Research Article

Antibiotic Resistance of *Escherichia coli* Strains Isolated From Pet Parrots in Hanoi, Vietnam

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Abstract | Pet birds can be birds can carry and spread various bacteria that cause illness in humans, including *E. coli*. We investigate the prevalence and antibiotic resistance of *E. coli* strains isolated from pet parrots raised in Hanoi, Vietnam. Overall, 53 (59.6%) out of 89 fecal samples from pet parrots contained *E. coli*. Red-breasted parakeet samples had the highest rate (75.0%, 9/12 samples), followed by Monk parakeet (70.0%, 7/10 samples), Macaw parrot (66.7%, 8/12 samples). Meanwhile, fecal samples from Lovebirds, Sun parakeet, and African grey parrot had *E. coli* positive rates ranging from 50.0-58.8%. The isolated *E. coli* strains exhibited resistance to all 10 antibiotics belonging to 7 different antibiotic classes. Resistance was highest to amoxicillin (94.3%), followed by trimethoprim/sulfamethoxazole (50.9%) and streptomycin (47.2%). Resistance to norfloxacin, levofloxacin, and nalidixic acid was 35.8%, 41.5% and 45.3%, respectively. Cefotaxime, kanamycin and neomycin were resistant at rates ranging from 30.2-34.0%. Notably, three strains (5.7%) were resistant to meropenem, a last-resort antibiotic for serious human infections. Only one isolate out of the 53 isolates was susceptible to all the antibiotics tested. The other 52 strains (98.1%) were resistant to at least one antibiotic and exhibited 31 different resistance phenotypes. The resistance rates for 1 and 2 antibiotic classes were 15.1% and 20.8%, respectively. Meanwhile, the resistance rates for 3-6 antibiotic classes ranged from 13.2% to 17.0%. Only one strain (1.9%) was resistant to 7 antibiotic classes. Of these, 33 (62.3%) were resistant to three or more different classes of antibiotics (multidrug-resistant). This suggests that pet birds could be reservoirs of antibiotic-resistant bacteria, which is a concern for both human and animal health.

Keywords | *Escherichia coli*, Antibiotic resistance, MDR, Pet-birds, Parrot, Parakeet

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INTRODUCTION

Birds are the third most popular pets, after dogs and cats, and are close companions to humans, and their numbers are rising worldwide and they play an important role in human life (Pomba *et al.*, 2017). The majority of captive birds belong to two orders: Passeriformes, which includes canaries and sparrows, and Psittaciformes, which includes parrots, parakeets, and lovebirds (Boseret *et al.*, 2013). However, many recent studies have shown that companion animals can carry and spread zoonotic bacteria, including *E. coli* (Day, 2016; Boroomand and Faryabi, 2020). *E. coli* is also one of the most common pathogens, responsible for a range of diseases such as colibacillosis,

respiratory infections and septicemia in birds (Machado *et al*., 2018), as well as urinary tract infections, diarrhea and blood infections in humans (Karpman and Ståhl, 2014; Pakbin *et al*., 2021), and is considered a source of bacteria containing genes associated with antibiotic resistance (Machado *et al*., 2018; Prestinaci *et al*., 2015). *E. coli* can easily adapt to different environments, which helps it develop many drug resistance mechanisms, and even harmless *E. coli* can spread antibiotic resistance genes in bacteria (Szmolka and Nagy, 2013).

Antibiotic resistance is a One Health problem, affecting humans, animals, and the environment (Argudín *et al*., 2017). Antibiotic resistance keeps getting worse and, unfortunately, has serious health and economic effects around the world. Numerous studies have shown that drug-resistant bacteria and/or bacteria carrying antibiotic resistance genes can be transmitted from animals to humans and vice versa, through contaminated food, the environment, or through contact (Damborg *et al*., 2016; Argudín *et al*., 2017; Pompa *et al*., 2017). Close contact between people and their pet birds creates many chances for bacteria to spread, including of antibiotic-resistant bacteria (Machado *et al*., 2018; Rahman *et al*., 2020; Hosseinian, 2022). Furthermore, owners often treat sick birds themselves, without veterinary advice, which can promote antibiotic resistance (Giacopello *et al*., 2015).

In recent years, keeping pet birds, including parrots, has become quite popular in Vietnam. However, few studies have looked at diseases in pet birds or the risk of them spreading diseases to people. Specifically, to our knowledge, there are currently no studies have examined antibiotic resistance in bacteria from pet birds in Vietnam. Therefore, investigating the prevalence and antibiotic resistance of *E. coli* strains isolated from pet parrots in this study will provide additional data on the antibiotic resistance situation in livestock in Vietnam.

MATERIALS AND METHODS

Sampling

In this study, we collected 89 fecal samples from healthy parrots kept as pets in people's homes in Hanoi, Vietnam, from June 2025 to April 2026. The samples were collected following Vietnam's national technical regulation on animal diseases - General requirements for sample collection, storage and shipment of the Ministry of Agriculture and Rural Development (2011). Briefly, fresh fecal samples from the cages were carefully collected by using sterile spoons, each sample in its own sterile bag, labeled, stored in a cooler with ice, and taken immediately to the laboratory of Department of Veterinary microbiology and Infectious diseases, Faculty of Veterinary Medicine, Vietnam National University of Agriculture for analysis within 24 hours.

Isolation of *E. coli*

At the laboratory, about one gram of each fecal sample was mixed with buffered peptone water (BPW, Merck, Germany) at a 1:9 ratio. Next, a loopful of the mixed culture was streaked onto MacConkey agar (Merck, Germany) and incubated at 37°C for 24 hours. Then, the pink colonies (Figure 1) were cultured onto eosin methylene blue agar (EMB, Merck, Germany) and continuously incubated at 37°C for 24 hours. Only one colony with the typical metallic green sheen on EMB agar (Figure 2) were streaked into triple sugar iron agar (TSI, Merck, Germany) tube and incubated at 37°C for 24 hours. Colonies exhibiting a typical TSI profile, including glucose and lactose fermentation with gas production and no H2S (Figure 3), were identified as *E. coli* by Gram staining and biochemical tests, such as indole production, methyl red, Voges-Proskauer, and citrate utilisation reactions, with the expected IMViC result being "++--" (Figure 4). We stored all isolates in brain heart infusion broth with 50% glycerol at -20°C for subsequent experiments.

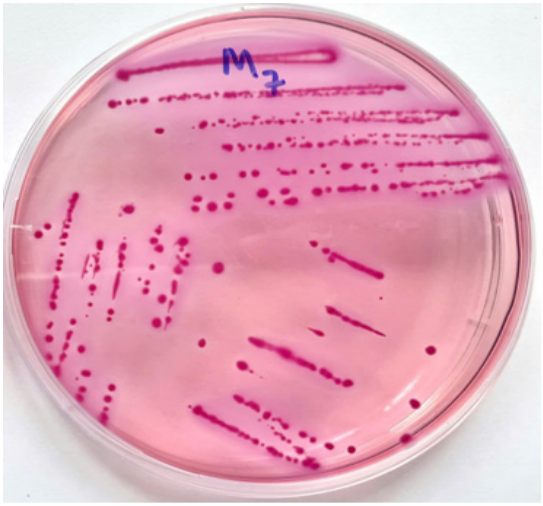

Figure 1: *E. coli* colonies isolated from parrot feces exhibited pink colour on MacConkey agar.

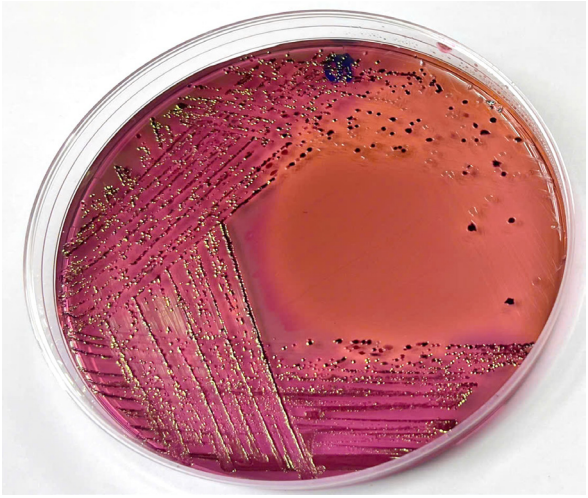

Figure 2: *E. coli* colonies isolated from parrot feces exhibited green metallic sheen on EMB agar.

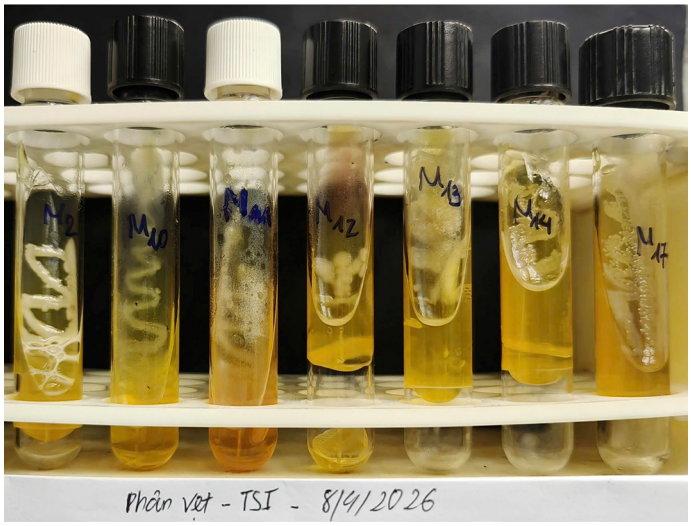

Figure 3: *E. coli* strains isolated from parrot on TSI agar. The yellow butts and yellow slants, accompanied by gas bubbles due to the production of acid and CO_2 during the fermentation of sugars such as glucose and lactose/sucrose.

Figure 4: The IMViC tests for *E. coli* confirmation (from left). Tube 1: Sugar fermentation and gas production on TSI agar by *E. coli*; Tube 2: Indole (+); Tube 3: Methyl red (+); Tube 4: Voges-Proskauer (-); Tube 5: Simmons citrate (-).

Confirmation of *E. coli*

DNA was extracted using the TopPURE® Genomic DNA Extraction Kit (ABT, Vietnam) according to the manufacturer's instructions. We used specific primers (Malinen *et al*., 2003) with the following sequences based on the *16S* gene for *E. coli* (5'-GTTAATACCTTTGCTCATTGA-3' and 5'-ACCAGGGTATCTAATCCTGTT-3') with an expected PCR product of 340 bp were used (Figure 5). PCR cycling conditions were initial denaturation at 94 °C for 5 min followed by 35 cycles of denaturation at 94 °C for 30 sec, annealing at 60 °C for 30 sec and extension at 72 °C for 45 sec followed by final extension at 72 °C for 10 min. The reaction components included 12.5 µl of GoTaq® Green Master Mix (Promega, USA), 1 µl each of the forward and reverse primers (10 µM), 8.5 µl of purified water, and 2 µl of template DNA. The PCR products were electrophoresed on 1.5% agarose gel supplemented with RedSafe™ nucleic acid staining solution (Intron, Korea).

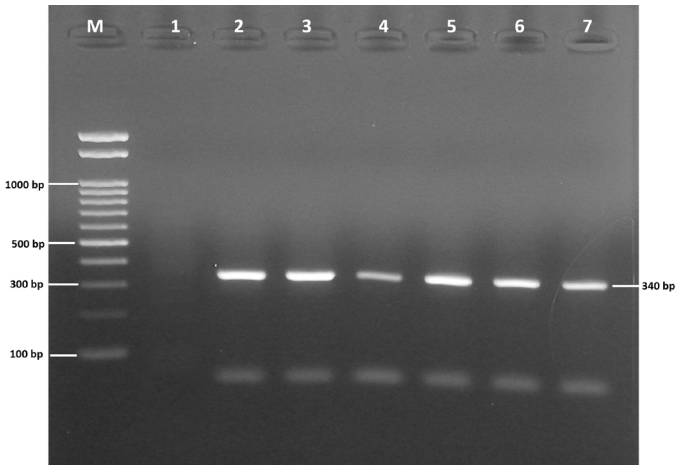

Figure 5: Representative electrophoresis of the 16S gene for *E. coli* isolates (M: marker, 100 bp; lane 1: negative control; lane 2: positive control; lane: 3, 4, 5, 6, 7 positive 16*S* genes).

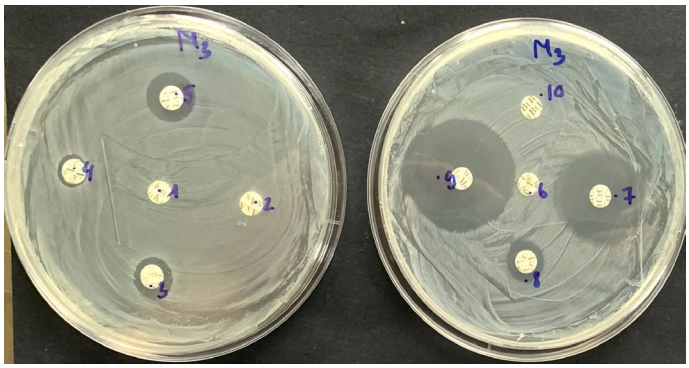

Figure 6: Antibiotic susceptibility testing of 10 antibiotics against *E. coli* strains isolated from parrot feces. (1): Kanamycin; (2): Amoxicillin; (3): Streptomycin; (4): Neomycin; (5): Levofloxacin; (6): Nalidixic acid; (7): Cefotaxime; (8): Norfloxacin; (9): Meropenem; (10): Trimethoprim/Sulfamethoxazole

Antimicrobial susceptibility test

Antibiotic susceptibility test was examined according to the guidelines of the Clinical and Laboratory Standards Institute (CLSI, 2020). Agar diffusion method was performed on Mueller-Hinton agar (MHA, Merck, Germany) following Bauer *et al*. (1966) and 10 different antibiotic agents (Nam Khoa, Vietnam) belonging to seven classes were used (Figure 6), including penicillins (amoxicillin, 10 µg), carbapenems (meropenem, 10 µg), cephalosporins (cefotaxime, 30 µg), aminoglycosides (kanamycin, 30 µg; neomycin, 30 µg; streptomycin, 10 µg), quinolones (nalidixic acid, 30 µg), fluoroquinolones (levofloxacin, 5 µg; norfloxacin, 10 µg), sulfonamides

(trimethoprim/sulfamethoxazole, 1.25/23.75 µg). The inhibition zone diameters of the ten antibiotics for *E. coli* are shown in Table 1. *Escherichia coli* ATCC 25922 strain was used for quality control. An isolate was determined to be antibiotic-resistant or multidrug-resistant (MDR) based on the definition of Magiorakos *et al.* (2012).

Table 1: CLSI breakpoints (inhibition zone diameters) for ten antibiotic tested.

Order	Antibiotic classes	Kind of antibiotic	Zone inhibition diameters (mm)		
			Susceptible	Intermediate	Resistance
1	Penicillin	Amoxicillin	≥ 17	14-16	13 ≤
2	Cephalosporin	Cefotaxime	≥ 26	23-25	22 ≤
3	Carbapenem	Meropenem	≥ 23	20-22	19 ≤
4	Aminoglycosides	Kanamycin	≥ 18	14-17	13 ≤
		Neomycin	≥ 18	14-17	13 ≤
		Streptomycin	≥ 15	12-14	11 ≤
5	Quinolone	Nalidixic acid	≥ 19	14-18	13 ≤
6	Fluoroquinolone	Levofloxacin	≥ 21	17-20	16 ≤
		Norfloxacin	≥ 17	13-16	12 ≤
7	Sulfonamide	Trimethoprim/ Sulfamethoxazole	≥ 16	11-15	10 ≤

Data analysis

The isolation and antibiotic resistance rates of *E. coli* strains were recorded and calculated using Microsoft Excel 2016. The 95% confidence intervals (95% CI) for the proportions were estimated using the Clopper-Pearson binomial distribution (Exact Binomial Test) with R software.

RESULTS

Isolation of bacteria

Overall, the rate of *E. coli* isolation from fecal samples was 59.6% (Table 2). Of these, the fecal samples from Red-breasted parakeet samples had the highest rate (75.0%), followed by Monk parakeet (70.0%), Macaw parrot (66.7%). Isolation rates for other species ranged from 50.0% to 58.8% in fecal samples from other parrot species such as Lovebirds, Sun parakeet, and African grey parrot.

Antibiotic susceptibility

The isolates showed resistance to each of the 10 antibiotics belonging to 7 different antibiotic classes, but at different rates (Table 3). Resistance was highest to amoxicillin (94.3%), followed by trimethoprim/sulfamethoxazole (50.9%) and streptomycin (47.2%). Resistance to norfloxacin, levofloxacin, and nalidixic acid was 35.8%, 41.5%, and 45.3%, respectively. Cefotaxime, kanamycin and neomycin were resistant at rates ranging from 30.2-34.0%. Notably, three (5.7%) strains were resistant to meropenem, a last-resort antibiotic for serious human infections.

Table 2: Isolation rates of *E. coli* from fecal samples collected from pet parrots (n = 89).

Order	Species	No. of samples	Positive n (%)	Negative n (%)	95% confidence interval
1	African grey parrot (*Psittacus erithacus)*	17	10 (58.8)	7 (41.2)	(32.9%, 81.6%)
2	Love-bird (*Agapornis fischeri)*	10	5 (50.0)	5 (50.0)	(18.7%, 81.3%)
3	Macaw parrot (*Ara chloropterus*)	12	8 (66.7)	4 (33.3)	(34.9%, 90.1%)
4	Monk parakeet (*Myiopsitta monachus)*	10	7 (70.0)	3 (30.0)	(34.8%, 93.3%)
5	Red-breasted parakeet (*Psittacula alexandri*)	12	9 (75.0)	3 (25.0)	(42.8%, 94.5%)
6	Sun parakeet/Sun conure (*Aratinga solstitialis*)	9	5 (55.6)	4 (44.4)	(21.2%, 86.3%)
7	Other species	19	9 (47.4)	10 (52.6)	(24.4%, 71.1%)
Total		89	53 (59.6)	36 (40.4)	(48.6%, 69.8%)

* Note: Other species include Alexandrine parakeet (Psittacula eupatria, n = 4); Amazon parrot (Amazona ochrocephala, n=5); Budgie (Melopsittacus undulatus, n=6); Cockatiel (Nymphicus hollandicus, n =4).

Table 3: Antibiotic susceptibility of *E. coli* strains isolated from pet parrot fecal samples (n = 53).

Order	Antibiotic classes	Kind of antibiotic	Resistance n (%)	Intermediate n (%)	Susceptible n (%)
1	Penicillin	Amoxicillin	50 (94.3)	3 (5.7)	0 (0.0)
2	Cephalosporin	Cefotaxime	16 (30.2)	6 (11.3)	31 (58.5)
3	Carbapenem	Meropenem	3 (5.7)	4 (7.5)	46 (86.8)
4	Aminoglycosides	Kanamycin	16 (30.2)	8 (15.1)	29 (54.7)
		Neomycin	18 (34.0)	23 (43.4)	12 (22.6)
		Streptomycin	25 (47.2)	5 (9.4)	23 (43.4)
5	Quinolone	Nalidixic acid	24 (45.3)	4 (7.5)	25 (47.2)
6	Fluoroquinolone	Levofloxacin	22 (41.5)	4 (7.5)	27 (50.9)
		Norfloxacin	19 (35.8)	1 (1.9)	33 (62.3)
7	Sulfonamide	Trimethoprim/ Sulfamethoxazole	27 (50.9)	2 (3.8)	24 (45.3)

Table 4: Antibiotic resistance phenotypes of the isolated *E. coli* strains (n = 53).

Order	Isolation sources (n)	Antibiotic resistance (AR) phenotypes	No. of AR	No. of AR classes	No. of strain n (%)
1	Monk parakeet (1)		0	0	1 (1.9)
2	Monk parakeet (3); Macaw parrot (2); Sun parakeet (1); Love-bird (2); *Budgie* (1); Red-breasted parakeet (1)	AMX	1	1	10 (18.9)
3	African grey parrot (1)	NAL	1	1	1 (1.9)
4	Macaw parrot (1); Amazon parrot (1); Alexandrine parakeet (1)	AMX, NEO	2	2	3 (5.7)
5	Alexandrine parakeet (1)	AMX, STM	2	2	1 (1.9)
6	Monk parakeet (1); Red-breasted parakeet (1)	AMX, SXT	2	2	2 (3.8)
7	Love-bird (1)	AMX, NAL	2	2	1 (1.9)
8	Love-bird (1)	AMX, KAN, NEO	3	2	1 (1.9)
9	Macaw parrot (1)	AMX, STM, NOR	3	3	1 (1.9)
10	Love-bird (1); Cockatiel (1); Sun parakeet (1)	AMX, STM, SXT	3	3	3 (5.7)
11	Red-breasted parakeet (1); African grey parrot (1)	AMX, CTX, LEV, SXT	4	4	2 (3.8)
12	*Budgie* (1)	AMX, CTX, NEO, STM	4	3	1 (1.9)
13	Red-breasted parakeet (1); Sun parakeet (1)	AMX, NAL, LEV, NOR	4	3	2 (3.8)
14	Macaw parrot (1)	AMX, KAN, STM, SXT	4	3	1 (1.9)
15	Sun parakeet (1)	AMX, KAN, NEO, STM, SXT	5	3	1 (1.9)
16	Monk parakeet (1)	AMX, STM, NAL, LEV	4	4	1 (1.9)
17	African grey parrot (1)	CTX, MEM, NAL, LEV, NOR	5	4	1 (1.9)
18	African grey parrot (1)	AMX, CTX, STM, NAL, LEV	5	5	1 (1.9)
19	Amazon parrot (1)	AMX, NAL, LEV, NOR, SXT	5	4	1 (1.9)
20	Macaw parrot (1)	AMX, CTX, KAN, STM, SXT	5	4	1 (1.9)
21	Alexandrine parakeet (1)	AMX, CTX, NAL, LEV, NOR, SXT	6	5	1 (1.9)
22	African grey parrot (1)	AMX, STM, NAL, LEV, NOR, SXT	6	5	1 (1.9)
23	Alexandrine parakeet (1)	AMX, KAN, NAL, LEV, NOR, SXT	6	5	1 (1.9)
24	Alexandrine parakeet (1)	AMX, CTX, KAN, NEO, STM, SXT	6	4	1 (1.9)
25	African grey parrot (1)	AMX, CTX, STM, NAL, LEV, NOR, SXT	7	6	1 (1.9)
26	Monk parakeet (1)	AMX, CTX, MEM, KAN, NAL, NOR, SXT	7	7	1 (1.9)
27	Red-breasted parakeet (1)	AMX, KAN, NEO, STM, NAL, LEV, NOR	7	4	1 (1.9)
28	Monk parakeet (1)	AMX, KAN, NEO, NAL, LEV, NOR, SXT	7	5	1 (1.9)
29	Macaw parrot (1)	AMX, MEM, NEO, STM, NAL, LEV, SXT	7	6	1 (1.9)
30	Macaw parrot (1)	AMX, CTX, NEO, STM, NAL, LEV, SXT	7	6	1 (1.9)
31	Red-breasted parakeet (1); African grey parrot (1)	AMX, KAN, NEO, STM, NAL, LEV, NOR, SXT	8	5	2 (3.8)
32	African grey parrot (3); Red-breasted parakeet (2)	AMX, CTX, KAN, NEO, STM, NAL, LEV, NOR, SXT	9	6	5 (9.4)

AMX: Amoxicillin; CTX: Cefotaxime; KAN: Kanamycin; LEV: Levofloxacin; MEM: Meropenem; NEO: Neomycin; NAL: Nalidixic acid; NOR: Norfloxacin; STM: Streptomycin; SXT: Trimethoprim/Sulfamethoxazole.

Antibiotic resistant phenotypes

Only one of the 53 isolates was susceptible to all the antibiotics tested (Table 4). The remaining 52 (98.1%) strains were resistant to at least one antibiotic and exhibited 31 different resistance phenotypes. The most common pattern was resistance to amoxicillin alone (10 strains, 18.9%), followed by AMX-CTX-KAN-NEO-STM-NAL-LEV-NOR-SXT resistance was found in 5 (9.43%) strains isolated from African grey parrots and Red-breasted parrots. The resistance rates for 1 and 2 antibiotic classes were 15.1% and 20.8%, respectively (Table 5). Meanwhile, the resistance rates for 3-6 antibiotic classes ranged from 13.2% to 17.0%. Only one strain (1.9%) was resistant to seven classes. Of these, 33 isolates (62.3%) were resistant to three or more antibiotic classes, meeting the definition of multidrug-resistant (MDR).

Table 5: Resistance to different antibiotic classes of isolated *E. coli* strains (n= 53).

Order	No. of antibiotic resistance classes	Antibiotic classes (n)	No. of strains n (%)
1	No resistance	-	1 (1.9)
2	Resistance to 1 class	Penicillin (10); quinolone (1)	11 (20.8)
2	Resistance to 2 classes	Penicillin (8); aminoglycosides (5); quinolone (1); sulfonamides (2)	8 (15.1)
3	Resistance to 3 classes	Penicillin (9); cephalosporin (1); aminoglycosides (7); quinolone (2); fluoroquinolone (3); sulfonamides (5)	9 (17.0)
4	Resistance to 4 classes	Penicillin (7); cephalosporin (5); carbapenem (1); aminoglycosides (4); quinolone (4); fluoroquinolone (6); sulfonamides (5)	8 (15.1)
5	Resistance to 5 classes	Penicillin (7); cephalosporin (2); aminoglycosides (6); quinolone (7); fluoroquinolone (7); sulfonamides (6)	7 (13.2)
6	Resistance to 6 classes	Penicillin (8); cephalosporin (7); carbapenem (1); aminoglycosides (8); quinolone (8); fluoroquinolone (8); sulfonamides (8)	8 (15.1)
7	Resistance to 7 classes	Penicillin (1); cephalosporin (1); carbapenem (1); aminoglycosides (1); quinolone (1); fluoroquinolone (1); sulfonamides (1)	1 (1.9)

*Note: "No resistance" means susceptible to all 10 antibiotics tested. The number of strains resistant to three or more antibiotic classes is 33 (62.3%).

DISCUSSION

Previous studies conducted in Bangladesh (Hasib *et al*., 2025) and Turkey (Diren Sigirci *et al*., 2020) reported isolation rates of 48.7% in 150 and 52.3% in 172 parrots and parakeets samples, respectively. However, lower isolation rates, ranging from 18.3% to 36.0%, were observed in studies conducted in Bangladesh (Nupur *et al*., 2023), Italy (Varriale *et al*., 2020), Brazil (Marques *et al*., 2024), and Egypt (Samir *et al*., 2025). These differences could be due to geography, sampling methods, or lab techniques. Additionally, sanitary conditions in the cages, along with the hot and humid climate in northern Vietnam, may be related to the high rate of *E. coli* isolates in fecal samples from parrot species.

We found that 52 of 53 isolates (98.1%) were resistant to at least one antibiotic, and the most common resistance was identified as amoxicillin (94.3%). High amoxicillin resistance (81-100%) has also been seen in other studies in Brazil (Pontes *et al*., 2018), Italy (Varriale *et al*., 2020) and Bangladesh (Nupur *et al*., 2023). Cefotaxime is a critically important antibiotic for human medicine (WHO, 2017), but resistance was observed in 30.2% of the *E. coli* strains in present study. One study in Egypt found even higher resistance (66.7%) in parrots with respiratory illness (Samir *et al*., 2025). Meropenem is a last-resort antibiotic for serious human infections (WHO, 2017). Similar studies conducted in Brazil (Marques *et al*., 2024), Egypt (Samir *et al*., 2025), and Bangladesh (Hasib *et al*., 2025) all showed that all isolated *E. coli* strains were susceptible to this antibiotic. Although only three strains (5.7%) were resistant to meropenem in this study, this is concerning because meropenem is not approved for use in animals.

Trimethoprim/sulfamethoxazole is an oral broad-spectrum antibiotic often used in birds, and it is particularly proper used for therapy of birds (Diren Sigirci *et al*., 2019). Resistance to trimethoprim/sulfamethoxazole were 44.4% and 46.0% in studies conducted in Egypt (Samir *et al*., 2025) and Turkey (Diren Sigirci *et al*., 2020). However, this antibiotic resistance rate reached 85.0% and 100% in studies from Bangladesh (Hasib *et al*., 2025) and Italy (Varriale *et al*., 2020). Notably, parrot species-derived *E. coli* strains exhibited trimethoprim/sulfamethoxazole resistance at rates ranging from 12.1-33.0% in a study conducted in Brazil (Machado *et al*., 2018; Pontes *et al*., 2018; Marques *et al*., 2024). The rates of resistance to aminoglycosides such as kanamycin, neomycin, and streptomycin were 30.2%, 34.0%, and 47.2%, respectively. Aminoglycosides are important therapeutic agents in clinical practice, often used to treat infections, especially severe infections caused by Gram-negative bacteria, but they are used less often in birds because they can be toxic (Flammer, 2006). However, some previous studies have documented aminoglycoside resistance in *E. coli* strains isolated from parrots, such as resistance rates of 25.0% and 34.0% for kanamycin and streptomycin in Turkey (Diren Sigirci *et al*., 2020); and resistance rates of 29.8% and 42.6% for kanamycin and neomycin in Bangladesh (Nupur *et al*., 2023). In Brazil, *E. coli* strains isolated from parrots showed streptomycin resistance ranging from 2.0% to 37.2% and 74.0% (Lopes *et al*., 2015; Machado *et al*., 2018; Pontes *et al*., 2018). Different lab methods and study populations may explain the varying resistance rates.

The rates of resistance to quinolone and fluoroquinolone classes such as norfloxacin, levofloxacin, and nalidixic acid ranged from 35.8% to 45.3%. Lower resistance rates for these antibiotics, from 13.0% to 17.0%, were observed

in *E. coli* strains isolated from parrots in Turkey (Diren Sigirci *et al*., 2020). In Brazil, parrot-derived *E. coli* strains showed resistance to nalidixic acid at levels of 6.1% - 25.6% - 30.0% (Lopes *et al*., 2015; Machado *et al*., 2018; Pontes *et al*., 2018). Levofloxacin resistance of *E. coli* strains in a similar study conducted in Bangladesh was 19.1% (Nupur *et al*., 2023). Notably, parrot-derived *E. coli* strains with respiratory tract infections in Egypt showed resistance to norfloxacin at a high level of 51.9% (Samir *et al*., 2025). Differences in antibiotic resistance rates and phenotypes may be related to differences in antibiotic use practices, veterinary surveillance, and differences in hygiene and biosecurity measures between countries.

We found 31 different resistance patterns among the isolates, of which 33 (62.3%) were identified as multidrug-resistant. This variety may come from sampling different parrot species kept under different conditions of care, disease prevention, and treatment. Household pets are recognised as significant risks for zoonotic diseases and considered as a source of multidrug-resistant (MDR) bacteria (Diren Sigirci *et al*., 2020; Ohene Larbi *et al*., 2021), which can pose serious risks. The rates of MDR *E. coli* were consistent with the 59.0% and 67.0% observed in *E. coli* strains isolated from parrots in Brazil (Pontes *et al*., 2018) and Turkey (Diren Sigirci *et al*., 2020). However, in previous studies conducted in Italy (Varriale *et al*., 2020) and Brazil (Lopes *et al*., 2015), the rates of multidrug-resistant strains were identified as 40.1% and 43.2%, respectively. Notably, MDR rates were reported as high as 100% in studies in Bangladesh (Hasib *et al*., 2025). The rise of MDR bacteria calls for tighter control of antibiotic use to minimize the spread of MDR pathogens in livestock, including pet birds, and avoid significant risks to animal and community health (Szmolka and Nagy, 2013; Monteiro *et al*., 2025).

Limitations

This study was only conducted with a small sample size on healthy parrots raised in Hanoi, and specific drug resistance genes such as ESBL, carbapenemase (bla_{NDM}, bla_{KPC}, bla_{OXA-48}, bla_{IMP}, bla_{VIM}…) have yet to be identified. However, this study has provided basic data on the infection rates and antibiotic resistance of *E. coli* isolates from pet birds, including many introduced species. Therefore, larger-scale studies on more bird species are needed, as well as the use of molecular methods to detect antibiotic resistance genes, in order to determine the relationship between drug resistance genes, including plasmids, and multidrug-resistant phenotypes. In fact, finding out exactly how these bacteria become resistant would help us understand their role in the One Health context.

CONCLUSION

Overall, the *E. coli* strains we isolated were resistant to many antibiotics, and many were MDR. This suggests that pet birds could be reservoirs of antibiotic-resistant bacteria, which is a concern for both human and animal health. Although we did not study transmission to humans, the presence of MDR *E. coli* in pet birds is a potential public health concern that warrants further investigation. Future studies should examine ESBL and carbapenemase genes using PCR, and birds should be sampled at different times to see if resistance changes over time.

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NOVELTY STATEMENT

This preliminary study documented the presence of antibiotic-resistant *E. coli* strains in pet parrots in Hanoi, Vietnam. The study results suggest that pet parrots may be carriers of multidrug-resistant *E. coli* and contribute to the spread of antibiotic resistance in the environment. This underscores the need for monitoring and controlling antibiotic use in both animal husbandry and veterinary medicine to mitigate this problem in Vietnam.

AUTHOR'S CONTRIBUTION

CTTH: Study design, investigation and methodology, and manuscript writing. HTH, NTT, NMH, LBN, NTTM: Sample collection, experimentation and data analysis. TLO: Laboratory research design, sample testing supervision. THT: Conceptualization, supervision, writing, review and editing, project management.

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The present study received no external funding. The authors contributed to this study independently.

Ethical approval

The present study was conducted by collecting samples in accordance with the guidelines outlined in the animal welfare and safety procedures of the Committee on Animal Research and Ethics (CARE), Faculty of Veterinary Medicine, Vietnam National University of Agriculture, Vietnam (Approval No. CARE-2025/08).

Generative AI and AI assisted technology statement

AI-generated tools were not used to create any scientific

content. Any AI assistance was limited to minor language editing, and all ideas, interpretations, and conclusions remain entirely the authors.

Statement of conflict of interest

The authors have declared no conflict of interest.

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