

## Original research

Antibiotic susceptibility of epizootic strains of *Pseudomonas aeruginosa* isolated from various animal species of the Dnipropetrovsk regionM. V. Bilan, N. H. Useieva, M. S. Orzhynska, V. V. Zazharskyi  
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**Abstract.** *Pseudomonas aeruginosa* is an opportunistic bacterium commonly found in the environment that causes life-threatening infections in livestock, poultry, fish, and humans. Infection with this microorganism is dangerous due to its natural and acquired resistance to antimicrobial agents. Our study focused on conducting laboratory analysis of biological material (parenchymal organs, conjunctival sac fluid, and wound pus) collected from animals with various pathological conditions, identifying the isolated strains, and determining their antibiotic sensitivity. The isolates were identified using standard methods employed in microbiological practice. The cultural and biochemical properties of the pure cultures were assessed on both non-selective and selective growth medium. Antibiotic sensitivity was determined using the disk diffusion method on Mueller-Hinton agar. As a result of the study, the isolates were identified as *P. aeruginosa*. They were gram-negative, short to medium-sized rods. The isolates exhibited well-expressed proteolytic activity, weak saccharolytic properties, and were oxidase- and catalase-positive. It was established that fluoroquinolones (norfloxacin and ciprofloxacin) were effective against 80% of *P. aeruginosa* strains, and two aminoglycosides were effective in 60% (kanamycin) and 40% (gentamicin) of cases. Only one epizootic strain, isolated from wound pus in a laboratory animal, was sensitive to polymyxin (20%). Two isolates, obtained from the parenchymal organs of chicks and lambs kept in private households, were sensitive to only one (norfloxacin) or three (kanamycin, norfloxacin, and ciprofloxacin) antibiotics tested in vitro. All epizootic strains of *P. aeruginosa* demonstrated 100% resistance to amikacin and tetracycline. Regular monitoring of *P. aeruginosa* isolates' resistance to antibacterial agents will help reduce the spread of antibiotic-resistant strains.

**Keywords:** pseudomonas infection; antibiotic resistance; cat; sheep; poultry.

Чутливість до антибіотиків епізоотичних штамів *Pseudomonas aeruginosa*, ізольованих у різних видів тварин Дніпропетровської області

**Анотація.** *Pseudomonas aeruginosa* – умовно-патогенна бактерія, яка зазвичай зустрічається в навколишньому середовищі, викликає небезпечні для життя інфекції сільськогосподарських ссавців, птиці, риби та людини. Зараження цим мікроорганізмом є небезпечним через його природну та набуту резистентність до антимікробних препаратів. Наша робота була спрямована на проведення лабораторного дослідження біологічного матеріалу (паренхіматозних органів, секрету з кон'юнктивального мішка, гною з рани) від тварин з різноманітними патологічними станами, ідентифікацію виділених ізолятів та визначення їх чутливості до антибіотиків. Ізоляти ідентифікували за стандартними в мікробіологічній практиці методами. Культуральні та біохімічні властивості чистих культур визначали на неселективних та селективних середовищах. Чутливість до антибіотиків визначали методом диск-дифузії на Мюллер-Хінтон агарі. У результаті досліджень виділені ізоляти ідентифіковано як *P. aeruginosa*. Це були грамнегативні короткі та середні палички. Ізоляти мали гарно виражені протеолітичні, слабкі цукролітичні властивості та були оксидазо- та каталазопозитивними. Встановлено, що ефективними проти усіх штамів *P. aeruginosa* були у 80% фторхінолони (норфлоксацин та ципрофлоксацин), та два аміноглікозиди (у 60% – канаміцин та у 40% – гентаміцин). Лише один епізоотичний штам, виділений з гною рани лабораторної тварини, був чутливим до поліміксину (20%). Два ізоляти, виділені з паренхіматозних органів курчат та ягнят, які утримувалися в приватних господарствах, були чутливими лише до одного (норфлоксацину) або трьох (канаміцину, норфлоксацину та ципрофлоксацину) антибіотиків, що досліджували in vitro. Усі епізоотичні штами синьогнійної палички продемонстрували 100% резистентність до амікацину та тетрацикліну. Регулярне визначення резистентності ізолятів *P. aeruginosa* до антибактеріальних препаратів, сприятиме зниженню поширення антибіотикорезистентних штамів.

**Ключові слова:** синьогнійна інфекція; антибіотикорезистентність; кішка; вівця; свійська птиця.

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## Introduction

Currently, infectious diseases caused by *Pseudomonas aeruginosa* represent a pressing issue in modern animal husbandry and poultry farming, both in Ukraine and globally. In birds, this disease manifests as septicemia and toxemia, resulting in high mortality rates among young animals and embryos, most frequently during the final days of incubation. In cattle, intestinal forms of pseudomonas infection are observed. In female arctic foxes and chinchillas at late stages of pregnancy, miscarriages and deaths due to sepsis have been reported (Poda, 2020). In dogs, rabbits, and sheep, pseudomonas infection presents as pyoderma, characterized by itching, irritation, skin lesions (papules, pustules), and pronounced alopecia (Fotina et al., 2018). According to Harada et al. (2012), *P. aeruginosa* is an etiological agent of otitis, dermatitis, and urinary tract infections in animals. It should be noted that *P. aeruginosa* has a zoonotic nature and can cause foodborne infections and poisoning in humans due to its ability to spoil meat and dairy products (Port, 2006; Fotina & Vashchuk, 2016; Abd El-Ghany, 2021). Moreover, *P. aeruginosa* is classified as an opportunistic pathogen that can cause pneumonia, endocarditis, osteomyelitis, meningitis, folliculitis, septicemia, and necrosis, especially in immunocompromised patients (Mena & Gerba, 2009; Chen et al., 2018).

The prevalence of pseudomonas infections varies across different regions of Ukraine (Boiko, 2012). Verzhychkovskiy et al. (2007), based on their studies, reported in respect to an increasing tension in the epizootic situation of this disease among pigs, poultry, and small domestic animals, alongside a decline in outbreaks among cattle and fur animals between 1991 and 2006. The authors recorded the lowest mortality rate for pseudomonas infection in small domestic animals (20.6%) and the highest in poultry (43.8%), which explains the significant economic losses in animal husbandry. Novhorodova & Mazur (2013), having conducted an epizootological analysis from 2003 to 2012, reported the presence of unfavorable conditions for pseudomonas infection in cattle and pigs in the Cherkasy, Lviv regions, and the Autonomous Republic of Crimea, with epizootic indices of 0.9, 0.3, and 0.2, respectively.

Microbiological monitoring conducted between 2015 and 2018 revealed that *P. aeruginosa* was isolated in 27% of broiler farms, 24% of egg-production farms, and 23% of hatcheries. In turkey farming enterprises, *P. aeruginosa* was isolated in 21.1% of samples from biological material and environmental objects, while in duck and goose farming enterprises, the pathogen was isolated in 20.5% and 22.3% of cases, respectively (Vashchuk & Fotina, 2018). Furthermore, these authors noted that *P. aeruginosa* was often isolated in associations with other microorganisms (*Escherichia coli*, *Proteus spp.*, cocci flora, and various enterobacteria) circulating in poultry farms.

Treating infections caused by *P. aeruginosa* is extremely challenging due to the pathogen's high level of resistance to antimicrobial drugs. For this reason, the World Health Organization includes *P. aeruginosa* in the list of "critically priority pathogens" (Vashchuk et al., 2021). *P. aeruginosa*, which can transmit antibiotic resistance genes from poultry products, is also a cause of disease in humans (Abd El-Ghany, 2021; Elfadadny et al., 2024).

The aim of the study was to determine the antibiotic susceptibility of epizootic strains of *Pseudomonas aeruginosa* isolated from various animal species in the Dnipropetrovsk region.

## Materials and methods

The study was conducted in the laboratory of the Department of Infectious Diseases of Animals at Dnipro State Agrarian and Economic University (DSAEU) over a three-month (October–December) period in 2024.

Cultures were isolated from biological material: parenchymal

organs of 3-month-old chickens (strain № 1), 6-month-old lambs (strain № 2) from private farms in the Dnipropetrovsk region; conjunctival secretions from a cat with conjunctivitis symptoms (strain № 3) housed in an animal shelter in Dnipro; and purulent discharge from a wound on a laboratory white rat (strain № 4) treated at the Faculty of Veterinary Medicine, DSAEU.

The isolates were identified via manner that based on their morphological characteristics, cultural, and biochemical properties according to Bergey's Manual of Determinative Bacteriology. Cultivation of isolates was performed on nutrient medium, including nutrient agar (NA), nutrient broth (NB), Hiss medium with various sugars (Farmaktiv LLC, Ukraine), and blood agar (Biomerieux, France). Incubation was conducted under aerobic conditions at  $35 \pm 1^\circ\text{C}$  and  $41 \pm 1^\circ\text{C}$  for 24–48 hours in a thermostat (TSO-80/1, MICROmed, China, 2018).

The purity of the cultures was assessed using Gram-stained smears and examined under a MICROmed XS-3330 light microscope (1600 $\times$ , China). The species identification of the isolates was confirmed through diagnostic tests, including oxidase and catalase activity determination and API 20E tests (Biomerieux, France).

The susceptibility of *P. aeruginosa* strains to antibiotics was determined using the agar diffusion method (disk diffusion) following the recommendations of the Clinical and Laboratory Standards Institute (CLSI). For this purpose, 1 cm<sup>2</sup> of a suspension (turbidity level of 0.5 McFarland standard) prepared from a 24-hour pure culture was inoculated onto sterile bacteriological plates with Mueller-Hinton agar (HiMedia Laboratories Pvt. Ltd, India). The turbidity of the suspension was measured using a digital densitometer DEN-1 (Latvia, 2020). Commercially manufactured antibiotic disks were placed on the agar surface using sterile tweezers. Plates were incubated upside down in a thermostat at  $35 \pm 1^\circ\text{C}$  for 16–18 hours.

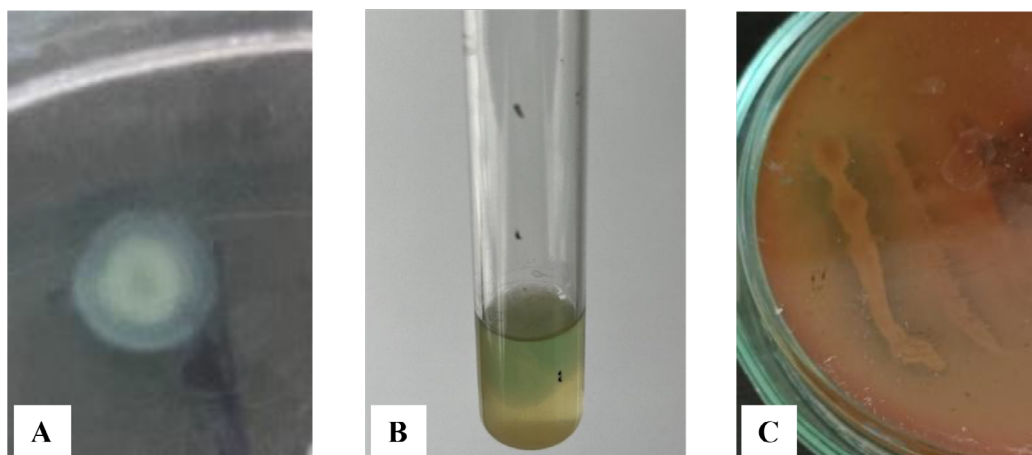
The results were evaluated by measuring the presence or absence of growth inhibition zones around the antibiotic disks using a ruler (Ogloblina, 2023). The strain *P. aeruginosa* ATCC 27853 was used as a control issue.

The following commercially manufactured antibiotic disks were used: polymyxin (300 IU), erythromycin (15  $\mu\text{g}$ ), enrofloxacin (10  $\mu\text{g}$ ), amoxicillin (10  $\mu\text{g}$ ), cephalexin (30  $\mu\text{g}$ ), tetracycline (30  $\mu\text{g}$ ), doxycycline (30  $\mu\text{g}$ ), gentamicin (30  $\mu\text{g}$ ), kanamycin (30  $\mu\text{g}$ ), amikacin (30  $\mu\text{g}$ ), norfloxacin (10  $\mu\text{g}$ ), ciprofloxacin (5  $\mu\text{g}$ ), and chloramphenicol (30  $\mu\text{g}$ ) (Farmaktiv LLC, Ukraine).

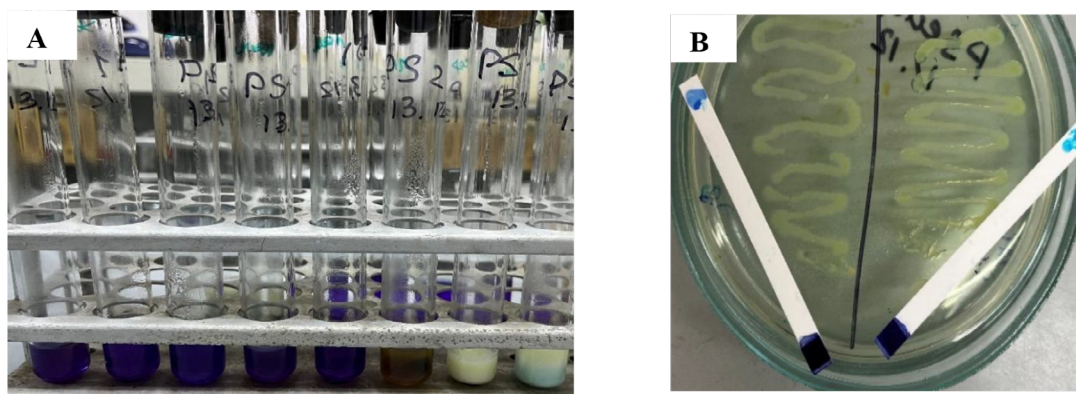
The obtained research results were subjected to statistical processing using the specialized Microsoft Excel software. Sample comparisons were performed using analysis of variance (ANOVA) with Bonferroni correction. Data in tables were presented as  $x \pm \text{SD}$  (standard deviation), and differences were considered statistically significant at  $P < 0.05$ .

## Results

A culture medium inoculated with suspensions of biological material; growth characteristic of *P. aeruginosa* was observed. On some plates, isolated wrinkled colonies (blue-green in color) resembling "daisy flowers" were detected, while on the others plates, confluent growth with mucoid colonies was absent. In the nutrient broth (NB), the following were observed: the formation of a silvery-gray surface film, progressive turbidity over time, a characteristic odor reminiscent of "strawberry soap", and the synthesis of the pigment pyocyanin. The cultures exhibited growth at both  $35 \pm 1^\circ\text{C}$  and  $41 \pm 1^\circ\text{C}$ . On 5% blood agar, zones of  $\beta$ -hemolysis were recorded (Fig. 1). On differential growth medium, the isolated cultures demonstrated weak fermentative activity: they oxidized glucose and reduced nitrates to nitrites. Additionally, isolated culture samples produced oxidase and catalase, and were capable of liquefying milk and gelatin (Fig. 2).



**Fig. 1.** Cultural properties of the isolated *P. aeruginosa* strains: A – wrinkled colonies resembling a "daisy flower"; B – pyocyanin pigment in nutrient broth (NB); C –  $\beta$ -hemolysis in blood nutrient agar (blood agar)



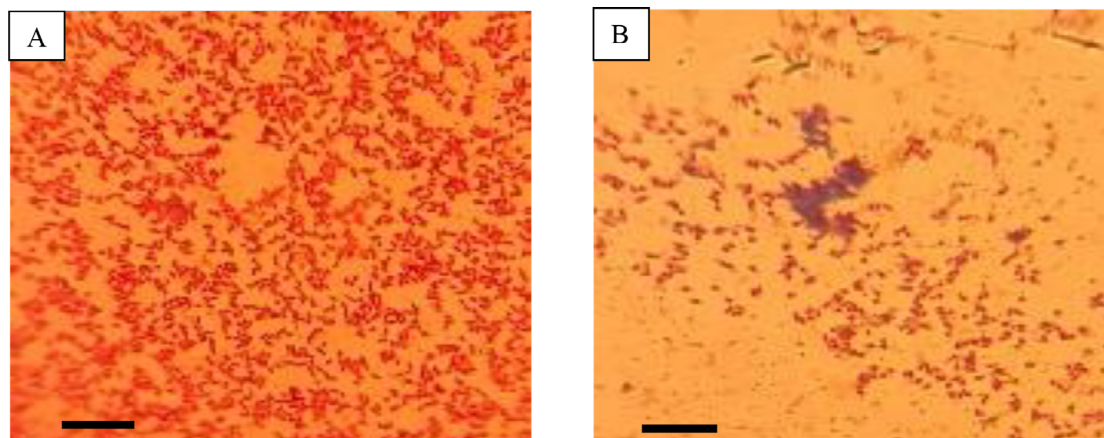
**Fig. 2.** Enzymatic properties of the isolates: A – glucose oxidation and milk liquefaction; B – positive oxidase test (blue color of the diagnostic zone of the strip)

Microscopy results (1600 $\times$ ) have shown that both short and medium gram-negative bacteria were present, arranged singly or in pairs, and did not form spores (Fig. 3). Based on our research, the isolated culture was identified as *P. aeruginosa*.

Our studies (Table) showed that the control strain *P. aeruginosa* ATCC 27853 in vitro was sensitive to five out of twelve antibiotics: aminoglycosides and fluoroquinolones (gentamicin, kanamycin, amikacin, norfloxacin, and ciprofloxacin – growth inhibition zones ranged from 18.7  $\pm$  0.40 mm to 28.2  $\pm$  0.40 mm).

Observed results demonstrated that the strain isolated from chicken biological material (№ 1) was most sensitive only to norfloxacin (growth inhibition zone 31.6  $\pm$  0.41 mm,  $P < 0.05$ ). However, it was resistant to polymyxin, amoxicillin, cephalixin, tetracycline, doxycycline, erythromycin, gentamicin, kanamycin, amikacin, ciprofloxacin, and chloramphenicol (growth inhibition zone 0–14.3 mm).

The strain № 2, isolated from the biological material of lambs, was susceptible only to one aminoglycoside – kanamycin (zone



**Fig. 3.** Morphological characteristics of *P. aeruginosa* strains isolated from biological material: A – from chicks; B – from lambs. Gram staining (bar = 5  $\mu$ m, 1600 $\times$ )

**Table** – Antibiotics sensitivity levels of isolated *Pseudomonas aeruginosa* strains ( $\bar{x} \pm SD$ ,  $n = 5$ )

Antibiotic	Strain, №				
	<i>Pseudomonas aeruginosa</i> ATCC 27853	1	2	3	4
	Growth inhibition zone, mm				
Polymyxin	8.4 ± 0.49	9.2 ± 0.75	0 ± 0*	10.2 ± 0.40*	16.0 ± 0.16*
Amoxicillin	10.0 ± 0.63	6.8 ± 0.51*	9.6 ± 0.49	29.2 ± 0.75*	27.8 ± 0.40*
Cephalexin	10.5 ± 0.45	0 ± 0*	18.6 ± 0.80*	14.3 ± 0.40*	21.9 ± 0.50*
Tetracycline	10.4 ± 0.49	7.7 ± 0.24*	15.0 ± 0.25*	12.0 ± 0.18*	12.0 ± 0.21*
Doxycycline	15.0 ± 0.63	6.2 ± 0.24*	21.0 ± 0.71*	21.0 ± 0.58*	22.1 ± 0.20*
Erythromycin	11.4 ± 0.80	0 ± 0*	8.2 ± 0.40*	20.1 ± 0.27*	9.3 ± 0.60*
Gentamicin	18.7 ± 0.40	14.0 ± 0.82*	15.0 ± 0.17*	25.1 ± 0.49*	21.9 ± 0.19*
Kanamycin	19.6 ± 0.49	14.0 ± 0.12*	22.1 ± 0.31*	22.1 ± 0.21*	34.5 ± 0.45*
Amikacin	22.2 ± 0.75	7.0 ± 0.21*	6.9 ± 0.74*	6.0 ± 0.55*	8.0 ± 0.71*
Norfloxacin	24.2 ± 0.20	31.6 ± 0.41*	20.0 ± 0.27*	26.2 ± 0.66*	22.0 ± 0.27*
Ciprofloxacin	28.2 ± 0.40	14.3 ± 0.94*	30.0 ± 0.12*	30.7 ± 0.40*	28.6 ± 0.40
Levomycesin	11.0 ± 0.89	0 ± 0*	0 ± 0*	14.1 ± 0.3*	8.0 ± 0.16*

Note: \* –  $P < 0.05$  compared to the control strain.

of inhibition diameter  $22.1 \pm 0.31$  mm) and two fluoroquinolones – norfloxacin and ciprofloxacin ( $20.0 \pm 0.27$  and  $30.0 \pm 0.12$  mm respectively). Bacteriostatic activity was observed with cephalexin and doxycycline ( $18.6 \pm 0.80$  and  $21.0 \pm 0.71$  mm respectively). Resistance of strain № 2 to polymyxin, amoxicillin, tetracycline, erythromycin, gentamicin, amikacin, and chloramphenicol was confirmed.

Five antibiotics (amoxicillin, gentamicin, kanamycin, norfloxacin, and ciprofloxacin) were effective in vitro against *P. aeruginosa* strain № 3, isolated from the conjunctival secretion of a cat with conjunctivitis: the zone of inhibition diameter ranged from  $22.1 \pm 0.21$  mm to  $30.7 \pm 0.40$  mm ( $P < 0.05$ ). Erythromycin and doxycycline demonstrated bacteriostatic effects against this strain (zones of inhibition  $20.1 \pm 0.27$  mm and  $21.0 \pm 0.58$  mm, respectively).

Strain № 4, isolated from the pus exudate of laboratory white rat, was susceptible to the greatest number of antibiotics (eight out of twelve): polymyxin, amoxicillin, cephalexin, doxycycline, gentamicin, kanamycin, norfloxacin, and ciprofloxacin. The inhibition zones for these antibiotics ranged from  $16.0 \pm 0.16$  mm to  $34.5 \pm 0.45$  mm ( $P < 0.05$ , Fig. 4).

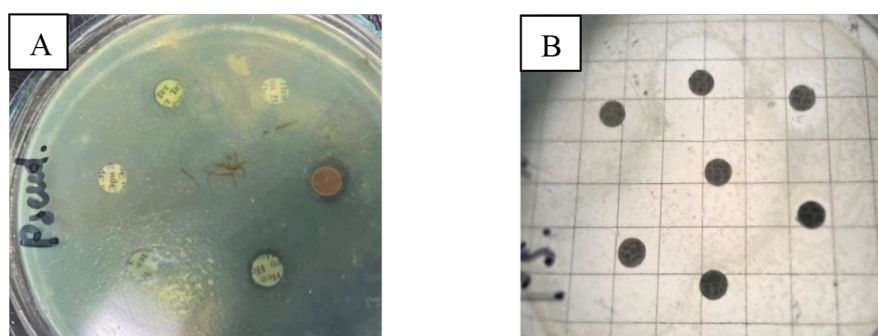
It should be noted that only the control strain of *P. aeruginosa* was sensitive to amikacin. All strains, including the control one, were resistant to tetracycline (the diameter of the growth inhibition zones ranged from  $7.7 \pm 0.24$  mm to  $15.0 \pm 0.25$  mm).

## Discussion

*P. aeruginosa* is an opportunistic pathogen, a widely distributed bacterium in the environment that causes diseases in livestock, poultry, and fish. *P. aeruginosa* is a gram-negative, motile, straight or slightly curved rod, an aerobe capable of synthesizing catalase and oxidase, and is a psychrophilic-mesophilic bacterium (Zazharskyi et al., 2023).

In Ukraine, animal infections caused by *P. aeruginosa* are most commonly reported during the autumn-winter period (from October to February) (Novhorodova & Mazur, 2013). The sources of infection may include sick or previously infected animals and poultry, contaminated water and bedding, manure, washing hoses in milking parlors, spray nozzles, reusable udder towels, the surrounding environment, and others (McLennan et al., 1997; Trautmann et al., 2009). *P. aeruginosa* is considered a nosocomial pathogen that plays an important role in wound infections in burn patients (Al-Ahmadi & Roodsari, 2016). Aforementioned results identified the isolates based on colony morphology, pigment production, a positive oxidase test, glucose fermentation, gelatin hydrolysis, and growth at  $42^\circ\text{C}$ .

*P. aeruginosa* has been isolated from clinical and subclinical mastitis with a high mortality rate in dairy cows, sheep, and goats in Australia, Ireland, Israel, and the Netherlands (Daly et al., 1999; Sela et al., 2007; Ma et al., 2024). Epidemiological studies



**Fig. 4.** Antibiotic susceptibility of *P. aeruginosa* strains: A – from chicks; B – from the conjunctival sac fluid. The disc technique.

conducted in various countries have revealed a great diversity of *P. aeruginosa* strains in animals suffering from mastitis (Sol et al., 1998; Zadoks et al., 2011; Schauer et al., 2021). This pathogen can also cause diseases in poultry, particularly in young birds, leading to significant losses. In infected embryos, *P. aeruginosa* caused shell mortality, while infected chicks showed signs of septicemia, damage to the respiratory and gastrointestinal tracts, and high mortality. Since *P. aeruginosa* has a zoonotic nature, chicken carcasses and poultry products can be sources of transmission of *P. aeruginosa* to humans (Zon & Vashchuk, 2013). Satish & Priti (2015) most frequently isolated *P. aeruginosa* (a gram-negative motile rods that synthesized a blue-green pigment, haemolytic, and grew at 42°C) from the liver, lungs, air sacs, nose, and heart of chickens. The disease manifested with respiratory tract lesions, diarrhea, and septicemia.

We isolated strains of *P. aeruginosa* from the biological material of animals most susceptible to the pathogen (chicks, sheep) and from the wound secretion of a laboratory animal, as indicated by Verzhikhovskiy et al. (2007), Vashchuk & Fotina (2018), and Al-Ahmadi & Roodsari (2016). The isolates were similar to each other in morphology and properties. The study confirmed that the isolated strains corresponded to the morphological, tinctorial, cultural, and biochemical characteristics reported in academic publications and matched the research findings of Satish & Priti (2015) and Al-Ahmadi & Roodsari (2016). The strain isolated from a shelter cat with conjunctivitis indicated the presence of this microorganism in the environment and its ability to cause inflammatory processes.

*P. aeruginosa* is most commonly isolated from environmental objects contaminated with hydrocarbons, pesticides, and feces. In unpolluted environments, the prevalence of this microorganism is relatively low (Crone et al., 2020). Ghosh et al. (2024) report contamination of the Mahanada River in India with *P. aeruginosa*, which is pathogenic to fish. Clinical signs in fish included hemorrhagic spots, loss of scales, and fin erosion. The authors claim that this pathogen contained a number of virulence and antibiotic resistance genes. Mena & Gerba (2009) mention the presence of this microorganism in lakes and rivers, with concentrations ranging from 10 to >1000 CFU/100 ml. *P. aeruginosa* is responsible for food spoilage and the degradation of petroleum products.

*P. aeruginosa* poses a serious global threat due to its ability to develop resistance to many pharmaceutical agents (Chatterjee et al., 2016; Wu et al., 2024). The World Health Organization (WHO) has classified this bacterium as part of the first critical group of antibiotic-resistant bacteria (Vashchuk et al., 2021). According to Laborda et al. (2022), *P. aeruginosa* exhibits low sensitivity to several important antibiotics ( $\beta$ -lactams, quinolones, aminoglycosides, and colistin) due to reduced permeability of the cell membranes, the synthesis of enzymes that inactivate antibiotics, and genes that encode efflux pumps. Strains of *P. aeruginosa* isolated from dogs and cats in various regions of the Iberian Peninsula between 2016 and 2018 showed the highest levels of antibiotic resistance compared to other bacteria (Li et al., 2021).

As a result of complex physiological and genetic processes, highly resistant *P. aeruginosa* bacterial populations are formed, which are capable of causing chronic infections (Oliver et al., 2008). Badawy et al. (2023) found that in domestic settings, the spread of *P. aeruginosa* (five times higher) and its multidrug resistance (81.4%) were greater than those isolated from farms. Household strains were resistant to sulfamethoxazole, imipenem, amoxicillin, gentamicin, cefepime, and erythromycin at rates of 91.3%, 82.6%, 75.4%, 75.4%, 68.1%, and 63.8%, respectively, while strains isolated from dairy farms were resistant to sulfamethoxazole, imipenem, cefepime, piperacillin-tazobactam, and gentamicin (100%, 72.7%, 72.7%, 68.8%, and 63.3%, respectively). Makhrmash (2022) observed the resistance of *P. aeruginosa* isolates to cefotaxime – 61 (95.3%), carbenicillin – 59 (92.2%), ampicillin – 38 (59.4%), piperacillin/tazobactam – 29 (45.3%), streptomycin – 28 (43.8%),

moxifloxacin – 27 (42.4%), ticarcillin – 26 (40.6%), ciprofloxacin – 24 (37.5%), gentamicin – 20 (31.3%), and neomycin – 13 (20.3%). The most active antibiotics against *P. aeruginosa* were neomycin, gentamicin, and ciprofloxacin.

Certain strains of *P. aeruginosa* are resistant to most available antimicrobial agents, including carbapenems and third-generation cephalosporins (Chatterjee et al., 2016). In Nigeria, at slaughter points and from domestic poultry, 22 *P. aeruginosa* isolates with genes for metallo- $\beta$ -lactamase resistance were phenotypically identified, and through polymerase chain reaction (PCR), 16 (72.7%) isolates showed high resistance to cephalosporins and carbapenems (Ejikegwu et al., 2021).

Our research established that the *P. aeruginosa* strain isolated from chicks exhibited resistance to 91.7% of the tested antibiotics, while the strain isolated from lambs was resistant to 58.3% of the antibiotics tested. The obtained data indicate the detection of *P. aeruginosa* strains on livestock farms, characterized by the presence of genes conferring resistance to widely used antibacterial agents. A 100% susceptibility of isolates to norfloxacin was observed, along with 80% susceptibility to ciprofloxacin, 60% to gentamicin and kanamycin, and only 20% to polymyxin, amikacin, and cephalixin. The high sensitivity of isolates to ciprofloxacin and gentamicin was consistent with the findings of Makhrmash (2022) but differed from the results reported by Badawy et al. (2023).

The increasing cases of resistance to antibacterial drugs indicate the variability of *P. aeruginosa* and its ability to adapt to environmental conditions, changing both phenotypically and genotypically (Verzhikhovskiy et al., 2007; Pang et al., 2019; Hemmati et al., 2024). However, Mena & Gerba (2009) reported that *P. aeruginosa* does not exhibit resistance to disinfectants (chlorine, chloramines, ozone, and iodine) used for water treatment. However, this bacterium is more resistant to UV radiation.

Work on developing innovative strategies to combat antibiotic resistance, including alternative antibacterial agents, holds great potential for overcoming multidrug resistance in various pathogens, including *P. aeruginosa* (Bilan et al., 2023; Kucherenko et al., 2024; Zazharskyi et al., 2024).

## Conclusions

The results of this study indicated that *P. aeruginosa* is a widely distributed microorganism capable of causing diseases in animals and poultry. The isolated *P. aeruginosa* strains exhibited similar morphological, cultural, and enzymatic properties, but these strains were vary in respect with their susceptibility to antibiotics. The most effective antibiotics against *P. aeruginosa* were norfloxacin and ciprofloxacin, with somewhat lower activity observed for gentamicin and kanamycin. It was also found that these pseudomonad strains were resistant to six out of twelve (50%) of the tested antibiotics. Detailed laboratory monitoring of biological material from animals and environmental objects will allow for the control of the presence of antibiotic-resistant *P. aeruginosa* in the environment.

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## Declaration of Competing Interest

Authors declare no conflict of interests with respect to this paper.

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