ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 16, Issue, 04, pp. 27672-27678, April, 2024
DOI: https://doi.org/10.24941/ijcr.46253.04.2024

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

A COMPARATIVE STUDY OF PIGEON MORTALITY AND NUTRITIONAL ANALYSIS AT DOULOTPUR, KHULNA

Md. Asaduzzaman Lovelu[1], Sabuj Kanti Nath[2,*] and Shamsul Arfin[3]

[1]Department of Animal Science, Faculty of Veterinary, Animal and Biomedical Sciences, Khulna Agricultural University, Khulna-9100, Bangladesh
[2]Department of Animal Nutrition, Faculty of Veterinary, Animal and Biomedical Sciences, Khulna Agricultural University, Khulna-9100, Bangladesh
[3]Upazila Livestock Officer, Upazila Livestock Office and Veterinary Hospital, Bagharpara-7470, Jessore, Bangladesh

ARTICLE INFO

Article History:
Received 24th January, 2024
Received in revised form
20th February, 2024
Accepted 19th March, 2024
Published online 17th April, 2024

Key words:
Pigeon mortality, Newcastle Disease, PPMV-1, Nutritional Analysis, Farm Management.

***Corresponding author:**
Sabuj Kanti Nath

ABSTRACT

A study was carried out to investigate the Newcastle disease outbreak of pigeons in Khulna, from 16 to 26 November 2019. In squabs, growers, and adult pigeons, a confirmed case of PPMV-1 was found to be the cause of the observed mortality. Diarrhea (92.86%), nervous signs (28.57%), shivering (21.43%), and respiratory signs (7.14%) were among the symptoms displayed by the affected population. Notably, pigeons that had not received vaccinations had a 100% attack rate. Potential risks, like ingesting plastic and foraging for toxic substances, were revealed by an examination of the gut content, emphasizing the importance of appropriate dietary management. Acceptable quantities of lead, cadmium, arsenic, pH, nitrate-nitrogen, total dissolved solids, and ammonia-nitrogen were found in the water, indicating no direct causative relationship with water. To rectify deficits in zinc, vitamin A, vitamin C, lipids, protein, and fats in pigeon feed, a feed analysis is essential. These results highlight how important immunization, a healthy diet, and stringent biosecurity protocols are in inhibiting PPMV-1 outbreaks. Effective strategies including regular surveillance, quarantine, and comprehensive diagnostic approaches are crucial for the management and control of Newcastle disease in pigeon populations.

Citation: ***Md. Asaduzzaman Lovelu, Sabuj Kanti Nath and Shamsul Arfin*****, 2024.** "A comparative study of pigeon mortality and nutritional analysis at Doulotpur, Khulna*". International Journal of Current Research*, 16, (04), 27672-27678.

INTRODUCTION

According to Agricultural Sample Survey in 2013, Bangladesh had a population of 10.8 million pigeons of which 11% were kept on what is termed commercial farms. In no division did pigeons kept in commercial farm conditions exceed 1% of the poultry population (Paul *et al*., 2015). In Bangladesh, domestic pigeon has been reared for meat purposes for many years. The domestic pigeon was derived from the rock dove or rock pigeon or common pigeon whose scientific name is *Colomba livia*. At present, PPMV (pigeon paramyxovirus) has a widespread distribution. The virus was first identified in pigeons in the Middle East in the late 1970s and subsequently spread across the Middle East to Europe, Japan, North America, and South Africa throughout the 1980s (Pestka *et al*., 2014). However, infectious disease outbreaks continue to be a serious threat to pigeon populations, resulting in significant financial losses and raising issues with public health.

Among these, Newcastle disease—which is brought on by the pigeon paramyxovirus virus (PPMV-1)—has become a major worldwide threat, especially to bird populations, which includes pigeons (Xiang *et al*., 2019; Zhan *et al*., 2020). Newcastle disease (ND) is on the A List of the World Organisation for Animal Health (OIE) as a highly infectious and contagious viral disease of birds, sometimes causing even 100% mortality. Newcastle disease in pigeons is called paramyxovirus is and is caused by an antigenic "pigeon variant" of the virus (pigeon paramyxovirus type 1, PPMV-1). PPMV-1 was first isolated in 1978 from meat pigeons in Iraq. A detailed characterization of the virus was carried out by (Kaleta *et al*., 1985). In the same year, the virus from the Middle East regions reached the eastern part of Europe and North Africa, causing respiratory and neural symptoms in pigeons, and in the years 1981-1983 it spread across Europe and the world (Kaleta *et al*., 1985). It is believed that such a rapid spread of PPMV-1 was closely related to trade,

competition flights, and exhibitions of carrier and ornamental pigeons (Pestka *et al*., 2014; Silva *et al*., 2022). The incidence varies from 30 to 70%, with mortality not exceeding 10%. In case of associated bacterial or parasitic infections, mortality may reach more than 30% (Dortmans *et al*., 2011; Guiton & Drevet, 2023). Avian Paramyxovirus a risk to human health-Human infection with this virus is extremely rare and usually occurs only in people who have close direct contact with infected birds (Hosseinian, 2022). The virus causes only mild, short-term conjunctivitis or influenza-like symptoms in humans (Dik & Aslim; Leighton *et al*., 2008). A comprehensive assessment of the nutritional profiles of pigeon feed and stomach contents is essential, as evidenced by the recent breakout of Newcastle disease in the pigeon population at a farm in Doulotpur. Understanding any potential inadequacies or imbalances that would make the pigeons more vulnerable to viral infections, such the PPMV-1 strain that is causing the outbreak, depends on the results of this examination. Research has demonstrated how important key nutrients—such as proteins, lipids, carbohydrates, vitamins, and minerals—are for maintaining the optimal potential health and production in pigeons (Kuraz Abebe, 2022; Nasir *et al*., 2022).

Moreover, an assessment of the gut contents of affected pigeons can offer crucial information about their dietary habits, possible exposure to pollutants, and the existence of any foreign objects that might threaten the health of their digestive systems (Andreini, 2022). The findings of the investigation will dictate focused efforts aimed at maximizing the nutritional value of pigeon feed and reducing the dangers of dietary imbalances and foreign body ingestion. The objective of the research is to investigate the cause of death, infection source, transmission patterns, and preventative measures for the Newcastle disease outbreaks. Additionally, it aims to investigate gut contents, analyze pigeon feed for nutritional imbalances, and assess water quality in relation to the outbreak.

Methods and Materials

Study Area and Timeframe: From 16 to 26 November, 2019, an investigation was carried out at the pigeon farm located at Doulotpur, Khulna. There were 248 pigeons on the farm that made up the research population, and 58 of those cases had been documented as having Newcastle disease in which:

Squab (0 to 30 days) - 46 death out of 65
Grower (31 to 180 days) - 2 death out of 82
Adult (181 to above) - 6 death out of 101

Study Design and Data Collection: The outbreak investigation procedure was illustrated in a flow chart **(Fig. 1)** as part of the study's descriptive investigation methodology. The study was conducted at Khulna Agricultural University, Khulna. The pigeons were carried out by the farmers of Khulna metropolitan and surrounding area to Khulna Agricultural University for diagnosis of different diseases and their treatment.

Outbreak investigation: A total of 248 pigeons were diagnosed based on clinical signs, post-mortem findings and laboratory test. A questionnaire was developed for data collection from the farmers. The farmers of pigeon farms were individually interviewed.

Physical examination was done for each attending. Based on questionnaire data on breed, age, sex, feeding, housing system was recorded. Data on diagnostic and therapeutic protocol used were also collected. Clinical signs were recorded. A questionnaire was developed for data collection from the farmers. The farmers of pigeon farms were individually interviewed. Physical examination was done for each attending. Data on diagnostic and therapeutic protocol used were also collected.

Case definition: Any patient from Doulotpur, Khulna from 16 to 26 November, 2019, with the following signs and postmortem lesions are considered as case.

➢**Clinical Signs:** The first sign is polyuria, then neural symptoms which appear only in individual birds in the flock. The most common neural signs that occur during infections with PPMV-1 include head and neck 180^0 twists (torticollis), imbalance, paralysis of wings and legs or difficulties in food intake. Infected birds sometimes have watery (increased urinary volume fractions resulting from kidney infection) or Greenish diarrhea, watery feces or bloody diarrhea. If infection occurs during moulting, problems with feather development may occur – feathers appear deformed, poorly developed and fragile (Dortmans *et al*., 2011).

➢**Postmortem Lesion:** Hemorrhagic on lesions found in liver, spleen, kidneys and proventriculus. Swelling and congestion found on blood vessels and brain. (Shaheen *et al*., 2005). Similarity of symptoms of paramyxoviros is to the pigeon herpes virusinfection (PHV), sodium chloride poisoning, overdose of ronidazole or vitamin B1 deficiency,

➢**Treatment:** FRAC-12, Lysovit, Enrocin, Saline+C, Lashota ND vaccine (Pestka *et al*., 2014).

Nutritional analysis: A number of common laboratory equipment and techniques were used to analyze the feeds. High-performance liquid chromatography was used to measure the amounts of carbohydrates (HPLC). The Kjeldahl method was used to calculate the protein content and the Soxhlet extraction method was utilized to determine the amount of fat. The levels of the vitamins A, B, C, and D were examined by the use of methods such as high-performance liquid chromatography (HPLC). Besides, Atomic absorption spectroscopy (AAS) was also used to analyze minerals (calcium, phosphorus, iron, zinc, magnesium, sodium, and potassium).

Gut content analysis: The gastrointestinal tracts of the affected pigeons were carefully dissected as part of the gut content investigating with an emphasis on identifying and documenting any substances that were consumed. In order to determine feeding patterns and possible exposure to foreign objects or dangerous substances, each pigeon received an identification number. Specifics such as the location of contents (crop or stomach) and remarks regarding the findings were also recorded.

Water samples analysis: Specific methodologies were employed to examine the water samples for various parameters. A pH meter or indicator solution was used to detect the pH levels, and atomic absorption spectroscopy (AAS) was probably used to evaluate the levels of lead (Pb), cadmium (Cd), arsenic (As), nitrate-nitrogen (NO3-N), and

ammonia-nitrogen (NH3-N). In order to assess the total dissolved substance (TDS) content in the water, gravimetric analysis methods were used to calculate total dissolved solids.

RESULTS

Outbreak analysis: From 16 to 26 November, there was the highest number of pigeons farm infected (20) and causing death (15) by 20.11.2019. Afterward, there was a gradual decrease in the onset of sign and death rate (Figure 2). From 16.11.2019 to 20.11.2019 there was a steady increase in the number of death of squab and the highest which is 13 by 20 November, 2017. After that the death rate were declined (Figure 3). There was no mortality rate recorded except the date of 20.11.2019 and 21.11.2019, and the number of death of grower (31-180 days) was only 1 (Figure 4). Figure 5 depicted that total no of death of adult (181 days above) was 6. The highest no of mortality took place in the date of 18.11.2019 and after 20.11.2019 no mortality was recorded. Figure 6 exhibited the Bar diagram showing the distribution of Frequency of clinical signs in 68 affected Pigeons with pigeon paramyxovirus. The highest percentage of the infected pigeon showed the clinical sign diarrohea, which accounted for 92.86. The second most common clinical sign of the affected pigeon was nervous signs that was 28.57%. 21.43% infected birds showed shivering sign. In addition, only 7.14% pigeons exhibited respiratory signs. Least common showing sign was paralysis of legs and wings that made up 5.20%.

The findings showed that the exotic breed accounted for 86% (50) of the instances of infection, whereas the native breed accounted for 14% (8) of the cases (Table 1). Additionally, the native breed had a comparatively lower death rate of 7.5% (4), but the exotic breed had a significantly higher mortality rate of 92.5% (50) of recorded deaths. The study's overall findings highlighted the exotic breed's susceptibility to pigeon paramyxo virus infection, underscoring the necessity of focused preventive measures and enhanced biosecurity regulations within the pigeon farming industry (Table 1). With a total sample size of 58 pigeons, the Table 2 shows the age-wise distribution of pigeon paramyxovirus infection at Doulotpur, Khulna. According to the data, 79% of the cases and 85% of the total deaths reported during the outbreak occurred in the squab group (0–30 days), which included the greatest percentage of infected pigeons. The adult pigeons (181 days and above) accounted for 14% of the cases and 11% of the total deaths, whereas the grower group (31–180 days) formed 7% of the cases and 4% of the overall fatalities. These results highlight the squabs' increased susceptibility to the pigeon paramyxovirus infection, which led to a significantly greater mortality rate than in the other age groups.

The results of the rearing place-wise distribution of pigeon paramyxo virus infection indicate that the majority of the affected pigeons were from captive rearing environments, constituting 81% (47 out of 58) of the cases (Table 3). Within this group, 80% (43 out of 54) of the affected pigeons succumbed to the infection. Comparatively, the incidence of the disease among free-ranging pigeons was lower, accounting for 19% (11 out of 58) of the cases, with 20% (11 out of 54) resulting in mortality (Table 3). In the Table 4. Out of 58 cases of pigeon paramyxo virus infection, the data showed that 4 cases (100% fatality) among the new entrants resulted in death, but no fatalities were detected among the vaccinated new entries. Four instances (66.7%) of the infected population of unvaccinated pigeons survived, while 48 cases (88.9%) resulted in death. The pigeon feed study showed in Table 5. that the protein level was slightly lower (17g/100g compared to 20g/day) and the carbohydrate content was slightly higher (49.5g/100g compared to 40g/day). Likewise, it was discovered that the fat level was marginally less than the daily required amount (10.5g/100g as opposed to 15g/day). Vitamin B and vitamin C were found to be within the recommended ranges (1.9 mg/100g compared to 1.5 mg/day and 28.7 mg/100g compared to 25 mg/day, respectively), but vitamin A and vitamin D levels exceeded the recommended daily values (4600 IU/100g compared to 2000 IU/day and 357 IU/100g compared to 300 IU/day, respectively) (Table 5). Additionally, the recommended levels of several critical minerals, including calcium, phosphorus, iron, zinc, magnesium, salt, and potassium, were generally exceeded.

Analysis of gut content: The results of the pigeons' gut content contents produced a variety of results (Table 6). Pigeons ID 003 and 004, who were grower pigeons, showed signs of a possible nutritional imbalance, whereas pigeon 004 had normal digestion. There were indications that Pigeon 002 may have consumed dangerous substances. Toxic plants may have been foraged by an adult pigeon (ID 005). Environmental pollution and regular intake of trash were demonstrated by growers and adults (ID 006 and 007). Possible interaction with industrial waste and regurgitation problems were reported by pigeons 009 and 010. According to these results, there may be a complicated interaction between environmental and dietary factors that is responsible for the Newcastle disease outbreak in pigeon populations

Analysis of water samples: In Table 7 the pH values in the water, according to the analysis, ranged from 6.9 to 7.3, which is within the recommended range of 6.5-8.5. At 2.2–2.7 mg/L, nitrate-nitrogen (NO3-N) levels were below the permissible range. At 147–161 mg/L, total dissolved solids (TDS) were within permissible limits. At 0.17–0.25 mg/L, ammonia-nitrogen (NH3-N) levels were below the advised range. A trace amount of lead (Pb) and cadmium (Cd) was found, both below the respective standards of <0.01 mg/L and <0.003 mg/L. At 0.004-0.006 mg/L, arsenic (As) levels were likewise within permissible ranges.

DISCUSSION

Newcastle disease is a serious problem in pigeons. Fairly high morbidity and mortality rate due to paramyxovirus-1 (PMV-1) infection was observed in pigeons in the present study. (Shaheen *et al*., 2005) reported 50 to 70% morbidity in an outbreak of PMV-1 in racing pigeons in India. They further reported mortality around 60% in field outbreaks that support my study. (Duchatel & Vindevogel, 1986) observed nervous signs in 86% cases, diarrhoea in 18% and paralysis of legs and wings in 9% of naturally affected pigeons. Signs including Diarrhea 92.86%, Nervous signs 28.57%, Shivering 21.43%, Respiratory signs 7.14%, Paralysis of legs and wings 5.20% that's have similar with other workers have reported similar signs of ND in pigeons in experimental (Shaheen *et al*., 2005) and field outbreaks (Wambura & Wilson, 2009). This mortality occur at late November that's have similar with (Shabbir *et al*., 2016) seasons were classified into three Summer consists of March to May, rainy consists of June to October and swinter consists of November to February (Dortmans *et al*., 2011).

Table 1. Breed wise distribution of pigeon paramyxo virus infection from 16 to 26 November, 2019 at Dpulotpur, Khulna (n=58)

Name of Breed	Onset of sign % (n)	Death % (n)
Native	14% (8)	7.5% (4)
Exotic	86% (50)	92.5% (50)
Total	100% (58)	100% (54)

Table 2. Age wise distribution of pigeon paramyxo virus infection from 16 to 26 November, 2019 at Dpulotpur, Khulna (N=58)

Age group	Onset of sign % (n)	Death % (n)
Squab (0-30 days)	79% (46)	85% (46)
Grower (31-180 days)	7% (4)	4% (2)
Adult (181 days above)	14% (8)	11% (6)
Total	100% (58)	100% (54)

Table 3. Rearing place wise distribution of pigeon paramyxo virus infection from 16 to 26 November, 2019 at Dpulotpur, Khulna (N=58)

Place	Onset of sign % (n)	Death % (n)
Captive	81% (47)	80% (43)
Free ranging	19% (11)	20% (11)
Total	100% (58)	100% (54)

Table 4. Table show the frequency of factors of pigeon paramyxo virus infection from 16 to 26 November, 2019 at Dpulotpur, Khulna (n=58)

Factors	Death			Alive		
	Number	Percentage	Total	Number	Percentage	Total
New entry	4	100	4	0	0	0
Un-Vaccinated	48	88.9	54	4	66.7	6

Table 5. Pigeon feed containing essential nutrients with their recommended value

Nutrient	**Amount per 100g**	**Recommended amount (Per day)**
Carbohydrate	49.5g	40g
Protein	17g	20g
Fats	10.5g	15g
Vitamin A	4600 IU	2000 IU
Vitamin B	1.9mg	1.5 mg
Vitamin C	28.7mg	25mg
Vitamin D	357 IU	300 IU
Calcium	1.40 g	1g
Phosphorus	1.1g	0.8g
Iron	9mg	8mg
Zinc	5.1mg	4mg
Magnesium	264mg	200mg
Sodium	2.1g	1.5g
Potassium	3.8g	3g

Table 6. Gut content analysis with age and location of the Pigeon

Pigeon ID	Age of the Pigeon	Location	Contents in the Gastrointestinal Tract	Remarks
001	Grower (31 to 180 days)	Crop	Corn kernels, tiny stones	No foreign objects were seen.
003	Grower (31 to 180 days)	Crop	Wheat grains and gravel	Potential imbalance in diet
002	Grower (31 to 180 days)	Stomach	Plastic pieces, Insects	Possible consumption of hazardous substances
004	Grower (31 to 180 days)	Crop	There were no significant contents discovered.	normal digestion
005	Adult (181 to above)	Crop	Unknown twigs and seeds	Potential foraging of toxic plants
006	Grower (31 to 180 days)	Stomach	Plant material and unknown debris	Further investigation is advised.
007	Adult (181 to above)	Stomach	broken plastic and fish bones	Potential environmental contamination
008	Adult (181 to above)	Crop	Sand with little stones	routine consumption of debris
009	Adult (181 to above)	Stomach	metallic pieces and fabric fibers	Possible contact with industrial waste
010	Adult (181 to above)	Crop	Feathers and partially digested food	indications of problems with regurgitation

Table 7. Water quality analysis with their recommended value

Parameters of Water Quality	Sample 1 (mg/L)	Sample 2 (mg/L)	Sample 3 (mg/L)	Sample 4 (mg/L)	Recommended limit ((mg/L))
pH	7.1	6.9	7.3	7.0	6.5-8.5
Nitrate-Nitrogen(NO3-N)	2.4	2.2	2.7	2.5	<10
Total Dissolved Solids (TDS)	149	154	147	161	<500
Ammonia-Nitrogen(NH3-N)	0.25	0.23	0.17	0.21	<1
Lead (Pb)	0.02	0.03	0.02	0.04	<0.01
Cadmium (Cd)	0.004	0.002	0.003	0.002	<0.003
Arsenic (As)	0.004	0.005	0.006	0.004	<0.01

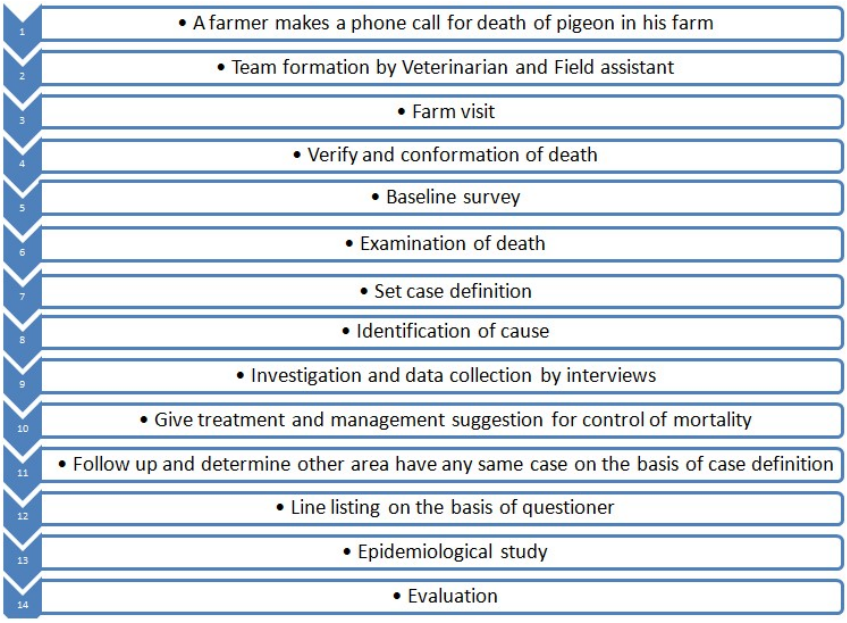

Figure 1. Flow chart of outbreak investigation

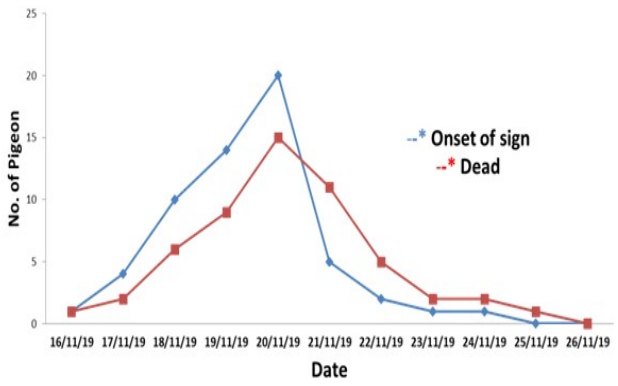

Figure 2. Epicurve of infected pigeon farm from 16 to 26 November, 2019 at Dpulotpur, Khulna (N=58)

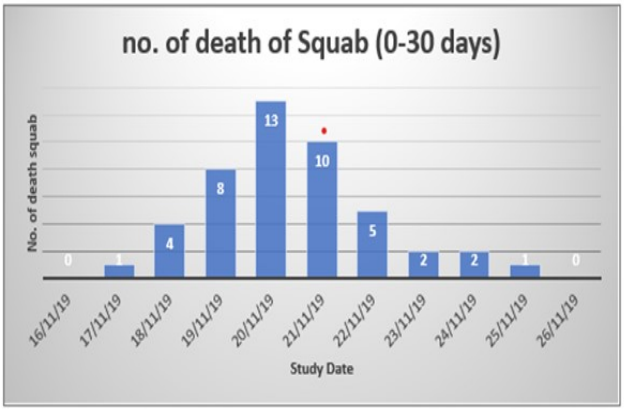

Figure 3. Epicurve of squab mortality from 16 to 26 November, 2019 at Dpulotpur, Khulna (N=46)

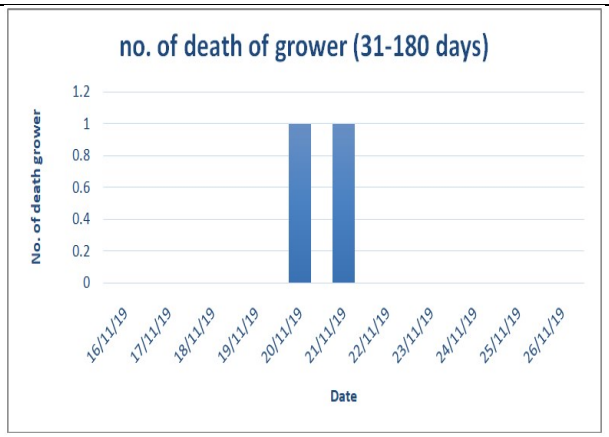

Figure 4. Epicurve of grower pigeon mortality from 16 to 26 November, 2019 at Dpulotpur, Khulna (N=2)

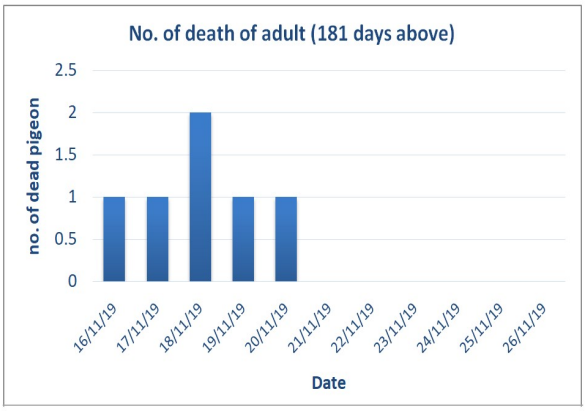

Figure 5. Epicurve of grower pigeon mortality from 16 to 26 November, 2019 at Dpulotpur, Khulna (n=6)

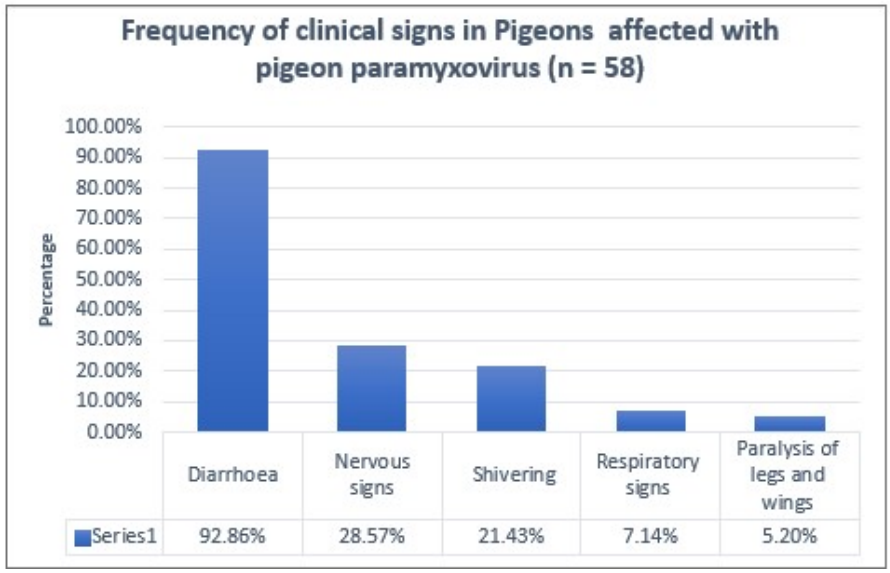

Figure 6. Bar diagram showing the distribution of Frequency of clinical signs in Pigeons affected with pigeon paramyxovirus from 16 to 26 November, 2019 at Dpulotpur, Khulna (n=58)

Potential routes of introduction include live bird transportation, fomites, poultry product transportation, contaminated food and water, contaminated vaccines and non-vaccinater carriers (Alexander, 2000). It has been shown that, despite the antigenic differences between LaSota and PPMV-1 strains, this vaccine effectively protects against disease caused by PPMV-1 (Dortmans *et al*., 2011). Proper and effective methods of prevention, control and diagnostics of NDV is highly important, especially for PPMV-1, as increasing outbreaks of pigeon paramyxovirosis (Aldous *et al*., 2014). The pigeon feed's nutritional analysis showed many deviations from the suggested values, suggesting possible nutritional deficiencies that might have enhanced the pigeons' vulnerability to Newcastle disease. The pigeons' immune system and general health may have been undermined by inadequate amounts of vital nutrients like calcium, phosphorus, and magnesium, as well as vitamins A, B, C, and D (Xu *et al*., 2023).

This would have increased their susceptibility to infectious diseases. Furthermore, the gut content analysis of some pigeons revealed the presence of foreign objects and possibly harmful substances, which raises the possibility of dietary imbalances and exposure to environmental contaminants, further increasing the pigeons' susceptibility to health risks (Noreen *et al*., 2023). According to the water quality analysis, the pigeon outbreak of Newcastle disease was not significantly caused by the water near the farm, as indicated by the acceptable levels of pH, nitrate-nitrogen, total dissolved solids, and various contaminants like lead, cadmium, arsenic, and ammonia (He *et al*., 2022; Hossain *et al*., 2023). The spreading and severity of the Newcastle disease outbreak, however, may have been significantly influenced by other possible sources of contamination, such as feed quality and environmental factors, even in spite of the acceptable water quality (Hossain *et al*., 2023). According to (Zhang *et al*., 2022), the study highlights the vital need for improved pigeon feed management techniques and strict quality control procedures to support the overall wellness and disease resilience of the pigeon population. In order to prevent potential health concerns and disease outbreaks in pigeon farming, it is essential to implement suitable housing and feeding protocols to avoid pigeons' exposure to dangerous substances and foreign objects (Crafton *et al*., 2023). To mitigate the risk of Newcastle disease and maintain sustainable pigeon farming management, it is essential to conduct routine feed and environmental quality monitoring in conjunction with thorough vaccination and biosecurity strategies (Shopland *et al*., 2022). To develop more efficient disease prevention and control strategies for pigeon populations in comparable farming contexts, more research concentrating on long-term nutritional management and environmental monitoring tactics is required (Giunchi *et al*., 2012; Todd, 2020). In conclusion, in order to reduce potential hazards and disease outbreaks in pigeon farming, the study underscores the significance of improved housing and feeding practices, stringent quality control, and better feed management. Newcastle disease risk reduction depends on comprehensive immunization and biosecurity protocols, as well as routine feed and environmental quality monitoring.

REFERENCES

Aldous, E., Fuller, C., Ridgeon, J., Irvine, R., Alexander, D., & Brown, I. (2014). The Evolution of Pigeon Paramyxovirus Type 1 (PPMV-1) in G reat B ritain: A Molecular Epidemiological Study. *Transboundary and emerging diseases*, 61(2), 134-139

Alexander, D. 2000. Newcastle disease and other avian paramyxoviruses. *Revue Scientifique et Technique-Office International des Epizooties*, *19*2, 443-455.

Andreini, R. 2022. Non conventional species as monitor of environmental pollution.

Crafton, M., Spiegel, O., Cahani, S., Lublin, A., & Rauer, L. 2023. Association between movement patterns, microbiome diversity, and potential pathogen presence in free-ranging feral pigeons foraging in dairy farms. *bioRxiv*, 2023.2010. 2011.561861.

Dik, I., & Aslim, H. P. Volume 2 Animal Health Perspectives.

Dortmans, J., Koch, G., Rottier, P., & Peeters, B. 2011. A comparative infection study of pigeon and avian paramyxovirus type 1 viruses in pigeons: evaluation of clinical signs, virus shedding and seroconversion. *Avian Pathology*, *40*2, 125-130.

Duchatel, J., & Vindevogel, H. 1986. Assessment of vaccination of pigeons against paramyxovirus type 1 infection with inactivated aqueous-suspension or oil-emulsion vaccines. *Avian Pathology*, *15*3, 455-465.

Giunchi, D., Albores-Barajas, Y. V., Baldaccini, N. E., Vanni, L., & Soldatini, C. 2012. Feral pigeons: problems, dynamics and control methods. *Integrated pest management and pest control. Current and future tactics, London, InTechOpen*, 215-240.

Guiton, R., & Drevet, J. R. 2023. Viruses, bacteria and parasites: infection of the male genital tract and fertility. *Basic and Clinical Andrology*, *33*1, 19.

He, S., Wu, J., Wang, D., & He, X. 2022. Predictive modeling of groundwater nitrate pollution and evaluating its main impact factors using random forest. *Chemosphere*, *290*, 133388.

Hossain, I., Parvin, R., Rahman, M. M., Begum, J. A., Chowdhury, E. H., Islam, M. R., Diel, D. G., & Nooruzzaman, M. 2023. Comparative pathogenicity of a genotype XXI. 1.2 pigeon Newcastle disease virus isolate in pigeons and chickens. *Microbial Pathogenesis*, *178*, 106068.

Hosseinian, S. A. 2022. Zoonotic diseases associated with pet birds. *Journal of Zoonotic Diseases*, *6*3, 91-112.

Kaleta, E., Alexander, D., & Russell, P. 1985. The first isolation of the avian pmv-1 virus responsible for the current panzootic in pigeons? *Avian Pathology*, *14*4, 553-557.

Kuraz Abebe, B. 2022. The dietary use of pigeon pea for human and animal diets. *The Scientific World Journal*, *2022*.

Leighton, F. A., Heckert, R. A., Thomas, N., Hunter, N., & Atkinson, C. 2008. Newcastle disease and related avian paramyxoviruses. *Infectious diseases of wild birds*, 3-16.

Nasir, M., Sidhu, J. S., & Sogi, D. S. 2022. Processing and nutritional profile of mung bean, black gram, pigeon pea, lupin, moth bean, and Indian vetch. *Dry Beans and Pulses: Production, Processing, and Nutrition*, 431-452.

Noreen, S., Khan, I. M., Khan, M. S., Zarnaab, B., Gul, I., Khan, M. Z., Jadoon, W. A., Ghayyur, S., & Liu, Y. 2023. Comparative valuation of the chlorpyrifos, acetamiprid, and lambda-cyhalothrin toxicity and their hematological and histopathological consequences in pigeons. *Environmental Science and Pollution Research*, *30*40, 92817-92829.

Paul, T., Amin, M., Alam, M., Rahman, M., Sarker, Y., & Rizon, M. 2015. Occurrence of pigeon diseases at Khulna Sadar, Bangladesh. *Bangladesh Journal of Veterinary Medicine*, *13*2, 21-25.

Pestka, D., Stenzel, T., & Koncicki, A. 2014. Occurrence, characteristics and control of pigeon paramyxovirus type 1 in pigeons. *Polish journal of veterinary sciences*, *17*2, 379-384.

Shabbir, M. Z., Akhtar, S., Tang, Y., Yaqub, T., Ahmad, A., Mustafa, G., Alam, M. A., Santhakumar, D., Nair, V., & Munir, M. 2016. Infectivity of wild bird-origin avian paramyxovirus serotype 1 and vaccine effectiveness in chickens. *Journal of General Virology*, *97*12, 3161-3173.

Shaheen, S., Anjum, A., & Rizvi, F. 2005. Clinico-pathological observations of pigeons Columba livia suffering from Newcastle disease. *Liver*, *2*, 7.14.

Shopland, S., Barbon, A. R., Greenwood, A., Tatayah, V., & Barrows, M. 2022. Translocation of european captive pink pigeons Nesoenas mayeri to Mauritius: disease risk analysis for production of a pre-export quarantine protocol. *Journal of Zoo and Aquarium Research*, *10*4, 171-182.

Silva, B. B. I., Urzo, M. L. R., Encabo, J. R., Simbulan, A. M., Lunaria, A. J. D., Sedano, S. A., Hsu, K.-C., Chen, C.-C., Tyan, Y.-C., & Chuang, K.-P. 2022. Pigeon Circovirus over Three Decades of Research: Bibliometrics, Scoping Review, and Perspectives. *Viruses*, *14*7, 1498.

Todd, E. 2020. Food-borne disease prevention and risk assessment. In Vol. 17, pp. 5129: MDPI.

Wambura, P., & Wilson, C. 2009. Protective antibody response following oral vaccination of feral pigeons Columba livia with Newcastle disease vaccine strain I-2 coated on oiled rice. *Veterinary research communications*, *33*8, 921-926.

Xiang, B., You, R., Kang, Y., Xie, P., Zhu, W., Sun, M., Gao, P., Li, Y., & Ren, T. 2019. Host immune responses of pigeons infected with Newcastle disease viruses isolated from pigeons. *Microbial Pathogenesis*, *127*, 131-137.

Xu, Q., Zhao, J., Jian, H., Ye, J., Gong, M., Zou, X., & Dong, X. 2023. Linoleic acid ameliorates intestinal mucosal barrier injury in early weaned pigeon squabs Columba livia. *Journal of Animal Science*, *101*, skad125.

Zhan, T., Hu, S., Chen, Y., Lu, X., Liao, T., Guo, L., Gao, X., Xu, X., Hu, Z., & Liu, X. 2020. Comparative pathogenicity of two closely related Newcastle disease virus isolates from chicken and pigeon respectively. *Virus research*, *286*, 198091.

Zhang, R., Ma, H., Han, P., Li, Y., Sun, Y., Yuan, J., Wang, Y., Ni, A., Zong, Y., & Bian, S. 2022. Effects of feed systems on growth performance, carcass characteristics, organ index, and serum biochemical parameters of pigeon. *Poultry science*, *101*12, 102224.

****