good hygiene level ( $P<0.01$ ) and those under the third vaccination protocol ( $P<0.01$ ).

**Conclusion:** These findings showed a high seroprevalence of IBV in Algeria and highlight the importance of continuous surveillance and molecular characterization of persistent strains to optimize vaccination strategies against emerging variants.

## \* Corresponding Author:

Nassim Ouchene, Professor.

Address: Institute of Veterinary Sciences, Saad Dahlab University of Blida, Ouled Yaïch, Algeria.

E-mail: [ouchene\\_nassim@univ-blida.dz](mailto:ouchene_nassim@univ-blida.dz)

Copyright © 2025 The Author(s).  
This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International license (<https://creativecommons.org/licenses/by-nc/4.0/>).  
Noncommercial uses of the work are permitted, provided the original work is properly cited.

## 1. Introduction

Infectious bronchitis virus (IBV), belonging to the genus gamma Coronavirus, is an important viral disease in chickens industry worldwide, causing several economic losses [1]. The virus is characterized by high genetic and pathogenic variability, and new strains continue to emerge [2]. Transmission occurs via inhalation or contact with contaminated objects [1].

In broiler chickens, the disease is characterized by respiratory signs (tracheal rales, coughing, and sneezing), weight losses, reducing in feed efficiency, and bacterial super-infections [1, 3]. IBV infections may result in reduced egg production of up to 70%, declines in eggshell quality in layer and breeders, and low mortality rate [1]. Nephropathogenic IBV strains, however, can cause high mortality due to kidney failure [1].

Different diagnostic methods are routinely used to detect antibody responses in sera samples, such as enzyme-linked immunosorbent assay (ELISA) [4]. Moreover, many molecular methods have been developed to detect IBV genotypes [5].

Reported seroprevalences of avian IBV varied between countries; ranging from 43% in South Africa [6] and 84% in Nigeria [7].

IBV has become a serious problem, especially in north Africa, due to intensive poultry farming practices [8]. In Algeria, it was first detected by Sid et al. [9] in Medea regions. The present study was conducted to investigate the antibody titers, the seroprevalence, clinical signs, and lesions of IBV in broiler chickens, and to assess the associated risk factors.

## 2. Material and Methods

### 2.1. Study area and design

The study was carried out in north- central, eastern and western Algeria from September 2022 to May 2023. It was conducted in sixty- three (63) broiler chicken farms, each containing 3,000 to 15,000 chickens with different strains (Arbor acres, Cobb 500, Big fast), aged between four and seven weeks.

In all farms, broiler chickens were vaccinated against IBV with live vaccines using three different protocols:

**Protocol 1:** Chicks were vaccinated against IBV at 7 days of age with a live IB H120 strain vaccine.

**Protocol 2:** Chicks were vaccinated against IBV at 3 days of age with a live H120 strain vaccine, followed by a booster at 14 days of age with a live MA5 strain vaccine.

**Protocol 3:** Chicks were vaccinated against IBV at 3 days of age with a live H120 strain vaccine, followed by a booster at 14 days of age with a live MA5 strain vaccine and a second booster at 35 days of age with a live 4/91 strain vaccine.

### 2.2. Clinical and lesional diagnosis

Clinical diagnosis of IBV disease was based on symptoms accompanied by lesion examination.

### 2.3. Blood samples

From the 63 farms, a total of 2142 chickens were randomly selected for two blood samples. The first sample was taken as soon as the first clinical signs of IBV appeared, and the second sample was taken 2 to 3 weeks later.

Blood samples were collected aseptically from the wing vein of each chicken. About 3-5 mL were collected in dry tubes and centrifuged (5000 rpm for 10 min) immediately to recover sera, which were stored at -20 °C until analysis.

### 2.4. Serological analysis

Serological analysis was conducted to measure antibody titer level against IBV and performed using the indirect ELISA method. The test was performed with a commercial kit (ID Screen® IBVS Indirect) of IDvet Innovative Diagnostics kits (Montpellier, France).

The protocol was standardized according to the manufacturer's instructions. Sera were diluted 1:500, then loaded to ELISA plates to start immunosorbent reaction. ELISA plates were read using ELx800 spectrophotometer (BioTek™, USA) equipped with a 405 nm filter; where the measured optical density (OD) was transformed into titrated antibody. The averages of the antibody titers and the coefficient of variation (CV) were automatically calculated by band and by series of samples using the software provided by the laboratory (ID Soft™ 5.05, Montpellier, France).

### 2.5. Interpretation of the ELISA results

According to the manufacturer’s instructions, the average antibody titers expected 3-5 weeks after using one live IBV vaccine range from 500 to 1000. For two live vaccines+Variant, the antibody titers vary from 1000 to 2000 after 3-5 weeks after vaccination. The CV should be between 40% and 60% for effective vaccination.

Antibody titers below 500 indicate poor or no vaccination or presence of an immunosuppressive disease and above 1000 for a single live vaccine and 2000 for two live vaccines+variant, indicate IBV disease.

### 2.6. Statistical analysis

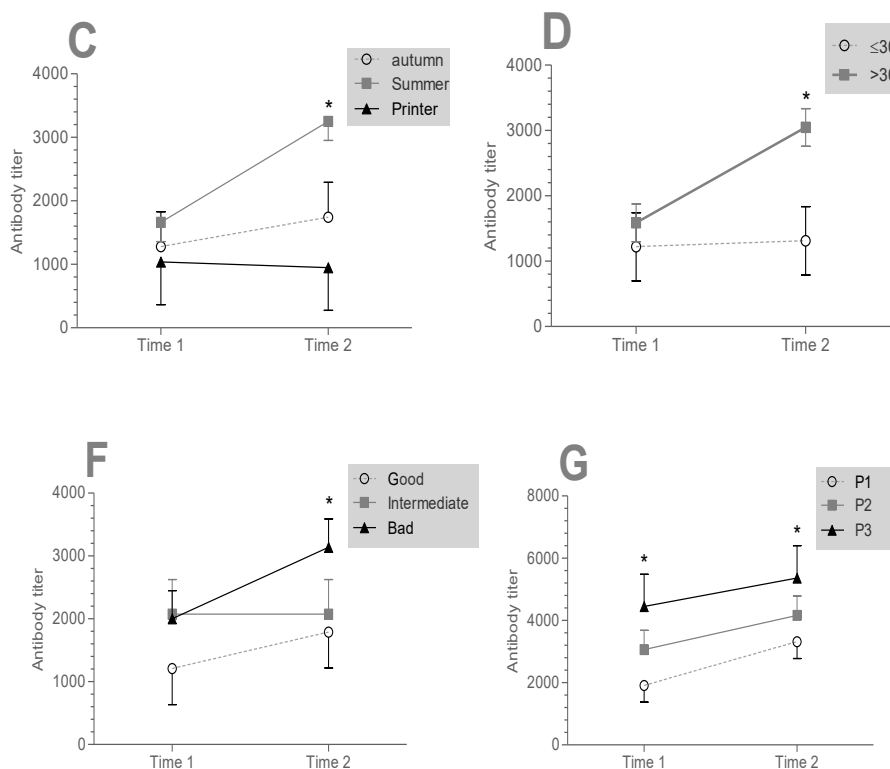
Descriptive statistics were used to characterize flocks according the different factors. Statistical analyses were performed with SAS (Version 9.1.3; SAS Institute Inc., Cary, NC). Antibody titers over the time were analyzed by fitting the fixed effects of day, group and the interaction of day×group in a repeated measures variance analysis using PROC MIXED models, with the random effect of herd (SAS Inst. Inc. 9.1). Covariance structure

used (compound symmetry or autoregressive [AR1]) was chosen based on the Akaike information criterion. The layout of our model can be summarized as follows:  $Y_{ijk} = \mu + G_i + T_k + GT_{ik} + \epsilon_{ijk}$ . Where  $Y_{ijk}$ =Antibody titer,  $\mu$ =overall mean,  $G_i$  = effect of group,  $T_k$  = effect of time of sampling (k=1 and 2),  $GT_{ik}$ =effect of group × time and  $\epsilon_{ijk}$ = random residual error. A stacked line plots of Antibody titer changes were generated using Prism 5.01 (GraphPad Software, Inc. La Jolla, CA USA).

### 3. Results

Out of 63 broiler chicken farms, 49(77.77%) were seropositive for IBV. A low CV (8-35%) was observed and the global means of antibody titer in the second time of sampling (4676) was significantly higher compared with the first time of sampling (1973) (SE=326.53) (P<0.0001).

At the second time of samples, antibody titers varied significantly according to the season, chicken age, chicken density in the farms, hygiene level in the farms and vaccination protocol (Table 1, Figure 1). The an-



**Figure 1.** Risk factors affecting antibody titers of IBV

Note: Time 1: First sample; Time 2: Second sample; C: Season, D: Age, F: Hygiene, G: Protocol of vaccination.

**Table 1.** Antibody titers of IBV in the first and second time of sampling (TS1 and TS2) according to the different factors

Factors		TS1	TS2	SE	P
Area	East	4448.16	5366.03	1038.28	0.62
	Center	1912.21	2314.65	537.54	
	West	3065.21	4162.75	618.19	
Climate	Dry	1715.66	2624.74	535.39	0.89
	Wet	1577.13	2872.91	382.58	
Season	Autumn	1278.5	1740.5 <sup>a</sup>	550.78	<0.01
	Winter	1661.25	3252.4 <sup>b</sup>	301.67	
	Spring	1038.5	948.00 <sup>a</sup>	674.56	
Age (d)	≤30	1220.14	1312 <sup>a</sup>	522.13	<0.01
	>30	1587.35	3047.78 <sup>b</sup>	288.05	
Density (birds/m <sup>2</sup> )	>10	1772.33	3658.6 <sup>b</sup>	332.69	<0.001
	≤10	1277.73	1771.55 <sup>a</sup>	388.5	
Mortality	<10	1812.72	3048.55	705	0.71
	≥10	1687.62	2805.03	371.14	
Hygiene	Good	1206.86	1788.71 <sup>a</sup>	571.71	<0.01
	Intermediate	2076.32	2076.32 <sup>b</sup>	549.96	
	Bad	2001.62	3139.7 <sup>b</sup>	447.8	
Strain	Arbor acres	2108.08	3274.8	564.63	0.48
	Cobb 500	1227.18	1227.18	1227.18	
	Big fast	2304.99	3231.72	610.57	
Protocol of vaccination	3	1912.21 <sup>a</sup>	3314.65 <sup>a</sup>	537.54	<0.01
	2	3065.21 <sup>ab</sup>	4162.75 <sup>ab</sup>	618.19	
	1	4448.16 <sup>b</sup>	5366.03 <sup>b</sup>	1038.28	

SE: Standard error.

Note: Values with different letters in the same column were different significantly.

tibody titers were higher in winter season compared with autumn and spring season ( $P<0.01$ ). Moreover, the antibody titers were higher in chickens aged >30 days, in farms with a high density (>10 birds/m<sup>2</sup>), in farms with poor hygiene level and under the first vaccination protocol. In contrast, titers were lower chickens aged ≤30 days ( $P<0.01$ ), in farms with a low density (≤10 birds/m<sup>2</sup>) ( $P<0.001$ ), in farms with good hygiene level ( $P<0.01$ ) and under the third vaccination protocol ( $P<0.01$ ) (Table 1, Figure 1).

However, there was no significant effect of area, climate, and strain groups on the antibody titers.

All chickens clinically suspected of IBV were confirmed seropositive. The most common clinical signs observed were: Wheezing, sneezing, coughing, and nasal discharge for respiratory form, and aqueous diarrhea, dehydration, and high rate of mortality for nephropathogenic form.

The most frequent lesions observed were: Tracheitis (congestion of the tracheal mucosa) and fibrin deposition for respiratory form, and hemorrhagic nephritis, uric acid deposition at the renal and visceral level (visceral gut), and uric acid deposition at the joint level (articular gout) for nephropathogenic form.

#### 4. Discussion

The IBV is characterized by the continuous emergence of new serotypes. Therefore, identification of the genotype of strains is necessary to reduce the low degree of cross-protection of commercial vaccines among the different serotypes [10]. It is well known that the occurrence of IBV disease in vaccinated flocks is quite frequent, possibly due to inappropriate vaccination or the emergence of new strains of the virus [11]. In many African countries, mass-produced IBV serotypes cause sporadic outbreaks in the commercial poultry industry [12]. Vaccination success also depends on the choice of vaccine strain and vaccination protocol [13].

The incidence of IBV in vaccinated flocks may be influenced also by inadequate vaccination practices. Messaï et al. [14] reported that the following factors influence the success of vaccination: Poor water quality, water that may contain disinfectants neutralizing the live vaccine, insufficient number of troughs on farms, and failure to maintain the vaccine storage cooling chain.

Effectively, all these factors can explain the presence of IBV, in this study, in broiler chicken farms despite vaccination.

The seroprevalence of IBV observed in this survey (77.77%) aligns with the reports from Nigeria 82.7% [15]. This high prevalence of IBV could be attributed to several factors including the presence of carriers of the virus in the environment, its ability to spread over significant distances via aerosol, and the highly transmissible nature of the IBV [16].

The overall seroprevalence of IBV revealed in this survey is higher than other studies conducted in Grenada (31.01%) [17] and Maiduguri (26.6%) [18], likely due to differences in agro-climatic conditions, sample size, management systems and increased IBV activity in the study area [19].

Protected poultry flocks should have an average antibody titer above the protection threshold without being very high compared to the titer resulting from vaccination, and without specific clinical signs [20]. In this

study, the sampled chickens were suspected of being infected with IBV and showed typical clinical signs and necropsy lesions despite being vaccinated. Two blood samples were taken; the first sample was taken at the onset of clinical signs of the disease and the second sample was taken two to three weeks later. The antibody titer increased significantly between the 0.2 sets of sera taken indicating a stimulation of the immune system due to recent infection, reported by Lopez [21], Salhi et al. [22], Messaï et al. [14].

In this investigation, the most common clinical signs observed were: Rales, sneezing, coughing, nasal discharge for the respiratory form, and aqueous diarrhea and dehydration, for the nephropathogenic suspected form. These findings are in agreement with Abdel-Moneim et al. [3].

Bing et al. [23] signaled that nephropathogenic IBV was prevalent in the vaccinated chickens and resulting in a high mortality for the 20 to 50-day-old chickens. This is in line with our finding herein.

The observed lesions were: Tracheitis, fibrin deposition and colibacillosis complication for the respiratory form. Interstitial nephritis, uric acid deposition at the renal level and viscera, uric acid deposition at the articulation level were observed in the nephropathogenic form. These observations are consistent with those reported by Abdel-Moneim et al. [3].

In this study, older hens (over 30 days old) were the most infected, likely due to continuous exposure to the disease, resulting in a higher prevalence in adult chickens [24]. This indicates that strengthening biosecurity measures on farms can help reduce virus transmission with adequate ventilation and reduction of overcrowding [24]. Overcrowding on farms is thought to be a factor in the introduction and implantation of the virus [1].

The IBV is observed mainly in winter [25], consistent with our results. The origin of this seasonality may be attributed to environmental changes, changes in host physiology or alterations in the virus [26].

The prevention of IBV disease is based on hygiene and medical prophylaxis, therefore, it is important to highlight that no vaccine can solve the problem of IBV if the necessary precautions are not taken, such as compliance with husbandry methods like cleaning and disinfection and sanitary vacuums [1]. In our case the dirty farms effectively presented the highest levels of antibody titers.

De Wit et al. [27] reported that vaccination with a single mass strain protects hens from 76.5% up to 100%, while using mass and a booster with a variant gives protection in the range of 99-100%, against wild variant strains circulating in the field, consistent with our results. Indeed, when we did boosters in the second and third vaccination protocols, the antibody titers were not high in the first and second sampling times, explaining why the herds were better protected compared to those herds using a single vaccine (first protocol).

The chicken strain had no effect on infection status in this study. However, in some studies, it has an effect on seroprevalence linked to a difference in the level of seroprotection of the disease or to a genetic difference in strains against the disease [27].

## 5. Conclusion

In conclusion, the IBV is a highly prevalent disease (77.77%) in broiler chicken farms in Algeria despite vaccination. The continuous appearance of new serotypes of the virus leads to the vaccine failure. The antibody titers were significantly higher in chickens sampled in winter, in chickens >30 days old, in high-density farms, and in farms with poor hygiene. The control of all these factors significantly certainly reduces the prevalence of IBV within farms. The continuous emergence of new variants of the virus underlines the importance of a continuous surveillance of IBV to optimize vaccination strategies. Therefore, the identification and molecular characterization of persistent serotypes of IBV circulating in the field are recommended.

## Compliance with ethical guidelines

Experimental procedures were approved by the Institutional Committee for the Protection of Animals of the National Administration of Higher Education and Scientific Research of Algeria (Code: 98-11, Act of 22 August 1998).

## Data availability

Data are available upon request from the corresponding author.

## Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

## Authors' contributions

Conceptualization, study design, and experiments: Omar Salhi and Chafik Redha Messai; Data analysis and interpretation: Mustapha Nabi, Nassim Ouchene and Nadjet Amina Khelifi Touhami; Writing: Omar Salhi, Nassim Ouchene, and Nadjet Amina Khelifi Touhami.

## Conflict of interest

The authors declared no conflict of interest.

## References

- [1] Rafique S, Jabeen Z, Pervaiz T, Rashid F, Luo S, Xie L, et al. Avian infectious bronchitis virus (AIBV) review by continent. *Front Cell Infect Microbiol.* 2024; 14:1325346. [DOI:10.3389/fcimb.2024.1325346] [PMID]
- [2] Abao ES, Manalo LA, Barro JR, Gonato RP, Keith C, Ybañez SA. Negative Sero-occurrence of Infectious Bursal Disease, Newcastle Disease and Infectious Bronchitis in Japanese Quail. *Int Res J Interdiscip Multidiscip Stud.* 2015; 7:13-8. [Link]
- [3] Abdel-Moneim AS, Zlotowski P, Veits J, Keil GM, Teifke JP. Immunohistochemistry for detection of avian infectious bronchitis virus strain M41 in the proventriculus and nervous system of experimentally infected chicken embryos. *Virologia.* 2009; 6:15. [DOI:10.1186/1743-422x-6-15] [PMID]
- [4] Desingu PA, Singh SD, Dhama K, Kumar OR, Singh R, Singh RK. Development of slide ELISA (SELISA) for detection of four poultry viral pathogens by direct heat fixation of viruses on glass slides. *J Virol Methods.* 2014; 209:76-81. [DOI:10.1016/j.jviromet.2014.08.010] [PMID]
- [5] Alhatami AO, Alaraji F, Abdulwahab HM, Khudhair YI. Sequencing and phylogenetic analysis of infectious bronchitis virus variant strain from an outbreak in egg-layers flocks in Baghdad, Iraq. *Vet World.* 2020; 13(7):1358-62. [DOI:10.14202/vetworld.2020.1358-1362] [PMID]
- [6] Thekisoe MM, Mbatia PA, Bisschop SP. Diseases of free-ranging chickens in the Qwa-Qwa District of the northeastern Free State province of South Africa. *J S Afr Vet Assoc.* 2003; 74(1):14-6. [DOI:10.4102/jsava.v74i1.490] [PMID]
- [7] Owoade AA, Ducatez MF, Muller CP. Seroprevalence of avian influenza virus, infectious bronchitis virus, reovirus, avian pneumovirus, infectious laryngotracheitis virus, and avian leukosis virus in Nigerian poultry. *Avian Dis.* 2006; 50(2):222-7. [DOI:10.1637/7412-071505r.1] [PMID]
- [8] Fellahi S, El Harrak M, Ducatez M, Loutfi C, Koraihi SI, Kuhn JH, et al. Phylogenetic analysis of avian infectious bronchitis virus S1 glycoprotein regions reveals emergence of a new genotype in Moroccan broiler chicken flocks. *Virologia.* 2015; 12:116. [DOI:10.1186/s12985-015-0347-8] [PMID]

- [9] Sid H, Benachour K, Rautenschlein S. Co-infection with Multiple Respiratory Pathogens Contributes to Increased Mortality Rates in Algerian Poultry Flocks. *Avian Dis.* 2015; 59(3):440-6. [DOI:10.1637/11063-031615-case.1] [PMID]
- [10] Jones RC, Savage CE, Naylor CJ, Cook JK, El-Houadfi M. A Possible North African progenitor of the major European infectious bronchitis variant (793B, 4/91, CR88). *Proceedings of the IV International Symposium on Avian Corona and Pneumovirus Infections.* Rauschholzhausen. 2004; 105-11. [Link]
- [11] Smati R, Silim A, Guertin C, Henrichon M, Marandi M, Arella M, et al. Molecular characterization of three new avian infectious bronchitis virus (IBV) strains isolated in Quebec. *Virus Genes.* 2002; 25(1):85-93. [DOI:10.1023/a:1020178326531] [PMID]
- [12] Bande F, Arshad SS, Omar AR, Hair-Bejo M, Mahmuda A, Nair V. Global distributions and strain diversity of avian infectious bronchitis virus: A review. *Anim Health Res Rev.* 2017; 18(1):70-83. [DOI:10.1017/s1466252317000044] [PMID]
- [13] Jordan B. Vaccination against infectious bronchitis virus: A continuous challenge. *Vet Microbiol.* 2017; 206:137-43. [DOI:10.1016/j.vetmic.2017.01.002] [PMID]
- [14] Messai CR, Salhi O, Khelef D, Lounas A, Mohamed-Cherif A, Kaidi R, et al. Serological, clinical, and risk factors of the Newcastle disease on broilers flocks in Algeria. *Vet World.* 2019; 12(7):938-44. [DOI:10.14202/vetworld.2019.938-944] [PMID]
- [15] Emikpe BO, Ohore OG, Olujonwo M, Akpavie SO. Prevalence of antibodies to infectious bronchitis virus (IBV) in chickens in southwestern Nigeria. *Afr J Microbiol Res.* 2010; 4(2):92-5. [Link]
- [16] Mungadi HU, Mera UM, Adamu YA, Musa U, Achi CR. Sero-prevalence of infectious bronchitis antibodies in local chickens in live bird markets in Sokoto State, Nigeria. *Sci J Anim Sci.* 2015; 4(7):53-6. [Link]
- [17] Sabarinath A, Sabarinath GP, Tiwari KP, Kumthekar SM, Thomas D, Sharma RN. Seroprevalence of infectious bronchitis virus in birds of Grenada. *Int J Poult Sci.* 2011; 10(4):266-8. [DOI:10.3923/ijps.2011.266.268]
- [18] Shettima YM, El-Yuguda AD, Zanna MY, Abubakar MB, Hamisu TM, Andrew A, et al. Serological evidence of infectious bronchitis virus among some poultry species in Maiduguri, Nigeria. *Alexandria J Vet Sci.* 2016; 51(1):135-9. [DOI:10.5455/ajvs.233895]
- [19] Adene DF. *The cornerstones in poultry health and production: Concepts, costs and the contemporary applications.* Ibadan: University of Ibadan; 2007. [Link]
- [20] Gardin Y, Soleil S, Rippa I. Use of serology for monitoring Epidemiology of poultry herds. In: *Interprofessional meetings of pathology of avian diseases,* Rennes. 2002. [Link]
- [21] Lopez JC. *The effect of environmental stressors on the immune response to avian infectious bronchitis virus.* Pennsylvania: Lincoln University; 2006. [Link]
- [22] Salhi O, Khelef D, Messai CR, Lounas A, Mohamed-Cherif A, Kaidi R, et al. Serological survey of dominant viral diseases (Newcastle disease (ND), Infectious bronchitis (IB) and Infectious bursal disease (IBD), in broilers flocks in Northern Algeria. *Bull Univ Agric Sci Vet Med.* 2018; 75(2):155-62. [Link]
- [23] Bing GX, Liu X, Pu J, Liu QF, Wu QM, Liu JH. Different genotypes of nephropathogenic infectious bronchitis viruses co-circulating in chicken population in China. *Virus Genes.* 2007; 35(2):333-7. [DOI:10.1007/s11262-007-0100-5] [PMID]
- [24] Cavanagh D, Gelb J. Infectious bronchitis. In: Saif YM, Fadly AM, Glisson JR, McDougald LR, Nolan NK, Swayne DE, editors. *Diseases of Poultry.* Ames, Iowa: Iowa State Press; 2008. [Link]
- [25] Animas SB, Otsuki K, Tsubokura M, Cook JK. Comparison of the susceptibility of chicks of different ages to infection with nephrosis/nephritis-causing strain of infectious bronchitis virus. *J Vet Med Sci.* 1994; 56(3):449-53. [DOI:10.1292/jvms.56.449] [PMID]
- [26] Dowell SF. Seasonal variation in host susceptibility and cycles of certain infectious diseases. *Emerg Infect Dis.* 2001; 7(3):369-74. [DOI:10.3201/eid0703.010301] [PMID]
- [27] de Wit JJ, Dijkman R, Guerrero P, Calvo J, Gonzalez A, Hidalgo H. Variability in biological behaviour, pathogenicity, protectotype and induction of virus neutralizing antibodies by different vaccination programmes to infectious bronchitis virus genotype Q1 strains from Chile. *Avian Pathol.* 2017; 46(6):666-75. [DOI:10.1080/03079457.2017.1346782] [PMID]

This Page Intentionally Left Blank