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Article Review

An overview of current status of Salmonellosis in duck farms in Egypt

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ABSTRACT

In the last two decades, the consumption of duck meat has increased rapidly, and it is expected that it will continue to grow in the future. In Egypt, ducks are regarded as a secondary meat source. More focus has been directed in recent years on enhancing meat production through duck breeding. In the rural area, ducks were well-known for their flavorful and tasty meat. Additionally, it's highly disease resistance was stated for a long time. Salmonella considered as one of the most important pathogens that incriminated in several economic losses to poultry industry. Recently, the appearance of antimicrobial resistances in Salmonella isolates contributed to the inability to control Salmonella infection in duck farms. Therefore this review will focus on the Salmonella isolation from ducks in particular, its incidence rate, serotypes, antimicrobial resistance patterns, different alternative therapy to antibiotics. In Egypt, the incidence rates of Salmonella in duck farms ranged from 0.5% to 20%. The most common serotype that recorded in duck farms was *S.* Typhimurium. The highest antibiotic resistances reported were aganist amoxicillin, cephradine, colistin sulfate, ampicillin, tetracycline, streptomycin, lincomycin and erythromycin. Recently, the misuses of antibiotics results in bacterial resistances in both human and animal fields. Therefore, the need to find alternatives to antibiotics is an important issue. Some substances like lactic acid, Prebiotics, probiotics, symbiotics, essential oils, cinnamaldehyde, organic acids, nanoparticles and chitosan exhibited antibacterial effectively against Salmonella. One of the most effective control measures against Salmonella was bacteriophage treatments that prevent bacterial colonization in the intestinal tracts of birds. The vaccines may provide promising results in the control and prevention of avian Salmonellosis. The findings in this review highlighted the needs of antimicrobial surveillances and biosecurity programs that should be implemented to control the Salmonella infections in different duck farms.

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INTRODUCTION

A significant portion of the poultry industry worldwide is comprised of duck breeding. In Egypt, more attention is focused lately on increasing meat production, particularly ducks which are considered the easiest domestic poultry (**ElSoukkary et al. 2005).** Due to their ability to adapt to a variety of environmental and natural situations, ducks are becoming more and more important and well-liked in Egypt. (**Galal et al. 2011).** There is no match information about duck's populations in many countries. There were 1.15 billion ducks (*Anas spp.*) worldwide of which 1.0 billion (88 percent) were found in Asia. The largest duck populations were found in China (**FAO, 2017).** Detection of Salmonellosis is considered a good tool in protection of poultry industry (**FAO, 1994).** Furthermore, Salmonellosis is one of the most important bacterial diseases in poultry causing heavy economic loss through mortality and reduced production (**Haider et al. 2004).**

Salmonella is a zoonotic microorganism (**Liu et al. 2018**) that responsible for foodborne illness globally (**Igbinosa et al. 2023**) and considered as one of the major global pathogen affecting poultry industry (**Sorour et al. 2023)**.

Ducks are one of the main reservoirs of Salmonella pathogen transmitted to human being (**Khalifa et al. 2021& Sorour et al. 2023**).

Numerous Salmonella serovars are existing. There are 2,600 serovars which grouped depending on the reactivity of antisera to O and H antigens (**Stevens et al. 2009).** The most pathogenic serovars in avian species are Salmonella pullorum and Salmonella gallinarium, which cause systemic illness and considerable economic losses in the poultry sector. Nontyphoidal Salmonella serotypes (Paratyphoid illness) provide a public health risk due to their role in food poisoning issues as well as their zoonotic significance (**El-Saadony et al. 2022**). Many Salmonella serotypes were reported in ducks, mostly have public health significance and some, including S. pullorum, *S.* gallinarum, *S.* enteritidis, *S.* typhimurium, and *S.* anatum caused considerable losses in the young birds lower than few-weeks old (**Buxton, 1957)**.

The infected ducks with Salmonella do not show any apparent clinical symptoms but rather exist as asymptomatic carriers **(Yu et al. 2008) and the** disease spreads rapidly resulting in serious losses in duck breeding industry (**Zhao et al. 2022**). One of the most causes of egg contamination and persistent infections in laying ducks caused by *S.* enteritidis (**Song et al. 2022**).

Incidence of Salmonella infection in ducks farm in Egypt

Salmonella was isolated from ducks, duckling and duck egg at Mansoura Governorate (Egypt) with incidences of 14.5%, 18.5% and 10% respectively. The most recorded serotypes were S. Typhimurium and S. Enteriditis (**El-Gaos et al. 2020).** Another study conducted in 2020 by **El-Maghraby et al. (2020)** on Egyptian duck farms recovered *S.* Typhimurium with a percentage of 20%, and this finding illustrated that most of the duck farms from which the Egyptian *S.* Typhimurium strain were located in the same geographical area in cattle farms adherent to the duck farms which indicated lack in the biosecurity requirements, that could facilitate the circulation and transmission of Salmonella strains between the human beings and animal farms, including duck farms. **Badr and Nasef, (2016)** mentioned that *S.* Typhimurium that isolated from Pekin duck farm suffered from higher mortality with 95% was responsible for 93% of the Salmonella infections in ducklings.

Some research studies reported lower incidences of Salmonella isolation. **Abd-El-Rahman et al. (2000)** isolated Salmonella with an incidence of 20% from 10 duck flocks in North Sinai while (**Khalifa et al. 2021**) recorded an overall percentage of Salmonella isolated from ducks in Assiut governorate, Egypt as 16.6% and *S.* Typhimurium and *S.* Infantis were recorded as circulating serotypes among duck farms in Assiut. **Abdelaziz et al. (2020)** revealed that Salmonella isolation from duckling farms at Qaluobia, Egypt, reach 14.9%. On the other side, **Abu-Zaid, (2014)** isolated

Salmonella from fecal samples collected from healthy and diseased birds with 12%. Also **Osman et al. (2014**) isolated Salmonella (*S.* Typhimurium, *S.* Enteritidis, *S.* Virchow and *S.* Shubra) from domestic ducklings in Egypt with an incidence of (12%). **Elgohary et al. (2017)** recovered Salmonella from diarrheic ducks with an incidence of 5.5% (6.15% from young ducks and 4.28% from adult ducks) and from slaughtered ducks with an incidence of 3.33% whereas *S.* Typhimurium, *S.* Infants, *S.*Virchow were isolated from adult ducks, *S.* Typhimurium, *S.* Agona, *S.* Kentucky, *S.* Infants, *S.* Virchow and *S.* Longhorn were isolated from young ducks and *S.* Kentucky and *S.* Typhimurium were detected from slaughtered ducks. However in Dakahlia Governorate (Egypt), Salmonella was recovered from ducks with an incidence of 7% and four serotypes were detected (*S.* Enteritidis, *S.* Typhimurium, *S.* Inganda and *S.* Kentucky) **(Hassan et al. 2019).** Also in a study conducted by **Abou Zeid et al. (2020)**, Salmonella was isolated from diseased ducklings in Kafr El Sheikh, Egypt with a percentage of 7% and the reported serotypes were *S.* Salamae, *S.* Miami, *S.* Kentucky, *S.* Paratyphi A and *S.* Magherafelt. **Elgohary et al. (2017)** reported that *S.* Kentuky is the most prevalent serotype in slaughtered ducks and diarrheic young duckling. On another side **El-nabarawy et al. 2020** isolated Salmonella from duck farms with a percentage of 4% and noticed that the litter of the poultry farms that used as a fertilizer in fish farms thus integrated fish-duck farming is common in some areas of Egypt. They explained that Salmonella pathogen may be found in the poultry litter and can contaminate fish ponds and infecting duck farms. Meanwhile in Ismailia Governorate (Egypt) **Eid et al. (2019)** isolated *S.* Typhimurium from diseased ducks with an incidence of (2.8%). In laying ducks farms located in Qaluobia governorate, Egypt. *S.* Typhimurium was isolated with 2% from spleen, liver, oviducts, ovaries and intestine (**Abd El Tawab et al. 2018**). Also, in Qaluobia Governorate **Abd El Tawab et al. (2020)** isolated *S.* Typhimurium, *S.* Enteritidis and *S.* Blegdam from commercial duckling farms located at Qaluobia Governorate.

Some studies performed by **Abd El-Tawab et al. (2020) and El shabrawy et al. (2021)** reported that *S.* Typhimurium was the predominant serotype that isolated from the Egyptian ducks and these results were in contrast to **Enany et al. (2018)** who stated that *S.* Ruzizi, *S.* Give and *S.* Enteritidis isolated from local duckling with an incidence of 0.5% for each. The variation in salmonella isolation rates in different localities may be attributed to the immunity of ducklings and the variations in hygienic measures degrees in the farms. Moreover, The differences in serotypes were due to the fact that the distribution of the most common Salmonella serotypes is largely determined by geographical factors that change over time (**Huehn et al. 2010),** and may be related to sampling methods and isolation techniques (**Vanantwerpen et al. 2016)**, despite the fact that several serotypes are consistently detected at a high rate around the world (**Gast, 2007).**

Antimicrobial susceptibility and multi-drug resistance in duck farms

Antimicrobial-resistant *Salmonella enterica* has a significant public health importance all over the world (**Tang et al. 2022**). The expanded misuse of antibiotics in both public and veterinary medicine has prompted to the rise of antibiotic resistance and as an outcome represents a serious risk to public health safety, However, the use of antibiotics together with the improvement of sanitation and hygiene in addition to immunization and proper nutrition has given significant advantages in human life expectancy **(WHO, 2002**). Salmonella isolated from ducks showed complete resistance to amoxicillin (100%), cephradine, streptomycin (60%), colistin sulfate (80%), chloramphenicol (33.3%), neomycin and ampicillin (26.7% of each) (**Khalifa et al. 2021**).

Hassan et al. (2019) recorded moderate sensitivity to norfloxacin and ciprofloxacin in addition to high resistance to ampicillin and amoxicillin in Salmonella isolated from ducks in Egypt. Another research study performed in Egypt recorded resistance of *S.* Typhimurium to ampicillin, doxycycline, colistin, gentamycin and neomycin (**Abdeltawab et al. 2018**).

Meanwhile antibiotic resistances of Salmonella isolated from pekin duck farm were recorded to penicillin, ampicillin and doxycycline (**Badr and Nasef, 2016**). The isolated S. Typhimurium from diseased ducks in Egypt exhibited resistance to erythromycin and amoxicillin (**Eid et al. 2019**). Salmonella isolates recorded from ducklings in Kafr El Sheikh, Egypt were highly resistant to norfloxacin (90%), followed by ciprocin, flumox and amoxicillin-clavulanic acid (70% for each) but showed 100% sensitive to amikacin followed by gentamicin and sulphamethoxazole/ trimethoprim (50% for each) (**Abou Zeid et al. (2020**). **Abdelaziz et al. (2020**) found that the antibiotic sensitivity tests for the isolated Salmonella strains showed multiple antibiotic resistances to oxytetracycline; amoxicillin; ampicillin; streptomycin; erythromycin and trimethoprim/ sulphamethoxazol while gentamycin, norfloxacin and ciprofloxacin were the most effective antibiotics and can be used for treatment of Salmonellosis in duck farms. In contrary to these results **El-shabrawy et al. (2021)** found that Salmonella isolates displayed high resistance rate to tetracycline (85%), amikacin and sulphamethoxazole/ trimethoprim (62.8% for each) and ampicillin (51.4%). Also, **El- Gaos et al. (2020)** detected high resistance to streptomycin (100%), lincomycin (88%) and erythromycin (82%) and the lowest resistances were against doxycycline (41%), flumequine (35%), norfloxacin (18%), ciprofloxxacin and colistin (6% for each).

Different alternative therapy to antimicrobial agents

For the control and treatment of Salmonella, antimicrobials usage is important. However, multidrug-resistant Salmonella has emerged and lead to treatment failure (**Gong et al. 2013).** Antimicrobial therapy is the first choice of treat bacterial infection; however, the misuse of antibiotics in both human and animal field resulted in the problem of antimicrobial resistance. It has been predicted that by 2050, antibiotic-resistant pathogens will cause around 10 million deaths worldwide (**Castro-Vargas et al. 2020**). For many years, antibiotics have been utilized as growth promoters which help the birds to develop their immune systems. Antibiotics usage may cause bacterial resistance. The use of antibiotics has been reduced and replaced with the dietary supplements as prebiotics and/or probiotic that enhance growth and modulate the immunity (**Al-Khalaifah, 2018**). Antibiotic use in poultry industry was decreased due to the emergence of antibiotic-resistant bacteria. Alternative treatments have been developed to overcome these challenges and provide safe, inexpensive, and organic poultry meat. Prebiotics, probiotics, symbiotics, essential oils, cinnamaldehyde, organic acids, nanoparticles, chitosan and vaccines are considered as available antibiotic alternatives that have shown promising results in the control and prevention of avian Salmonellosis, ensuring strategies for control and prevention of avian Salmonellosis in either developing or developed countries and providing safe and liable poultry meat for human consumption and filling the meat gap and deficit as a source of protein (**El-Saadony et al. 2022**).

Non antibiotic solutions have been researched in recent years with an emphasis on feeding- based tactics to decrease or manage Salmonella infections in poultry farm **Adhikari et al. (2018)** housed 60–65 w old white Leghorn hens with a supplemented with 0.1% of the prebiotic (FOS) and challenged against a nalidixic acid-resistant *S.* Enteritidis strain (2.4×10^8 CFU), the results revealed reduction of fecal shedding of *S.* Enteritidis numbers and increased TLR-4, IFN γ, and IgA expression. On other side **Khan and Chousalkar, (2020)** allocated hens on floor pens and supplemented with the probiotic combination (1 g/kg of feed) to be challenged against *S.* Typhimurium(10^6 CFU/mL) , Probiotic supplementation (Bacillus subtilis DSM 32324, Bacillus subtilis DSM 32325, and Bacillus amyloliquefaciens) decreased Salmonella counts in feces. One of the most effective substances against Salmonella isolated from ducks was lactic acid prebiotic which inhibited Salmonella growth in- vitro at a concentration of 0.5% (**Hassan et al. 2019).**

Probiotics have the ability to prevent the colonization of *S.* Typhimurium in the intesti-

nal tract of chickens by the mechanism of competitive exclusion (**El-Sharkawy et al. 2020**). On another side, the reduction of Salmonellosis in chicks was achieved by combining organic acid mixture and a Lactobacillus-based probiotic culture (**Wolfenden et al. 2007**). A study conducted by **Abd El-Ghany et al. (2012**) mentioned the role of the double doses application of autogenous *S.* Enteritidis bacterin and the probiotic in the prevention of *S.* Enteritidis in chickens. **Iwi´nski et al. (2022**) reported antibacterial effects of phytobiotics mixture against *S.* Enteritidis, *S.* Typhimurium and S. Kentucky. New technique using chitosan-nanoparticle vaccine can induce a specific immunity against Salmonella and reduce its cecal colonization in broiler (**Acevedo-Villanueva et al. 2020**). A research study performed by **Abou Elez et al. (2021**) revealed the potential antimicrobial activity of the biosynthesized silver nanoparticles (AgNPs) against multidrug resistant *S.* Typhimurium and *S.* Enteritidis. Also, bacteriophage therapy considered as a potential approach to control bacterial infections. The phage therapy has reduced side effects in comparison with antibiotics and it has the ability to control the colonization of Salmonella in a short period (**Nabil et al. 2018).**

Salmonella control measures

According to the incidence of isolation and according to high percent of antimicrobial resistance study conduct by **Adel et al. (2023)** survey for the evaluation of biosecurity practices at small-scale commercial duck farms in and around two districts of Qalyoubia, Egypt, based on a mini-survey conducted from March to September 2021, Organs from deceased and diseased ducks, such as the liver, spleen, kidney, intestine, tongue, trachea, heart, and lung, have been taken from each farm and examined bacteriologically. A proposed questionnaire was created to gather information regarding the biosecurity measures from farm managers, owners, veterinarians, and employees, as well as researcher's observations, A questionnaire sheet with 30 implementation-related biosecurity measures was included (Supplementary data). These items were divided into three major groups. Farms with ratings above 50% had high biosecurity, while those with values below 50% had low biosecurity. The findings showed a deficiency in the application of some crucial biosecurity measures. According to biosecurity, the rate of bacterial isolation varies from farm to farm. In all the farms included in this study, the most pervasive deficiency was the absence of a mechanism for disinfecting the water. A significant factor in lowering disease spread through farming is water sanitation. Water sanitation issues were often noted in farms housing various species in Egypt. Additionally, the findings of this mini-survey study revealed a gap in the implementation of personal biosecurity measures and advocated for a strict biosecurity implementation strategy to lower mixed infections. Also it offers a biosecurity framework for small-scale duck production that may be applied to later research and risk evaluations about the introduction and spread of infectious diseases. The study suggested strengthening biosecurity procedures in duck farms and making an effort to close the knowledge and practice gap among farmers by increasing national farmer, breeder and workers awareness through radio, television programming, training sessions, and official interactions, also registrations and licenses issued for the establishment of duck farms should be examined with a focus on the application of biosecurity regulations.

CONCLUSION

Salmonella is one of the most important pathogen facing duck farms. It produces higher morbidity and mortality rates and considered as main cause of economic losses. From the recorded data in this review, the incidences of Salmonella isolation from ducks in Egypt were ranged from 0.5% to 85.5% and the most isolated serotype was S. Typhimurium. The higher antibiotic resistances were recorded against amoxicillin, cephradine, colistin sulfate, ampicillin, tetracycline, streptomycin, lincomycin and erythromycin. Prevention and control measure should be implemented to overcome salmonellosis in duck farms in addition to find out alternatives to antibiotics to solve the difficulties in the treatment of antibiotic resistance. Strength regulations in the uses of antimicrobial agents should be applied to overcome the resistance problems. Biosecurity programs should be implemented to control the Salmonella infections.

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