Review Article

Journal of Advanced Veterinary Research
(2025) Volume 15, Issue 4, 524-528

Paratyphoid salmonellosis: A disease of significance in pigeons (*Columba livia*)

Wafaa A. Abd El-Ghany*

Poultry Diseases Department, Faculty of Veterinary Medicine, Cairo University, Giza, 12211, Egypt.

ARTICLE INFO

Recieved: 12 July 2025

Accepted: 18 August 2025

*Correspondence:

Corresponding author: Wafaa A. Abd El-Ghany
E-mail address: wafaa.soliman@cu.edu.eg

Keywords:

Clinical picture, Diagnosis, Paratyphoid *Salmonellae*, Pigeons, Treatment

ABSTRACT

Pigeons may be kept in captivity as pet and companion birds, or raised for laboratory specimens, sport or racing, and meat production. Pigeons (*Columba livia*) belong to order *Columbiformes* and family *Columbidae*. Pigeons are susceptible to many important bacterial, viral and parasitic threats. One of the most important bacterial diseases that affect all breads of pigeons is salmonellosis or paratyphoid. Until now, the disease still constitutes one of the most important serious diseases of economic and zoonotic significance for owners of pigeons. Different serotypes of *Salmonella* have been isolated from pigeons. However, *Salmonella* (*S.* Typhimurium) and S. Enteritidis are the most common. Salmonellosis in young squab pigeons causes high mortalities, besides the enteric and nervous manifestations. Chronic carrier diseased pigeons create a hazard to the other avian species and humans. The close contact with pigeons and their droppings is a risk for people who frequently share the same environment. Therefore, pigeon's flocks should be regularly checked for the early detection of *Salmonella* infection status, and the positive reactors should be eradicated with a strict biosecurity plan. Antibiotic sensitivity test is very important before any treatment of *Salmonella* infection in pigeons as a result of continuous development of resistance. Since the multiple needs for raising pigeons and the scientific literature discussing the most important infections of pigeons are insufficient, this article spots-light on salmonellosis in pigeons regarding the disease infection and transmission, signs and lesions, diagnosis, treatment, and vaccination.

Introduction

Pigeons (*Columba livia*) belongs to the order of *Columbiformes* and *Columbidae* family (Harrison and Greensmith, 1994). Many breeds of pigeons such as Nose Divers, Rollers, Doneks, Archangel, Blondinette, Chinese owl, Egyptian Swift, Fantail and messenger are raised for their aerial abilities. Pigeons have been raised for meat (Husein *et al*., 2024), racing sports (Israili and Iqbal, 2017), exhibitions and shows (Abolnik, 2014), and experimental research purposes (Uyttebroek *et al*., 1989, 1991; Abolnik *et al*., 2018). People start pigeon farming to satisfy public demand (Tan and Hackenberg, 2015). Currently, the pigeon breeding industry has become the fourth mainstream poultry industry after chickens, ducks and geese (Ji *et al*., 2020; Li *et al*., 2021). Pigeon's meat is characterized by high nutritive contents due to high levels of protein, amino acids, vitamins, calcium, iron, and zinc, but low fat, making it favored by consumers (Mahdy, 2021; Wang *et al*., 2021). So, pigeon's meat is gaining popularities among consumers world-wide (Wang *et al*., 2022).

Different factors contribute to pigeon stress, such as changes in the rearing environment and alterations in feeding methods and nutrition (Wen *et al*., 2022). Homing pigeons which are housed in lofts may facilitate long-term keeping of zoonotic bacterial pathogens (Teske *et al*., 2013; Santos *et al*., 2020), particularly *Salmonella* spp. (Kaczorek-Lukowska *et al*., 2021). Domestic and urban pigeons may come in close contact with other avian species and humans and act as a reservoir of zoonotic pathogens with public health significance (Lawson *et al*., 2014). Humans get infected with *Salmonella* spp. via the food chain, while racing pigeons can transmit the bacterium through the direct contact and droppings (de Oliveira *et al*., 2018). Besides, there is a danger for transmitting *Salmonella* spp. and their antimicrobial resistance among avian species that may represent economic losses (Osman *et al*., 2014).

Salmonella spp. are members of the family Enterobacteriaceae, and they are etiologic agents of food-borne poisoning-salmonellosis (Jahantigh and Nili, 2010). Salmonellosis is a prevalent zoonotic bacterial disease (WHO, 2017), as 91,857 cases of salmonellosis were reported in Europe and 1.2 million infections in the United States every year (CDC, 2018).

Pigeons have an important role in spreading bacterial agents to free-range poultry and have been considered as a fecal contaminator of drinking water sources (Lillehaug *et al*., 2005). Salmonellosis or paratyphoid is one of the most important diseases of pigeons as it is caused by different spp. of *Salmonellae* particularly *Salmonella enterica* subsp. enterica serovar Typhimurium (*S.* Typhimurium), *Salmonella enterica* serovar Enteritidis (*S.* Enteritidis), and *Salmonella typhimurium var. Copenhagen* (Pasmans *et al*., 2004; Majer-Dziedzic *et al*., 2014; Haesendonck *et al*., 2016). Only *S.* Typhimurium persistently causes this disease (Branchu *et al*., 2018), however, *Salmonella typhimurium var. Copenhagen* was detected in over 95 % of pigeons infected with *Salmonellae* (Pasmans *et al*., 2008; Ledwoń *et al*., 2019). Osman *et al*. (2014) succeeded in isolation of new *Salmonella* types from squabs, including *S.* Braenderup and *S.* Lomita which have a significant cause of food poisoning and enteric fever in humans (WHO, 2017). The close contact of pigeons with humans should be considered a potential risk to human health, especially for those most susceptible, such as children and immunocompromised individuals (Hale *et al*., 2012).

Despite this bacterial infection was found to adhere to the intestinal epithelium of pigeons causing enteritis, other clinical manifestations may be shown including conjunctivitis, arthritis, oophoritis, meningitis, and high mortality (Dutta *et al*., 2013). *Salmonella* spp. have been isolated from the droppings, intestine, and organs of infected pigeon's in Spain (Casanovas *et al*., 1995; Adesiyun *et al*., 1998), Belgium (Kimpe *et al*., 2002), Chile (Toro *et al*., 1999; González-Acuña *et al*., 2007), Croatia (Vucemilo *et al*., 2003), Slovenia (Dovc *et al*., 2004), Japan (Tanaka *et al*., 2005), Norway (Lillehaug *et al*., 2005), Unites States (Pedersen *et al*., 2006), Brazil (De Sousa *et al*., 2010; Carvalho *et al*., 2020), Czech Republic (Kriz *et al*., 2011), Bangladesh (Hosain *et al*., 2012; Karim *et al*., 2020; Bupasha *et al*., 2021), Germany (Methner and Lauterbach, 2003; Teske *et al*., 2013), Italy

ISSN: 2090-6277/2090-6269/

(Antonio *et al*., 2014; Gargiulo *et al*., 2014), Brazil (Santana *et al*., 2023), Egypt (Ibrahim, 2008; Ammar *et al*., 2014; Osman *et al*., 2014; Yousef and Mamdouh, 2016; Abdeen *et al*., 2018; Gaber *et al*., 2019; El Gresly *et al*., 2021; Eid *et al*., 2023; Hamed *et al*., 2023), Iran (Ranjbar *et al*., 2020), Canada (Gabriele-Rivet *et al*., 2016), Poland (Piasecki, 2006; Stenzel *et al*., 2013; Ledwoń *et al*., 2019; Kaczorek-Lukowska *et al*., 2021), and China (Liang *et al*., 2016; Yang *et al*., 2023; Zhang *et al*., 2024). The incidence of *Salmonellae* are presented in Table 1.

Therefore, this article summarizes salmonellosis in pigeons. The infection and transmission, signs and lesions, diagnosis, treatment, and vaccination were described in this review.

Infection and transmission

Any age of pigeons can be infected with *Salmonella* spp. causing a high number of deaths (Rabsch *et al*., 2002). *Salmonella* spp. among pigeon lofts may spread either horizontally or vertically. For example, *Salmonella* spp. can infect breeding pigeons and then transmit to the hatched eggs via vertical transmission resulting in decreasing the hatchability rate (Jawale and Lee, 2014). Moreover, adult breeders can infect squab pigeons via feeding on crop milk, leading to infection and consequent high deaths and losses. Rodents and wildlife birds can spread *Salmonella* into pigeon flocks, especially when biosecurity measures are not adopted (Żebrowska *et al*., 2017). Feed chain is an important source for the lateral spread of the bacterium (Djeffal *et al*., 2018).

Signs and lesions

The clinical signs of salmonellosis in pigeons vary depending on the age, general health conditions, and immune status of birds (Figure 1). Infection of squab pigeons with *Salmonella* spp. is characterized by high mortality rate particularly during the first few days of life (Tanaka *et al*., 2005), however, *Salmonella* infections in adult pigeons are progressed very slowly and associated with anorexia, greenish diarrhea (Gaber *et al*., 2019), panophthalmitis, polydipsia, arthritis, weight loss, and neurological manifestations (Vereecken *et al*., 2000; Dumitrache, 2013). *Salmonella* spp. are capable to survive for a long-term in the hosts' macrophages causing chronical carriage. The sub-clinically infected pigeons become chronic carriers and may shed *Salmonella* in droppings, which is the main route of infection in pigeon flocks (Pasmans *et al*., 2008).

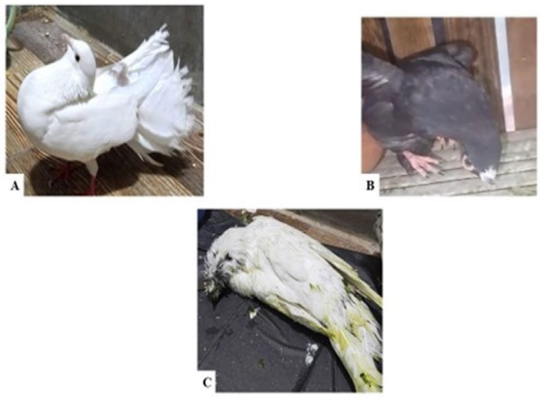

Figure 1. Pigeons show nervous manifestations (A &B) and greenish diarrhea (C) due to *Salmonella* spp. infection.

Post-mortem lesions of *Salmonella* spp. infected pigeons are shown in Figure 2. Septicemia, bronzy colored liver (Gaber *et al*., 2019), enlarged liver and spleen with haemorrhages, enteritis, nodules on the internal organs, and hemorrhages on the brain are the most common post-mortem lesions (Farghaly and Badr, 2011). Severe necrosis and sloughing of the intestinal mucosa, along with vascular congestion as well as heterophil and mononuclear infiltrations were reported in *Salmonella* infected pigeons (Dutta *et al*., 2013).

Laboratory diagnosis

For the conventional isolation of *Salmonella* spp., samples should be subjected for pre-incubation in non-selective broth such as tetrathion-

Table 1. *Salmonella* isolates from pigeons in different countries.

Country	*Salmonella* spp.	Reference
Spain	*Salmonella* was detected as 1.4% from 18 farms (1110 squabs), 4.3% from 1 farm (250 squabs) and 4.1% from 23 farms (2900 squabs)	Casanovas *et al*. (1995)
Chile	Six *Salmonella* strains were detected in faecal samples of pigeons	Toro *et al*. (1999)
Germany	*Salmonellae* isolates belonged to serogroups D1 (84. 26%), B (8. 33%), and C1 (7. 41%) were isolated from 111 samples	Methner and Lauterbach (2003)
Egypt	The incidence of *S*. Typhimurium isolation was 20.8%	Ahmed and El-Sisi (1965)
	The incidence of *Salmonella* isolation was 12.4%	El-Shater (1979)
	S. Paratyphi A and *S*. Typhimurium var. Copenhagen (100%) followed by *S*. Typhimurium (83.33%) were detected	Ibrahim (2008)
	The incidence of *Salmonella* isolation was 9.52% and the isolated *S*. Typhimurium and *S*. Enteritidis were with frequencies of 88.5% and 11.5% respectively	Mohamed (2008)
	Six isolates were identified from 45 (13.3%) squab's samples. *S*. Typhimurium (4/6; 66.7%), *S*. Braenderup (1/6; 16.7%), and *S*. Lomita (1/6; 16.7%) were identified	Osman *et al*. (2014)
	Out of 147 pigeons, *S*. Typhimurium (12 strains), *S*. Enteritidis (5 strains), and *S*. Muenster (one strain) in a percentage of 66.6%, 27.7%, and 5.55% respectively were detected. The incidence of *Salmonella* isolation was 12.24 %	Gaber *et al*. (2019)
	The prevalence rate of *Salmonella* spp. for squabs, pigeons, and environmental samples was 5%, 3. 5% and 4. 6% respectively. The isolated serotypes recovered from squabs were 4 isolates of *S*. Typhimurium, and 2 isolates from each of *S*. Enteritidis, *S*. Agona, and *S*. Montevideo. While in adults were *S*. Typhimurium and *S*. Enteritidis (3 isolates from each) and one isolates from *S*. agona. Serotyping results of environmental samples revealed 3 serotypes of *S*. Typhimurium, *S*. Agona, and *S*. Virginia	Ammar *et al*. (2014)
	Out of 200 samples, *S*. Virchow was more frequently isolated (25%), followed by *S*. Typhimurium and *S*. Paratyphi (16.6% each). Meanwhile, *S*. Akay, *S*. Salamae, *S*. Anderlecht, *S*. Magherafelt, and *S*. Montevideo were 8.3%, each	El Gresly *et al*. (2021)
Brazil	Out of 41 pigeons, 3 strains of *S*. Typhimurium were isolated	Carvalho *et al*. (2020)
	Salmonella spp. were found in 9 (19.1%) pigeons (n=18; isolation rate of 50%), while *S*. Typhimurium and *S*. Heidelberg were isolated from 6 (66.7%) and 3 pigeons, respectively	Santana *et al*. (2023)
China	Out of 215 samples, 32 *Salmonella* isolates belonged to *S*. Typhimurium var. Copenhagen were detected	Zhang *et al*. (2024)

ate broth, Selenite-F broth medium, buffered peptone water or Rappaport-Vassiliadis soy broth and incubated at 41.5°C for 24 h. Afterwards, they were transferred into the selective media such as xylose lysine desoxycholate agar, Brilliant Green agar, *Salmonella*-Shigella agar, MacConkey, and bismuth sulfite and then incubated at 41.5°C for 48 ± 2 h under aerobic conditions (Park *et al*., 2012). The morphological characteristics of specific *Salmonella* colonies vary according to the media type. A film from suspected colonies was stained with Gram stain and examined microscopically for morphological characters. The identification was performed using commercial API 20E and latex agglutination tests. The biochemically identified *Salmonella* culture was subjected to serological identification using polyvalent and monovalent "O" and "H" *Salmonella* antisera.

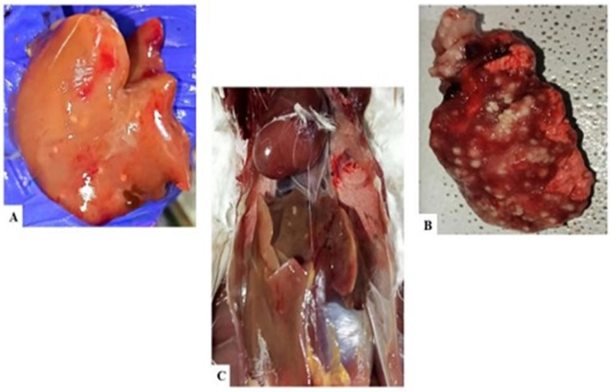

Figure 2. Pigeons show liver hemorrhages and necrosis (A), lung nodules (B), and septicaemia (C) due to *Salmonella* spp. infection.

Different molecular techniques are used to replace the conventional method for the diagnosis of *Salmonella enterica* serovars (Sukhnanand *et al*., 2005; Achtman *et al*., 2012). The multilocus sequence typing showed high discriminative ability for typing *Salmonella* serovars in pigeons (Kaczorek-Lukowska *et al*., 2021). Besides, Enterobacterial repetitive intergenic consensus polymerase chain reaction (PCR) and PCR-melting profile could be used to evaluate the genetic diversity of *Salmonella* strains (Anjay *et al*., 2015; Zaczek *et al*., 2015). Partial-genome sequencing is a high-quality sequence technique which can detect the clinical *Salmonella* strains of antimicrobial resistance and their virulence genes (Ahrenfeldt *et al*., 2017).

Prevention and control

Strict sanitary compliance can greatly help in inhibiting the spread of infections in the flocks of pigeons. Continuous and regular flock monitoring, biosecurity measures, feed additives, and vaccines are the tools for reducing the incidence of salmonellosis, the possibility of human's food poisoning, and the use of antibiotics during production. However, the pigeon industry has not yet established a strict biosecurity measure system, besides the defects in the treatment and immunization measures. Thus, once pigeon's *Salmonella* infections occur, serious damage occurs (EFSA, 2018).

Treatment

Different antibiotics including amoxicillin/clavulanic acid, ampicillin, ceftriaxone, doxycycline, rifampicin, erythromycin, nalidixic acid, gentamicin, enrofloxacin, flumequine, norfloxacin, chloramphenicol, ciprofloxacin, Amikacin, levofloxacin and oxytetracycline were used for the treatment pigeon's diseases (Jahantigh and Nili, 2010; Abulreesh, 2011; Stenzel *et al*., 2014; Gaber *et al*., 2019).

Despite antibiotic treatment of *Salmonella*-infected pigeons is the most popular way, the treatment fails to give satisfactory results. This difficulty in the treatment may be due to improper selection of active antibiotics ingredients, too short period of administration or incorrect dose of drugs, and presence of *Salmonella* intracellularly with a high resistance to environmental factors. The ability of some *Salmonella* serotypes to form a biofilm may indicate a difficult future course of veterinary treatment (Olson *et al*., 2002; Marin *et al*., 2009; Merino *et al*., 2019). In addition, presence of sub-clinical chronic carriers to such infection even after long term treatment can shed the bacterium to other birds in the flock (Majer-Dziedzic *et al*., 2014). New generations of *Salmonella* containing multidrug-resistant genes for different antibiotics have been recently merged as a result of misusing of these antibiotics in the treatment protocols (Torres-Mejía *et al*., 2018). Cautious regarding the development of resistant strains against different antibiotics necessitated frequent updated studies on antimicrobial susceptibility test.

Early, field *Salmonella* strains of pigeon's origin were frequently susceptible to all the tested antibiotics (Kimpe *et al*., 2002). Later, the antimicrobial resistance to such strains was seriously increased due to the overuse of antibiotics by pigeon breeders. It is important to mention that domestic pigeons are used as racing birds (carrier pigeons) or as ornamental birds (fancy pigeons), so their treatment is not subject to veterinary control. The previous results of phenotypic and genotypic studies of *Salmonella* s antibiotic resistance were not always constant, likely due to the presence of silent genes (Kime *et al*., 2019).

One of the promising antibiotic alternatives is a bacteriophage. The use of host-specific bacteriophages is increasingly considered in controlling salmonellosis (Atterbury *et al*., 2020). Some studies revealed effectiveness of bacteriophages in eradicating *Salmonella* spp. on chicken's surfaces (Abhisingha *et al*., 2020; Atterbury *et al*., 2020).

Some phytogenic substances are used for the treatment of *Salmonella* infected pigeons with successful results. For instance, oral supplementation of *Salmonella* infected 28-days-old pigeon with 10mg *Yucca schidigera* enhanced humoral immunity, improved intestinal health by promoting intestinal morphology and altering the beta diversity and composition of ileal microbiota, and ameliorated serum biochemical indexes (Sun *et al*., 2023).

Vaccination

Vaccination is a valuable option to control *Salmonella* infection in pigeons. Despite, vaccination mainly reduces the clinical signs and mortality rates, it does not eliminate the possibility of a clinical infection (Proux *et al*., 1998). Moreover, a significant reduction in the faecal excretion of *Salmonella* was observed in pigeons following infection and vaccination with a bacterin (Uyttebroek *et al*., 1991).

A clear reduction in morbidity and mortality rates has been demonstrated in *Salmonella* challenged and vaccinated pigeons (Duchatel *et al*., 1998). Khedr *et al*. (2016) evaluated the efficacy of a combined oil-adjuvant inactivated vaccine of pigeon paramyxo-virus 1 and *S.* Typhimurium and found that it was safe, potent, and protective.

Conclusion

This review provides insights for pigeon's handlers to develop effective and efficient way to detect and control salmonellosis as one of the important bacterial diseases affecting pigeons world-wide. It is important to reinforce the significance of pigeon population control due to their potential role in the transmission of zoonotic paratyphoid salmonellosis.

Conflict of interest

The author declares that there is no conflict of interest.

References

Abdeen, E., Elmonir, W., Suelam, I.A., Mousa, W.S., 2018. Antibiogram and genetic diversity of *Salmonella enterica* with zoonotic potential isolated from morbid native chickens and pigeons in Egypt. Journal of Applied Microbiology 124, 1265-1273. https://doi.org/10.1111/

jam.13697
Abhisingha, M., Dumnil, J., Pitaksutheepong, C., 2020. Efficiency of phage cocktail to reduce *Salmonella* Typhimurium on chicken meat during low temperature storage. LWT - Food Science and Technology 129, 109580. https://doi. org/10.1016/j.lwt.2020.109580
Abolnik, C.A., 2014. Current review of avian influenza in pigeons and doves (*Columbidae*). Veterinary Microbiology 170, 181-196. https://doi.org/10.1016/j.vetmic.2014.02.042
Abolnik, C., Stutchbury, S., Hartman, M.J., 2018. Experimental infection of racing pigeons (*Columba livia domestica*) with highly pathogenic Clade 2.3.4.4 sub-group B H5N8 avian influenza virus. Veterinary Microbiology 227, 127-132. https://doi.org/10.1016/j.vetmic.2018.10.028
Abulreesh, H.H., 2011. Free living rock pigeon (*Columbia livia*) as an environmental reservoir of enteric bacterial pathogens resistant to antimicrobial drugs in Saudi Arabia. Current Research in Bacteriology 4, 28-33. https://doi.org/10.3923/crb.2011.28.33
Achtman, M., Wain, J., Weill, F. X., Nair, S., Zhou, Z., Sangal, V., Krauland, M.G., Hale, J.L, Harbottle, H., Uesbeck, A., Dougan, G., Harrison, L.H., Brisse, S., 2012. S.E.M.S. Group. Multilocus sequence typing as a replacement for serotyping in *Salmonella enterica*. PLoS Pathogens 8, e1002776. https://doi.org/10.1371/journ al.ppat.1002776
Adesiyun, A.A., Seepersadsingh, N., Inder, L., Caesar, K., 1998. Some bacterial enteropathogens in wildlife and racing pigeons from Trinidad. Journal of Wildlife Diseases 34, 73–80. https://doi. org/10.7589/0090-3558-34.1.73
Ahmed, A.A.S., El-Sisi, M.A., 1965. Observation on diseases affecting pigeons in Egypt and their incidence with special reference to ornithosis, paratyphoid and trichomoniasis. Veterinary Medical Journal 7, 319-330.
Ahrenfeldt, J., Skaarup, C., Hasman, H., Pedersen, A.G., Aarestrup, F.M., Lund, O., 2017. Bacterial whole genome-based phylogeny: construction of a new benchmarking dataset and assessment of some existing methods. BMC Genomics 18, 19. https://doi.org/10.1186/s12864-016-3407-6
Ammar, A., Sultan, H., El-Sayed, I., Yousef, S., Mamdouh R., 2014. Seroprevalence of salmonellosis among pigeon and its surrounding environment and isolation of *Salmonella* species. International Journal of Scientific Research 3, 1856-1862.
Anjay, A.K., Agarwal, R.K., Ramees, T.P., Dubal, Z.B., Kaushik, P., Kumar, M.S., Dudhe, N.C., Milton, A.A.P., Abhishek, B.K., Shagufta, B., 2015. Molecular typing of *Salmonella* Typhimurium and S. Enteritidis serovars from diverse origin by ERIC-PCR. Journal of Pure and Applied Microbiology 9, 2627-2634. https://doi.org/10.1111/ jam.12805
Antonio, G., Pasqualina, R.T., Rita, S., Karina, M., Mariarosaria, C., Francesca, M.L., Pasquale, R., Ugo, P., 2014. Occurrence of enteropathogenic bacteria inurban pigeons (*Columba livia*) in Italy. Vector-Borne Zoonotic Diseases 14, 251-255. https://doi.org/10.1089/vbz.2011.0943
Atterbury, R.J., Gigante, A.M., Rubio Lozano, M., Méndez Medina, R. D., Robinson, G., Alloush, H., Barrow, P.A., Allen, V.A., 2020. Reduction of *Salmonella* contamination on the surface of chicken skin using bacteriophage. Virology Journal 17, 98. https://doi. org/10.1186/s1298 5-020-01368 -0
Branchu, P., Bawn, M., Kingsley, R.A., 2018. Genome Variation and Molecular Epidemiology of *Salmonella enterica* Serovar Typhimurium Pathovariants. Infection and Immunity 6, e00079-18. https://doi.org/10.1128/iai.00079-18
Bupasha, Z.B., Begum, R., Karmakar, S., Akter, R., Bayzid, M., Ahad, A., Sarker, M.S., 2021. Multidrug-resistant *Salmonella* spp. isolated from apparently healthy pigeons in a live bird market in Chattogram, Bangladesh. World Veterinary Journal 10, 508-513. https://doi.org/10.54203/scil.2020.wvj61
Carvalho, D., Kunert-Filho, H.C., Simoni, C., de Moraes, L.B., Furian, T.Q., Borges, K.A., Breunig, J.G., Medeiros, L.P., Kobayashi, R.K.T., de Brito, K.C.T., de Brito, B.G., 2020. Antimicrobial susceptibility and detection of virulence-associated genes of *Escherichia coli* and *Salmonella* spp. isolated from domestic pigeons (*Columba livia*) in Brazil. Folia Microbiologica (Praha) 65, 735-745. https://doi.org/10.1007/s12223-020-00781-w
Casanovas, L., Simon, D.E., Ferrer, M., Arques, M.J., Monzón, G., 1995. Intestinal carriage of campylobacters, *Salmonella*s, yersinias and listerias in pigeons in the city Barcelona. Journal of Applied Bacteriology 78, 11-13. https://doi.org/10.1111/j.1365-2672.1995.tb01666.x
CDC (Center of Disease Control and Prevention), 2018. Retrieved from https://www.cdc.gov/nationalsurveillance/pdfs/Na tionalSalmSurveillOverview_508.pdf.
De Oliveira, M.C.V., Camargo, B.Q., Cunha, M.P.V., Saidenberg, A.B., Teixeira, R.H.F., Matajira, C.E.C., Moreno, L.Z., Gomes, V.T.M., Christ, A.P.G., Barbosa, M.R.F., Sato, M.I.Z., Moreno, A.M., Knöbl, T., 2018. Free-ranging synanthropic birds (Ardea alba and *Columba livia domestica*) as carriers of *Salmonella* spp. and diarrheagenic *Escherichia coli* in the vicinity of an Urban Zoo. Vector-Borne Zoonotic Diseases 18, 65-69. https://doi.org/10.1089/vbz.2017.2174
De Sousa, E., BerchieriJúnior, A., Pinto, A.A., Machado, R.Z., Carrasco, A.O.T., Marciano, J.A., Werther, K., 2010. Prevalence of *Salmonella* spp. antibodies to Toxoplasma gondii, and Newcastle disease virus in feral pigeons (*Columba livia*) in the city of Jaboticabal, Brazil. Journal of Zoo and Wildlife Medicine 41, 603-607. https://doi.org/10.1638/2008-0166.1
Djeffal, S., Bakir, M., Rachid, E., Sana, H., Omar, B., 2018. Prevalence and risk factors for *Salmonella* spp. contamination in broiler chicken farms and slaughterhouses in the northeast of Algeria. Veterinary World 11, 1102-1108. https://doi.org/10.14202/vetworld.2018.1102-1108
Dovc, A., Zorman-Rojs, O., VerglesRataj, A., Bole-Hribovsek, V., Krapez, U., Dobeic M., 2004. Health status of free-living pigeons (*Columba livia domestica*) in the city of Ljubljana. Acta Veterinaria Hungarica 52, 219-226. https://doi.org/10.1556/avet.52.2004.2.10
Duchatel, J.P., De Ree, J.M., Vindevogel, H., 1998. Essais de vaccination depigeons contre la paratyphose au moyen de vaccins inactiv´es en suspension aqueuse: d´etermination de la dose vaccinale. Annales de Médecine Vétérinaire 142, 35-38.
Dumitrache, D., 2013. Salmonellosis and mycoplasmosis in pigeons. Journal of Applied Bacteriology, 78, 11-13.
Dutta, P., Borah, M., Sarmah R., Gangil R., 2013. Isolation of *Salmonella* typhimurium from pigeons (*Columba livia*) in Greater Guwahati, its histopathological impact and antibiogram. Comparative Clinical Pathology 22, 147-150. https://doi.org/10.1007/s00580-012-1614-3
Eid, S., Ibrahim, H.M., Shaltot, S.H., El Oksh, A.S.A., 2023. An overview of the current situation of salmonellosis in pigeons, house hold chickens, and commercial broilers with a special reference to a customized vaccine developing trial. Journal of Advanced Veterinary Research 13, 322–332.
El Gresly, I., Elfeil, W., Eltarabili, R., Abdein, H., 2021. Virulence-determinants and antibiotic resistance pattern of *Salmonella* species isolated from fancy pigeons in Port Said governorate, Egypt. Zagazig Veterinary Journal 49, 42-55. https://doi.org/10.21608/zvjz.2021.51547.1125
El-Shater, S.A., 1979. Studies on paratyphoid infections in pigeons. MVSc. Thesis, (Poultry Diseases), Faculty of Veterinary Medicine, Cairo University, Egypt.
EFSA (European Food Safety Authority), 2018. The European Union One Health 2018. Zoonoses Report. EFSA, 17.
Farghaly, E.M., Badr, H., 2011. The role played by some aerobic bacteria in sudden death among adult pigeons. Egyptian Poultry Science Journal 31, 549-556.
Gaber, A.M., Ibrahim, A.I., Nasef, S.A., Osman, N., 2019. Pathogenicity characterization and antibiogram of paratyphoid isolates from pigeons in Upper Egypt. ARC journal of Animal Veterinary Science 5, 10-20. http://dx.doi.org/10.20431/2455-2518.0503002
Gabriele-Rivet, V., Fairbrother, J.H., Tremblay, D., Harel, J.; Côté, N., Arsenault, J., 2016. Prevalence and risk factors for Campylobacter spp., *Salmonella* spp., Coxiella burnetii, and Newcastle disease virus in feral pigeons (*Columba livia*) in public areas of Montreal, Canada. Candian Journal of Veterinary Research, 80, 81-85.
Gargiulo, A., Russo, T.P., Schettini, R., Mallardo, K., Calabria, M., Menna, L.F., Raia, P., Pagnini, U., Caputo, V., Fioretti, A., Dipineto, L., 2014. Occurrence of enteropathogenic bacteria in urban pigeons (*Columba livia*) in Italy. Vector Borne Zoonotic Diseases, 14, 251-255. https://doi. org/10.1089/vbz.2011.0943
González-Acuña, D., Silva, F.G., Moreno, L.S., Cerda, F.L., Donoso, S.E., Cabello, J.C., López, J.M., 2007. Detection of some zoonotic agents in the domestic pigeon (*Columba livia*) in the city of Chillán, Chile. Revista chilena de infectología 24, 199-203. http://dx.doi.org/10.4067/S0716-10182007000300004
Haesendonck, R., Rasschaert, G., Martel, A., Verbrugghe, E., Heyndrickx, M., Haesebrouck, F., Pasmans, F. 2016. Feral pigeons: A reservoir of zoonotic *Salmonella* Enteritidis strains? Veterinary Microbiology 15, 101-103. https://doi.org/10.1016/j.vetmic.2016.09.017
Hale, C.R., Scallan, E., Cronquist, A.B., Dunn, J., Smith, K., Robinson, T., Lathrop, S., Tobin-D'Angelo, M., Clogher, P., 2012. Estimates of enteric illness attributable to contact with animals and their environments in the United States. Clinical Infectious Diseases 54, S472-479. https://doi.org/10.1093/cid/cis051
Hamed, E.A., Abdelaty, M.F., Sorour, H.K., Roshdy, H., Samir, A., El badiea, Z.A., 2023. Molecular heterogeneity of *Salmonella* gene isolated from chickens, ducks, pigeons, and rabbits in Egypt. Alexandria Journal of Veterinary Science 76, 15-26. http://dx.doi.org/10.5455/ajvs.134919
Harrison, C., Greensmith A., 1994. Aves del mundo. Barcelona: Ediciones Omega 159.
Hosain, M.S., Islam, M.A., Khatun, M.M., Dey, R.K., 2012. Prevalence and antibiogram profiles of *Salmonella* spp. isolated from pigeons in Mymensingh, Bangladesh. Microbes and Health 1, 54-57. https://doi.org/10.3329/mh.v1i2.14090.
Husein, S.M.A., Agbolosu, A.A., Shaq, N., 2024. Performance characteristics of pigeons (*Columba livia domestica*) reared under deep litter system in Ghana. Journal of Veterinary Science & Technology 13, 18-26.
Ibrahim, H.S., 2008 Bacteriological studies on pathogens in Egyptian pigeons. Egyptian Journal of Agricultural Research, 86, 187-197.
Israili, Z.H., Iqbal, N.J., 2017. Effect of pigeon keeping on health and family life. International Journal of Advances in Social Science and Humanities 5, 5-14. https://doi.org/10.4172/2471-9846.1000190
Jahantigh, M., Nili, H., 2010. Drug resistance of *Salmonella* spp. isolated from pigeon eggs. Comparative Clinical Pathology 19, 437-439. https://doi.org/10.1007/s0058 0-010-1005-6
Jawale, C.V., Lee, J.H., 2014. An immunogenic *Salmonella* ghost confers protection against internal organ colonization and egg contamination. Veterinary Immunology and Immunopathology 162, 41-50. https://doi.org/10.1016/j.vetimm.2014.08.015
Ji, F., Zhang, D., Shao, Y., Yu, X., Liu, X., Shan, D., Wang, Z., 2020. Changes in the diversity and composition of gut microbiota in pigeon squabs infected with Trichomonas gallinae. Scientific Report 10, 19978. https://doi.org/10.1038/s41598-020-76821-9
Kaczorek-Lukowska, E., Sowinska, P., Franaszek, A., Dziewulska, D., Malaczewska, J., Stenzel, T., 2021. Can domestic pigeon be a potential carrier of zoonotic *Salmonella*? Transboundary and Emerging Diseases 68, 2321-2333.
Karim, S.J.I., Islam, M., Sikder, T., Rubaya, R., Halder, J., Alam, J., 2020. Multidrug-resistant *Escherichia coli* and *Salmonella* spp. isolated from pigeons. Veterinary World 13, 2156-2165. https://doi.org/10.14202/vetworld.2020.2156-2165
Khedr, A.A., Abdel Latef, A.A., Sayed, M.L., Abdrabo, M.A., Nagy, N., Radwan, A.A., Abo Dalal, S.E., 2016. Efficacy of an experimental combined inactivated *Salmonella* typhimurium and paramyxovirus vaccine in pigeons. Zagazig Veterinary Journal, 44, 149-155. https://doi.org/10.21608/zvjz.2016.7857
Kime, L., Randall, C.P., Banda, F.I., Coll, F., Wright, J., Richardson, J., Empel, J., Parkhill, J., O'Neill, A.J., 2019. Transient silencing of antibiotic resistance by mutation represents a significant potential source of unanticipated therapeutic failure. mBio 10, e01755-19. https://doi.org/10.1128/mBio.01755 -19
Kimpe, A., Decostere, A., Martel, A., Haesebrouck, F., Devriese, L.A., 2002. Prevalence of antimicrobial resistance among pigeon isolates of Streptococcus gallolyticus, *Escherichia coli* and *Salmonella enterica* serotype Typhimurium. Avian Pathology 31, 393-397. https://doi.org/10.1080/03079450220141679
Kriz, P., Sisak, F., Slana, I., Karpiskova, R., Docekal, J., Skoric, M., Fictum, P., Babak, V., Pavlik, I., 2011. Mycobacterium avium subsp. avium and *Salmonella enterica* serotype Typhimurium var. Copenhagen phage type DT2 in pigeons. Foodborne Pathogens and Disease 8, 1135-1137. https://doi.org/10.1089/fpd.2010.0836
Lawson, B., de Pinna, E., Horton, R.A., Macgregor, S.K., John, S.K., Chantrey, J., Duff, J.P., Kirkwood, J.K., Simpson, V.R., Robinson, R.A., Wain, J., Cunningham, A.A., 2014. Epidemiological evidence that garden birds are a source of human salmonellosis in England and Wales. PLoS One 9, e88968. https://doi.org/10.1371/journ al.pone.0088968
Ledwoń, A., Rzewuska, M., Czopowicz, M., Kizerwetter-Świda, M., Chrobak-Chmiel, D., Szeleszczuk, P., 2019. Occurrence and antimicrobial susceptibility of *Salmonella* spp. isolated from domestic pigeons *Columba livia* var. domestica in 2007–2017 in Poland. Medycyna Weterynaryjna 75, 735-737. https://doi.org/10.21521/ mw.6280
Li, X., Wang, X.M., Shao, Y.X., Wang, Z., Ji, F., Huang, J.G., 2021. Research progress on pigeon salmonellosis and prevention and control measures of its antibiotic substitutes. China Animal Husbandry & Veterinary Medicine 48, 2584-2593. https://doi.org/10.16431/j.cnki.1671-7236.2021.07.035
Liang, D.M., Xu, X.B., Wang, W.F., Zhan, Z.Q., Ren, X.X., Lin, J.T., Liao, M., Zhang, J.M., 2016. Isolation, identification and analysis of serotype and drug resistance of *Salmonella* from pigeon in Shanghai. China Animal Husbandry & Veterinary Medicine 43, 3322-3328.
Lillehaug, A., Monceyron Jonassen, C., Bergsjø, B., Hofshagen, M., Tharaldsen, J., Nesse, L.L., Handeland, K., 2005. Screening of feral pigeon (*Columba livia*), mallard (Anas platyrhynchos) and graylag goose (*Anser anser*) populations for Campylobacter spp., *Salmonella* spp., avian influenza virus and avian paramyxovirus. Acta Veterinaria Scandinavica 46, 193-202. https://doi.org/10.1186/1751-0147-46-193
Mahdy, M.A.A., 2021. Comparative morphological study of the oropharyngeal floor of squabs and adult domestic pigeons (*Columba livia domestica*). Microscopy Research and Technique 84, 499-511. https://doi.org/10.1002/jemt.23606
Majer-Dziedzic, B., Pochodyła, M., Tokarzewski, S., Pochodyła, A., 2014. Isolation of *Salmonella typhimurium var. Copenhagen* strains from dead pigeons and evaluation of their immunogenicity. Medycyna Weterynaryjna 70, 620-625.
Marin, C., Hernandez, A., Lainez, M., 2009. Biofilm development capacity of *Salmonella* strains isolated in poultry risk factors and their resistance against disinfectants. Poultry Science 88, 424-431. https://doi.org/10.3382/ps.2008-00241
Merino, L., Procura, F., Trejo, F.M., Bueno, D.J., Golowczyc, M.A., 2019. Biofilm formation by *Salmonella* sp. in the poultry industry: Detection, control and eradication strategies. Food Research International 119, 530-540. https://doi.org/10.1016/j.foodr es.2017.11.024
Methner, U., Lauterbach, L., 2003. The detection of *Salmonella* Typhimurium varatio copenhagen DT 2 in purebred pigeons. Deutsche tierärztliche Wochenschrift 110, 239-244.
Mohamed, M.A., 2008. A study on genetic variability on *Salmonella* strains isolated from pigeons using entero bacterial repetitative integrated consensus-PCR (ERIC-PCR) and plasmid profiling. XIII Scientific Congress, Faculty of Veterinary Medicine, Assuit University, 2008.
Olson, M., Ceri, H., Morck, D., Buret, A., Read, R., 2002. Biofilm bacteria: Formation and comparative susceptibility to antibiotics. Canadian Journal Veterinary Research 66, 86–92.
Osman, K.M., Marouf, S.H., Mehana, O.A., AlAtfeehy, N., 2014. *Salmonella enterica* serotypes isolated from squabs reveal multi drug resistance and a distinct pathogenicity gene repertoire. Revue Scientifique et Technique 33, 997-1006. https://doi.org/10.20506/ rst.33.3.2336
Park, S.H., Ryu, S., Kang, D.H., 2012. Development of an improved selective and differential medium for isolation of *Salmonella* spp. Journal of Clinical Microbiology 50, 3222-2226. https://doi.org/10.1128/jcm.01228-12
Pasmans, F., Van Immerseel, F., Hermans, K., Heyndrickx, M., Collard, J.M., Ducatelle, R., Haesebrouck, F., 2004. Assessment of virulence of pigeon isolates of *Salmonella enterica* subsp. enterica serovar typhimurium variant copenhagen for humans. Journal of Clinical Microbiology 42, 2000-2002. https://doi.org/10.1128/ jcm.42.5.2000-2002.2004
Pasmans, F., Baert, K., Martel, A., Bousquet-Melou, A., Lanckriet, R., De Boever, S., Van Immerseel, F., Eeckhaut, V., De Backer, P., Haesbrouck, F., 2008. Induction of the carrier state in pigeons infected with *Salmonella enterica* subspecies enterica serovar typhimurium PT99 by treatment with florfenicol: A matter of pharmacokinetics. Antimicrobial Agents And Chemotherapy 52, 954-961. https://doi.org/10.1128/AAC.00575 -07

Pedersen, K., Clark, L., Andelt, W.F., Salman, M.D., 2006. Prevalence of shiga toxin-producing *Escherichia coli* and *Salmonella enterica* in rock pigeons captured in Fort Collins, Colorado. Journal of Wildlife Diseases 42, 46-55. https://doi.org/10.7589/0090-3558-42.1.46

Piasecki, T., 2006. Evaluation of urban pigeon (*Columba livia* f. urbana) health status in relation to their threat to human's health. Medycyna Weterynaryjna 62, 531-535.

Proux, K., Humbert, F., Guittet, M., Colin, P., Bennejean, G., 1998. Vaccination of pigeon by *Salmonella* typhimurium. Avian Pathology 27, 161-167. https://doi.org/10.1080/03079459808419318

Rabsch, W., Andrews, H.L., Kingsley, R.A., Prager, R., Tschäpe, H., Adams, L.G., Bäumler, A.J., 2002. *Salmonella enterica* serotype Typhimurium and its host-adapted variants. Infection and Immunity 70, 2249-2255. https://doi.org/10.1128/iai.70.5.2249-2255.2002

Ranjbar, V., Basiri, S., Abbasi-Kali, R., 2020. Paratyphoid infection caused by *Salmonella* Typhimurium in a pigeon flock (Columbia livia) in Iran. Journal of Zoonotic Diseases 4, 43-48. https://doi.org/10.22034/jzd.2020.10587

Santana, J.A., Ramos, C.P., Silva, B.A., Lima, G.K., Comerlato, A.T., Araújo, A.C., Colombo, S.A., Bicalho, G.C., Silva, R.O.S., 2023. Identification and characterization of pathogenic and multidrug-resistant bacteria in feral pigeons surrounding a veterinary hospital in Minas Gerais, Brazil. Ciência Rural 53, e20220244. https://doi.org/10.1590/0103-8478cr20220244

Santos, H.M., Tsai, C.Y., Catulin, G.E.M., Trangia, K.C.G., Tayo, L.L., Liu, H.J., Chuang, K.P., 2020. Common bacterial, viral, and parasitic diseases in pigeons (*Columba livia*): A review of diagnostic and treatment strategies. Veterinary Microbiology 247, 108779. https://doi.org/10.1016/j.vetmic.2020.108779

Stenzel, T., Szulia, G., Fordońska, J., Górska, J., Śmiałek, M., Tykałowski, B., Pestka, D., Koncicki, A., 2013. Antimicrobial resistance of selected bacteria isolated from pigeons in Poland in the years 2010-2013. Conference proceedings: Actual problems in poultry pathology. 27-28, June, 2013, 174-181.

Stenzel, T., Bancerz-Kisiel, A., Tykałowski, B., Śmiałek, M., Pestka, D., Koncicki, A., 2014. Antimicrobial resistance in bacteria isolated from pigeons in Poland. Polish Journal of Veterinary Sciences 17, 169-171. https://doi.org/10.2478/pjvs-2014-0023

Sukhnanand, S., Alcaine, S., Warnick, L.D., Su, W.L., Hof, J., Craver, M.P.J., McDonough, P., Boor, K.J., Wiedmann, M., 2005. DNA sequence-based subtyping and evolutionary analysis of selected *Salmonella enterica* serotypes. Journal of Clinical Microbiology 43, 3688-3698. https://doi.org/10.1128/JCM.43.8.3688-3698.2005

Sun, X., Wang, Z., Li, X., Du, S., Lin, D., Shao, Y., 2023. Effects of *Yucca schidigera* extract on serum biochemical parameters, humoral immune response, and intestinal health in young pigeons. Frontiers in Veterinary Science 9, 1077555. https://doi.org/10.3389/fvets.2022.1077555

Tan, L., Hackenberg, T.D., 2015. Pigeons' demand and preference for specific and generalized conditioned reinforcers in a token economy. Journal of the Experimental Analysis of Behavior, 104, 296-314. https://doi.org/10.1002/jeab.181

Tanaka, C., Miyazawa, T., Watarai, M., 2005. Ishiguro N. Bacteriological survey of faeces from feral pigeons in Japan. Journal of Veterinary Medical Science 67, 951-953. https://doi.org/10.1292/jvms.67.951

Teske, L., Ryll, M., Rubbenstroth, D., Hänel, I., Hartmann, M., Kreienbrock, L., Rautenschlein, S., 2013. Epidemiological investigations on the possible risk of distribution of zoonotic bacteria through apparently healthy homing pigeons. Avian Pathology 42, 397-407. https://doi.org/10.1080/03079457.2013.822468

Toro, H., Saucedo, C., Borie, C., Gough, R., Alcaíno, H., 1999. Health status of free-living pigeons in the city of Santiago. Avian Pathology 28, 619-623. https://doi.org/10.1080/03079459994416

Torres-Mejía, A.M., Blanco-Peña, K., Rodríguez, C., Duarte, F., Jiménez-Soto, M., Esperón F., 2018. Zoonotic agents in feral pigeons (*Columba livia*) from Costa Rica: possible improvements to diminish contagion risks. Vector Borne Zoonotic Diseases 18, 49-54. https://doi.org/10.1089/vbz.2017.2131

Uyttebroek, E., Gevaert, D., Devriese, L.A., 1989. Effect of different chemotherapeutics on experimental salmonellosis in pigeons. Vlaams Diergeneeskundig Tijdschrift 58, 51-54.

Uyttebroek, E., Devriese, L.A., Gevaert, D., Ducatelle, R., Nelis, J., Haesebrouck, F., 1991. Protective effects of against experimental salmonellosis in racing pigeons. Veterinary Record 128, 152-153. https://doi.org/10.1136/vr.128.7.152

Vereecken, M., De Herdt, P., Ducatelle, R., Haesebrouck, F., 2000. The effect of vaccination on the course of an experimental *Salmonella* typhimurium infection in racing pigeons. Avian Pathology 29, 465-471. https://doi.org/10.1080/030794500750047225

Vucemilo M., Vlahovic K., Dovc A., Muzinic J., Pavlak M., Jercic J., Zupancic Z., 2003. Prevalence of *Campylobacter jejuni*, *Salmonella* Typhimurium and avian Paramyxovirus type 1 (PMV-1) in pigeons from different regions in Croatia. Zeitschrift Fur Jagdwissenschaft 49, 303-313.

Wang, F., Liu, J., Hu, X., Zhong, Y., Wen, F., Tang, X., Yang, S., Zhong, S., Zhou, Z., Yuan, X., Li, Y., 2021. The influence on oxidative stress markers, inflammatory factors and intestinal injury-related molecules in Wahui pigeon induced by lipopolysaccharide. PLoS One 16, e0251462. https://doi.org/10.1371/jour nal.pone.0251462

Wang, Z., Li, X., Du, S., Sun, X., Huang, J., Shao, Y., 2022. Protective effects of zinc on *Salmonella* invasion, intestinal morphology and immune response of young pigeons infected with *Salmonella enterica* Serovar Typhimurium. Biological Trace Element Research 200, 4817-4827. https://doi.org/10.1007/s12011-021-03057-7

Wen, J.S., Xu, Q.Q., Zhao, W.Y., Hu, C.H., Zou, X.T., Dong, X.Y., 2022. Effects of early weaning on intestinal morphology, digestive enzyme activity, antioxidant status, and cytokine status in domestic pigeon squabs (*Columba livia*). Poultry Science 101, 101613. https://doi.org/10.1016/j.psj.2021.101613

WHO (World Health Organization), 2017. The burden of foodborne diseases in the European region. : World Health Organization. Retrieved from https://www.euro.who.int/__data/asset s/pdf file/0005/40298 9 / 5 0 6 0 7-WHO- Food-Safety- publication V 4 _Web.pdf

Yang, M.L., Zheng, S.Q., Peng, K., Wang, W., Huang, Y.H., Peng, J., 2023. Isolation and Identification of pigeon-derived *Salmonella* typhimurium and pathogenic analysis. Acta Veterinaria et Zootechnica Sinica 54, 4880-4888. https://doi.org/10.11843/j.issn.0366-6964.2023.11.042

Yousef, S., Mamdouh R., 2016. Class I Integron and β-lactamase encoding genes of multidrug resistance *Salmonella* isolated from pigeons and their environments. Cellular and Molecular Biology 62, 48-54. https://doi.org/10.14715/cmb/%202016.62.14.8

Zaczek, A., Wojtasik, A., Izdebski, R., Gorecka, E., Wojcik, E.A., Nowak, T., Kwiecinski, P., Dziadek, J., 2015. PCR melting profile as a tool for outbreak studies of *Salmonella enterica* in chickens. BMC Veterinary Research 11, 137. https://doi.org/10.1186/s1291 7-015-0451-4

Żebrowska, J.P., Witkowska, D., Sobczak, J., Mituniewicz, T., Sowińska, J., 2017. Occurrence of *Salmonella* on poultry farms, in flocks of pigeons and feed monitored by the Department of Veterinary Hygiene in Olsztyn in the years 2014–2015. Medycyna Weterynaryjna 73, 111-117. https://doi.org/10.21521/ mw.5636

Zhang, Y., Lu, Z., Zhao, H., Li, S., Zhuang, H., Wang, J., Li, R., Zheng, W., Zhu, H., Xie, P., Hu Y., Zhou, C., Mao, Q., Sun, L., Li, S., Wang, W., Wang, F., Pan, W., Wang, C., 2024. Antimicrobial resistance and genomic characterization of *Salmonella* isolated from pigeons in China. Transboundary and Emerging Diseases 2024, 3315678.