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Comparison of the susceptibility to and pathology of the velogenic Newcastle disease virus infection in chicken pullets of the Dominant Black and Isa Brown breeds

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Abstract

It is locally believed anecdotally that the Dominant Black (DB) breed of chicken pullets is more resistant to Newcastle disease virus (NDV) infection than the Isa Brown (IB) breed. The present study investigated the comparative susceptibility to and pathology of velogenic Newcastle disease virus (NDV) infection in DB and IB pullets. A total of 120 day-old pullets**,** comprising 60 DB and 60 IB chicks were procured from a reliable hatchery for the study. They were brooded and reared to 10 weeks of age before they were used for the study. Baseline serological screening prior to inoculation confirmed that none of the birds had detectable NDV antibodies. They were randomly assigned into four groups of 30 each (Group 1 – Infected DB, Group 2 – Uninfected DB, Group 3 – Infected IB, and Group 4 Uninfected IB). Pullets in Groups 1 and 3 were intramuscularly inoculated with 0.1 ml of the velogenic NDV strain Kudu 113, while pullets in Groups 2 and 4 served as the uninfected controls for each breed, respectively. Following viral challenge, clinical signs, which included anorexia, depression, huddling, and white-greenish diarrhoea, were observed in both infected DB and IB pullets from day 2 post-infection (PI), with 100% morbidity by day 3 PI and marked weight loss by day 5 PI. All birds from both groups succumbed to the infection (100% mortality), precluding follow-up serology. Necropsy revealed gross lesions including congested skeletal muscles, proventricular haemorrhages, intestinal ulcers, swollen caecal tonsils and atrophy of the bursa and thymus, the presence and degree of which were equally comparable in both breeds. Histopathological examination showed severe lymphocyte depletion and fibrin deposition in the spleen and thymus of both infected breeds by day 3 PI. It was concluded that the clinical signs, gross and histological findings associated with NDV infection in Dominant Black and Isa Brown pullets do not significantly differ; both breeds were equally susceptible to NDV infection.

Keywords: Chicken breeds*;* Pullets; Dominant Black; Isa Brown; Newcastle disease virus infection; Susceptibility; Pathology.

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Introduction

Poultry production is a vital source of income, food security and nutrition globally (Mottet and Tempio, 2017). However, the sector faces persistent threats from infectious diseases, with Newcastle disease (ND) being one of the most significant disease challenges (Moustapha *et al*., 2023). Newcastle disease virus (NDV), which is the causative agent of the disease, is a paramyxovirus (Dimitrov, 2023). A variety of birds, including poultry and wild birds are susceptible, and chickens are reportedly the most susceptible (Dimitrov, 2023). The most severe form of ND is the velogenic pathotype of ND in which the velogenic viscerotropic pathotype is enzootic in Africa (Onyema *et al*., 2019). In Nigeria, outbreaks of ND continue to undermine poultry development despite widespread vaccination and other control measures (Shittu *et al*., 2016; Ekiri *et al*., 2021). Vaccination and biosecurity remains the main control measures for ND (Dimitrov *et al*., 2016; Mayers *et al*., 2017). Vaccination has been reported to protect against the clinical signs, but not the multiplication and shedding of the velogenic viscerotropic pathotype of the virus (Sá *et al*., 2015; Okechukwu *et al*., 2020).

The pathogenesis and pathology of Newcastle disease is well documented in chickens (Dimitrov, 2023). However, there is limited information on the effect of types and breed variation of chickens on the severity of the disease (Goto *et al*., 2021). Among poultry farmers in Benin City, Edo State, Nigeria, there is this belief that the Dominant Black (DB) breed of pullets exhibit greater resistance to Newcastle disease virus (NDV) infection than the Isa Brown (IB) breed. While anecdotal, such perceptions warrant scientific investigation, especially considering the potential role of genetic variation in disease resistance among poultry breeds. Understanding breed-related differences in resistance or susceptibility to NDV could inform choices by poultry farmers and breeders, and contribute to the development of more effective disease control strategies in poultry production. This present study evaluated and compared the susceptibility to and pathology of velogenic NDV infection in Dominant Black and Isa Brown pullets.

Materials and Methods

Chickens: A total of 120 day-old chicken pullets**,** comprising 60 Dominant Black (DB) and 60 Isa Brown (IB) chicks, were procured from a certified commercial hatchery in Ibadan, Nigeria. The birds were raised under standard and uniform husbandry conditions without prior vaccination against Newcastle disease (ND). They were brooded and reared to 10 weeks of age before they were used for the study, and prior to start off of the study proper, serological screening using the haemagglutination inhibition (HI) test was performed on all birds to confirm absence of NDV antibodies.

Experimental Design and Methods: At 10 weeks of age, the birds were randomly assigned into four groups (n = 30 per group): Group 1 – Infected DB; Group 2 – Uninfected DB; Group 3 – Infected IB; and Group 4 – Uninfected IB. Pullets in Groups 1 and 3 were inoculated intramuscularly with 0.1 ml of the velogenic Newcastle disease virus (NDV) strain Kudu-113**,** while those in Groups 2 and 4 served as the uninfected controls for each of the breeds. The Groups 2 and 4 pullets were each given a placebo injection of 0.1 ml of phosphate-buffered saline (PBS), intramuscularly.

Following the NDV challenge, the pullets were monitored for clinical signs**,** morbidity**,** mortality and body weight changes**.** Dead birds were subjected to necropsy, and selected tissues (spleen**,** Bursa of Fabricius and thymus) were processed routinely for histopathology using standard procedures (Damairia *et al*., 2023), and evaluated using a light microscope. To confirm infection, virus

re-isolation was carried out on deceased birds (Gough *et al*., 1988).

This study was approved by the Institutional Animal Care and Use Committee (IACUC) of the Faculty of Veterinary Medicine, University of Nigeria, Nsukka (Approval Reference Number is FVM-UNN-IACUC-2024-12/200) and conducted in accordance with relevant ethical guidelines.

Statistical Analysis: Data on body weights**,** morbidity**,** mortality, and lesion scores were analyzed using Student's t-test for equality of means and Levene's test for equality of variances. All statistical analyses were performed at a 5% level of significance.

Results

Clinical Signs and Mortality Pattern: Both Dominant Black (DB) and Isa Brown (IB) pullets developed clinical signs following challenge with the velogenic Newcastle disease virus (NDV) strain Kudu-113. Early signs were observed in both breeds from day 2 post-infection (PI), which included depression, ruffled feathers, huddling, and inappetence (Table 1). These progressed to diarrhoea, paralysis, coma, and ultimately death. By day 5 PI, both Infected DB and Infected IB groups (Groups 1 and 3) experienced 100% mortality (Table 2).

Table 1. Morbidity pattern in Dominant Black and Isa Brown chicken pullets infected with velogenic Newcastle disease virus, compared to uninfected controls.

Day post infection	Dominant Black (DB) pullets		Isa Brown (IB) Pullets	
	Infected DB (n = 30)	Uninfected DB (n = 30)	Infected IB (n = 30)	Uninfected IB (n = 30)
1	0/30 (0%)	0/30 (0%)	0/30 (0%)	0/30 (0%)
2	5/30 (16.67%)	0/30 (0%)	6/30 (20%)	0/30 (0%)
3	24/24 (100%)	0/30 (0%)	22/22 (100%)	0/30 (0%)
4	3/3(100%)	0/30 (0%)	6/6 (100%)	0/30 (0%)
5	All dead	0/30 (0%)	All dead	0/30 (0%)

Results are presented as: Number of pullets that exhibited clinical signs/Total number of pullets in the Group, with percentage morbidity in brackets.

Table 2. Cumulative mortality pattern in Dominant Black and Isa Brown chicken pullets infected with velogenic Newcastle disease virus, compared to uninfected controls.

Day post infection	Dominant Black (DB) pullets		Isa Brown (IB) Pullets	
	Infected DB (n = 30)	Uninfected DB (n = 30)	Infected IB (n = 30)	Uninfected IB (n = 30)
1	0/30 (0%)	0/30 (0%)	0/30	0/30 (0%)
2	1/30 (3.3%)	0/30 (0%)	0/30	0/30 (0%)
3	6/30 (20%)	0/30 (0%)	8/30 (26.7%)	0/30 (0%)
4	27/24 (90%)	0/30 (0%)	24/30 (80%)	0/30 (0%)
5	30/30 (100%)	0/30 (0%)	30/30 (100%)	0/30 (0%)

Results are presented as: Total number of dead pullets/Total number of pullets in the Group, with percentage cumulative mortality in brackets.

The percentage of Dominant Black pullets that exhibited clinical signs of ND on Day 2 PI was 16.67%, while 20% of Isa Brown pullets exhibited clinical signs on Day 2 PI (Table 1). Mortality rates increased progressively in both groups, reaching 100% mortality by day 5 PI (Table 2). The uninfected control groups (Groups 2 and 4) exhibited no clinical signs of disease or mortality throughout the study period. The daily morbidity and mortality trends showed comparable pattern of disease progression in the infected groups of both breeds (Tables 1 and 2).

Body Weight Changes: The mean live body weights of infected groups (Group 1 and 3) significantly declined by day 4 PI when compared to their respective uninfected controls ($p < 0.05$). However, there was no significant difference in the body weight of the two infected groups (Table 3).

Table 3. Mean live weight (g) of Dominant Black and Isa Brown chicken pullets infected with velogenic Newcastle disease virus, compared to uninfected controls [Results are presented as mean ± standard error].

Day post infection	Dominant Black (DB) pullets		Isa Brown (IB) Pullets	
	Infected DB (n = 30)	Uninfected DB (n = 30)	Infected IB (n = 30)	Uninfected IB (n = 30)
1	706.00 ± 19.90	702.00 ± 16.81	735.00 ± 36.80	733.00 ± 36.80
4	572.00 ± 31.30 *	794.00 ± 33.80	629.00 ± 34.60 *	773. 50 ± 27.42

* Asterisk indicates mean live weights of the infected groups that are significantly ($p < 0.05$) lower than their uninfected controls.

Gross Lesions: Post-mortem examination of the carcasses revealed that the frequency and pattern of gross lesions did not differ between the infected Dominant Black (DB) and Isa Brown (IB) pullets. Lesions were consistently observed between days 3 and 5 post-infection (PI), with no significant differences ($p > 0.05$) in lesion frequency or severity between the two infected groups (Table 4). No lesions were observed in the uninfected control groups.

Pullets in both infected groups exhibited marked congestion of the skeletal muscles (breast, thigh, and leg) focal hemorrhages at the tips of the proventricular glands**,** catarrhal to hemorrhagic enteritis**, s**egmental mucosal ulcerations in the intestinal tract and caecal tonsils, which also showed enlargement and accumulation of cheesy necrotic debris (Figure 1). No notable differences were observed between DB and IB pullets in the persistence or distribution of these lesions (Figure 1).

Histopathological Lesions: Histopathological examination revealed comparable lesions in the infected Dominant Black (DB) and Isa Brown (IB) pullets. In the Bursa of Fabricius of infected DB pullets, there was marked hyperemia, lymphocytic necrosis and depletion, inter-follicular 0edema, and ballooning degeneration of the follicular structures (Figure 2I). Additionally, epithelial hyperplasia of the follicular lining was observed. Similarly, infected IB pullets exhibited lymphocytic necrosis and depletion in the Bursa of Fabricius, along with fibrin deposition in the follicular regions (Figure 2J).

In the spleen of the DB group, lesions observed included severe necrosis, lymphoid depletion, and extensive fibrin deposition, particularly surrounding the sheathed arterioles (Figure 2K)**,** indicating acute lymphoid destruction and vascular injury. For the IB pullets, the spleens showed comparable

patterns of lymphoid necrosis, cellular depletion, and perivascular fibrin accumulation (Figure 2L).

The thymus in both infected DB and IB pullets demonstrated severe lymphocytic necrosis and depletion, with diffuse destruction of the cortical and medullary regions (Figures 2M and 2N).

No histological lesions were observed in the uninfected control birds.

Overall, there were no obvious differences in histopathological lesions between the infected DB and IB pullets.

Discussion

The results of this study summarily revealed no significant differences in the clinical progression, mortality, gross pathology and histopathological lesions following NDV infection in Dominant Black and Isa Brown pullets, despite anecdotal reports from poultry farmers suggesting superior resistance of DB pullets to NDV infection.

Following viral challenge, both infected breeds developed classical signs of velogenic NDV infection, which included anorexia, depression, diarrhea, and progressive neurological signs, culminating in 100% mortality within five days. These observations align with the known high virulence of velogenic NDV strains, particularly those of the viscerotropic form, which are capable of causing systemic disease and high mortality rates regardless of breed (El-Morshidy *et al*., 2021; Dharmayanti *et al*., 2024).

Table 4. Comparison of the frequency and persistence of lesions in Dominant Black (DB) and Isa Brown (IB) chicken pullets infected velogenic Newcastle disease virus.

Organs and lesions observed on them.		Number of bird carcasses with lesions/Number of birds necropsied					
		Day 3 PI		Day 4 PI		Day 5 PI	
Organs	**Lesions**	**DB**	**IB**	**DB**	**IB**	**DB**	**IB**
Skeletal muscle	Congestion	3/3	3/3	21/21	16/16	3/3	6/6
Proventriculus	Haemorrhages	0/3	3/3	11/21	9/16	3/3	5/6
Thymus	Atrophy	3/3	3/3	21/21	16/16	3/3	1/6
Bursa of Fabricius	Atrophy	3/3	3/3	21/21	16/16	3/3	6/6
Spleen	Mottling	3/3	3/3	21/21	16/16	3/3	6/6
	Enlargement	3/3	3/3	21/21	16/16	0/3	6/6
Kidneys	Congestion and Enlargements	3/3	0/3	21/21	16/16	3/3	6/6
Intestines	Ulcers	0/3	3/3	21/21	16/16	3/3	6/6
Cecal tonsils	Haemorrhages and enlargement	3/3	0/3	11/21	9/16	3/3	6/6

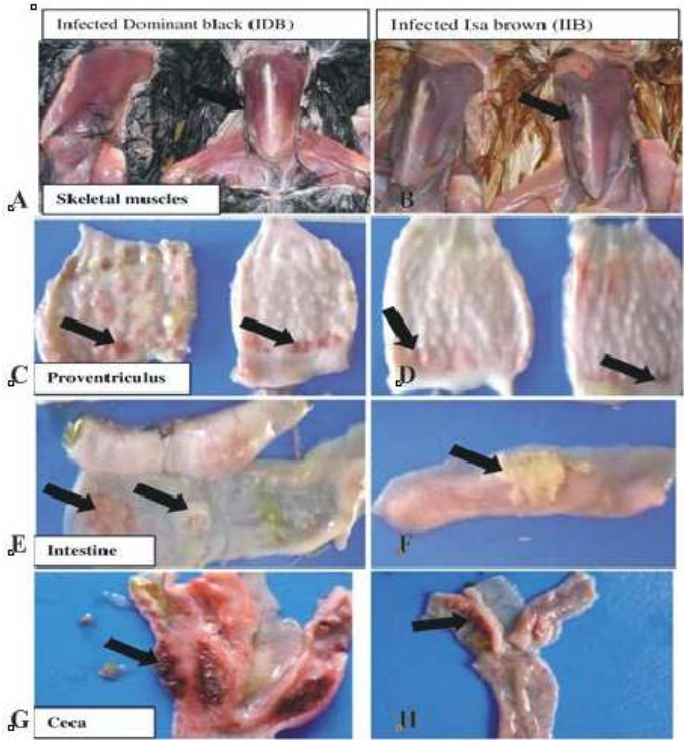

Figure 1. Comparison of the gross lesions observed in Dominant Black (DB) and Isa Brown (IB) chicken pullets infected with velogenic Newcastle disease virus.

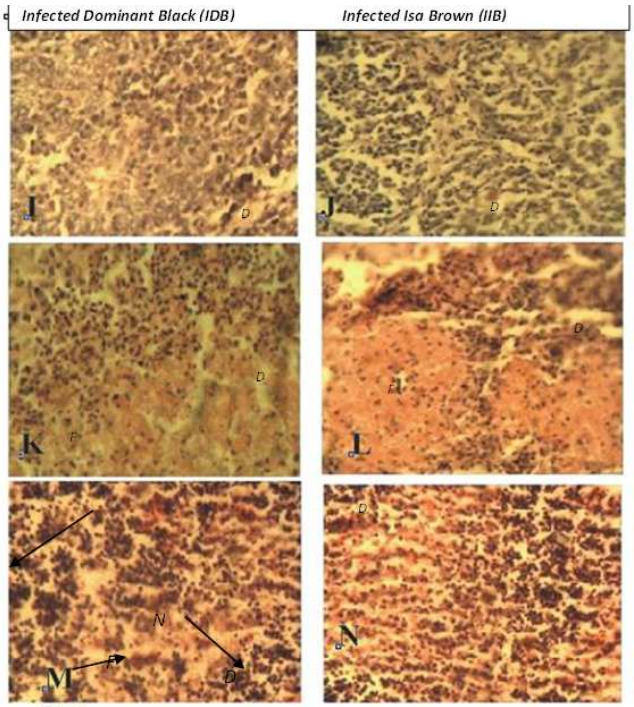

Figure 2. Comparison of the histopathology lesions observed in tissue sections of Dominant Black (DB) and Isa Brown (IB) chicken pullets infected with velogenic Newcastle disease virus: I – Bursa of Fabricius of DB pullets; J – Bursa of Fabricius of IB pullets; K – Spleen of DB pullets; L – Spleen of IB pullets; M – Thymus of DB pullets; N – Thymus of IB pullets. [H & E; × 400]

The incubation period in infected pullets of both breeds (DB and IB) which was 2 days PI in the present study, is in line with the results of other works where the velogenic strain of NDV was used for infection of chickens (Rahman, 2014). Dimitrov (2023) studied various velogenic NDV strains and reported incubation periods of 2 to 3 days in unvaccinated birds of age range of 4 – 6 weeks old. Kabiraj *et al*. (2020) recorded incubation periods of 2 – 16 and 3 – 5 days in unvaccinated chickens of age range 7 and 20 weeks, infected with NDV respectively. The earlier reported variations in incubation periods could be a result of factors such as presence of maternal antibody, pathogenicity of the virus, host adaptability and genetic endowment (Baron *et al*., 2023). In the present study, infection of the chickens took place at the 10^{th} week of age with no detectable maternal antibody; this may be responsible for the short incubation period of 2 days PI recorded for both breeds in the present study.

The 100% morbidity and mortality recorded for the infected groups within five days post-infection concurs with reports in earlier studies (Hussein et al., 2022). In this study, severe systemic illness with marked clinical signs of depression, huddling, inappetence, coma and white-greenish diarrhoea culminating in 100% mortality was recorded in the two breeds of infected pullets. Similar clinical signs have been observed by other workers in chicken infected with velogenic viscerotropic NDV (Aldous *and* Alexander, 2007; Ravishankar *et al*., 2022; Manual, 2025).

Severe weight loss was recorded in the infected groups in the present study, when compared to the uninfected controls. Weight losses have earlier been reported in chickens infected with velogenic viscerotropic NDV (Onyema *et al*., 2019; Botchway *et al*., 2022). This could attributed to drop in feed and water consumption by the infected birds (Ben, 2019).

Both infected breeds showed similar gross lesions, namely: congestion of the skeletal muscles, enlargement and mottling of spleen, atrophy of the lymphoid organs, and intestinal ulcers. Earlier studies by Mostaree *et al*. (2021), Ezema *et al*. (2024) and Rabiei *et al*. (2024) reported such lesions with velogenic NDV infection in chicken.

The most consistent gross lesions in the pullets were severe and sharply demarcated haemorrhagic intestinal ulcers which started at day 4 PI, while haemorrhage on the cecal tonsils and proventriculus were observed on day 3 PI; these concur with findings in earlier studies by Ezema *et al*. (2024) who observed intestinal ulcers, cecal tonsils and proventricular haemorrhage in chickens infected with velogenic Newcasle disease virus infection. These recorded gross lesions were consistent in both breeds throughout the duration of the experiment. Similar lesions were reported by Eze *et al*. (2013) and Mostaree *et al*. (2021) in chickens following infection with NDV. Moura *et al*. (2015); Lee *et al*. (2016) and Okafor *et al*. (2024) further reported that viscerotropic strains of velogenic NDV is better differentiated from neurotropic strain if the infected birds died rapidly within 4 – 8 days and presented with enteric lesions. Haemorrhagic lesions in the gastrointestinal tract of the infected chickens have also been used by other researchers to distinguish viscerotropic velogenic NDV from neurotropic velogenic NDV (Cattoli *et al*., 2011; Kim *et al*., 2012; Nooruzzaman *et al*., 2021). The ulceration of intestinal mucosa may be due to active viral replication in the intestinal lymphoid follicles (Almurshedy *et al*., 2023). In chickens, intestinal ulcers, though not pathognomonic, is not found in any other disease except in highly pathogenic avian influenza (HPAI) (Costa-Hurtado *et al*., 2015), which is however, not endemic in Nigeria (Chieloka, 2021). Therefore, the lesion can be useful in diagnosis of velogenic ND in areas where HPAI outbreaks are not suspected.

In this study, the onset and persistence of haemorrhagic ulcers in the intestines were the same for both breeds. There was no appreciable difference in the distribution and severity of the lesions in both infected breeds.

The uniform susceptibility observed in this study suggests that both Dominant Bakck and Isa Brown breeds lack sufficient innate or acquired resistance against highly virulent NDV strains. This finding differs from local beliefs that Dominant Black breed of pullets are inherently more resistant; this finding highlights the importance of evidence-based approaches in disease management.

The gross and histopathological lesions documented, including hemorrhages in the proventriculus and intestines, mottling and enlargement of the spleen, and lymphoid tissue atrophy in the thymus and Bursa of Fabricius, are consistent with previous descriptions of velogenic NDV infections (Kabiraj *et al*., 2020; Ekiri *et al.,* 2021). Severe lymphocyte depletion in lymphoid organs across both groups underscores the immunosuppressive nature of NDV and its impact on systemic immunity (Rabiei *et al*., 2024).

The lack of differences in the histopathological lesions in both breeds further confirms the absence of genetic resistance differences to NDV in these breeds. Notably, all birds were sero-negative before challenge, and none survived to allow a post-infection serological response, reinforcing the acute and overwhelming pathogenicity of the Kudu-113 strain (Eze *et al*., 2013).

The outcome of this study emphasizes the need for vaccination, which remains the cornerstone of Newcastle disease control in poultry, as genetic resistance alone does not appear to offer protection in these commercial breeds when faced with high-virulence NDV challenge. Moreover, the findings in the present study further underscore the need for farmer education to dispel myths surrounding breed-based resistance and to promote robust biosecurity and immunization protocols.

Conclusion: This study demonstrated that the KUDU 113 strain used in this experiment was comparably highly pathogenic in both Dominant Black and Isa Brown pullets. Though the strain of the virus, dose, immune status and route of infection may have contributed to the high pathogenicity of the infection with resultant high morbidity and mortality, the susceptibility and pathology of the virus was not significantly different in both breeds.

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Conflict of Interest

The authors declare no conflict of interest.

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