International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(4): 92-100
www.biochemjournal.com
Received: 15-01-2024
Accepted: 27-02-2024

Bratati Deb Sarkar
Department of Veterinary Clinical Medicine, Ethics and Jurisprudence, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam, India

Ditul Barman
Assistant Professor, Department of Veterinary Clinical Medicine, Ethics and Jurisprudence, C.V.Sc, AAU, Khanapara, Guwahati, Assam, India

Arabinda Phukan
Professor, Department of Veterinary Clinical Medicine, Ethics and Jurisprudence, C.V.Sc, AAU, Khanapara, Guwahati, Assam, India

Mousumi Hazorika
Assistant Professor, Department of Veterinary Clinical Complex, C.V.Sc, AAU, Khanapara, Guwahati, Assam, India

Tanay Ghosh
Ph.D. Scholar, Department of Animal Nutrition, C.V.Sc, AAU, Khanapara, Guwahati, Assam, India

Corresponding Author:
Bratati Deb Sarkar
Department of Veterinary Clinical Medicine, Ethics and Jurisprudence, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati, Assam, India

Bacterial respiratory tract infection in dog

Bratati Deb Sarkar, Ditul Barman, Arabinda Phukan, Mousumi Hazorika and Tanay Ghosh

DOI: https://doi.org/10.33545/26174693.2024.v8.i4Sb.912

Abstract
The research entitled "Bacterial Respiratory Tract Infection in Dog" was undertaken *w.e.f.* October 2022 to June 2023 in the Veterinary Clinical Complex, College of Veterinary Science, Assam Agricultural University, Khanapara, and Guwahati with the objective of isolation and identification of bacterial isolates along with therapeutic regimen based on *in-vitro* antibiotic sensitivity test. Nasal swab samples were collected by using sterile swabs aseptically from the suspected animals for isolation, identification of the bacteria and performed *in-vitro* antibiotic sensitivity test and rendered treatment in the three treatment groups (Group B, Group C and Group D). The most common clinical findings observed were moist cough, inappetence and wheezing sound of the lung elicited through thoracic auscultation. *Staphylococcus* spp. concurrently with *Escherichia coli* (30.00%) were common isolates. In *in-vitro* antibiotic sensitivity test *Staphylococcus* spp., *Klebsiella pneumoniae, Pseudomonas* spp. and *Bacillus* spp. showed highest sensitive to Ceftriaxone. *Escherichia coli* and *Bacillus* spp. showed highest sensitive to Doxycycline. Ceftriaxone sodium was found (100.00%) effective followed by Doxycycline hydrochloride and Enrofloxacin (90.00%).

Keywords: Ceftriaxone, *Staphylococcus* spp., isolation, wheezes, crackles

Introduction
Dog (*Canis familiaris*) is an affectionate and faithful pet animal which can learn easily and is obeyed by the master. Dogs are the first domesticated animal and have interaction with human (Freedman and Wayne, 2017) [10]. In a research study by Pescini *et al.*, 2019 explained that dogs as well as human both release oxytocin when they spend time together and they inferred that oxytocin is the main reason for creating a strong social bond between human and pet animal. Dogs are affected by both infectious as well as non-infectious diseases. Respiratory tract infections (RTI) is caused by viruses, bacteria, fungus, parasites, mycoplasma etc and out of all, bacterial involvement is one of the common reasons for the onset of RTI. *Staphylococcus* spp., *Streptococcus* spp., *Escherichia coli*, *Pasteurella* spp., *Klebsiella* spp., *Pseudomonas* spp., *Bordetella bronchiseptica* etc. are the common bacteria associated with RTI (Qekwana *et al.*, 2020) [21]. During the infection, patient exhibit clinical manifestation like dyspnea, fever, coughing, sneezing, loss of appetite, nasal discharge, lethargy, weight loss etc. Doxycycline and Amoxicillin-clavulanic acid are preferred for first line systemic antibiotic therapy; Fluoroquinolones, Azithromycin etc. can be indicated for second line antibiotic therapy. But in the present scenario due to indiscriminate use of antibiotics, they become ineffective against pathogens.

In North Eastern Region of India, investigation on bacteria associated respiratory tract infection in canine has not been studied so far. Hence, an attempt was made to study the association of bacteria in respiratory tract infection of dogs and to generate proper therapeutic management for the affected animals. Considering the importance of canine respiratory tract infection present study was undertaken considering of few objectives namely isolation and identification of the bacteria associated with respiratory tract infection, *in vitro* antimicrobial sensitivity pattern of the isolates and therapeutic management of the affected dogs.

Materials and Methods
From October, 2022 to June 2023, dogs presented to the Veterinary Clinical Complex (VCC), College of Veterinary Science, Assam Agricultural University, Khanapara from

different parts of Assam and neighboring states of the North Eastern Region, irrespective of their age, sex and breed having clinical signs like coughing, sneezing, presence of nasal discharge, fever, respiratory distress, loss of body weight etc were included in the study. Nasal swab samples were collected by using sterile swabs aseptically for isolation, identification of the bacteria up to genus level. The samples which were collected by sterile cotton swabs kept into the Brain Heart Infusion Broth and incubated at 37°C overnight. The incubated broth sample was streaked over Brain Heart Infusion Agar and further incubated for 24 hours aerobically to obtain a single colony for primary isolation. After that the smear was prepared from the pure colonies and subjected to Gram's staining.

On the basis of the characteristic of Gram's staining the single colony was streaked on selective media *i.e.* Eosin Methylene Blue agar (EMB) and Mannitol Salt Agar (MSA). Then the plate was incubated at 37°C for 24 hours for the growth of the organism. Further confirmation series of biochemical test was done *viz.* catalase test, IMViC test etc (Quinn *et al*., 2011) [22].

After isolation and identification of the organisms *in-vitro* antibiotic sensitivity test was done by disc diffusion techniques in Mueller Hinton Agar (Quinn *et al*., 2011) [22]. A single isolate of pure culture was inoculated into 5 ml of Nutrient Broth and incubated overnight at 37°C. The Mueller Hinton Agar plates were inoculated with the pure culture grown in the Nutrient Broth with the help of a sterile swab. The antibiotic discs were placed over the agar plates and then incubated for 24 hours before reading the sensitivity (CLSI, 2022). The antibiotic discs used for the antibiotic sensitivity test were Amoxicillin-Clavulanic acid, Ceftriaxone, Ceftriaxone-Tazobactam, Enrofloxacin, Doxycycline and Gentamicin. Discs were procured from Hi-Media Pvt. Ltd., Mumbai

In the current study, for therapeutic management, dogs with bacteria-associated respiratory tract infections were divided into three therapeutic trial groups (Group B, Group C and Group D) comprising of 10 animals in each group. Each group *viz.* Group B, Group C and Group D was administered three different antibiotics *i.e.* Doxycycline, Enrofloxacin and Ceftriaxone respectively based on *in-vitro* antibiotic sensitivity test and supportive treatment was also rendered based on animal condition. The dogs were evaluated on the 10th day. A therapeutic trial was conducted for 10 days according to Lappin *et al.* (2017) [12] and Vientòs-plotts *et al.* (2021) [25]. Babesiosis, Canine distemper, Chronic liver disease along with ascites and Heart related disease with bacteria-associated respiratory tract infection was treated accordingly as per requirements of the affected dogs. Further statistical analysis of data was done with Microsoft excel.

Results

Clinical Manifestation of Bacteria Associated Respiratory Tract Infection in Dogs: In the present study, different clinical manifestations are recorded in the Fig 1. The most common clinical findings observed were moist cough (90.00%), sneezing (40.00%), transparent and watery nasal discharge (30.00%), exercise intolerance (20.00%), inappetence (93.33%) and wheezing sound of the lung (66.67%) elicited through thoracic auscultation.

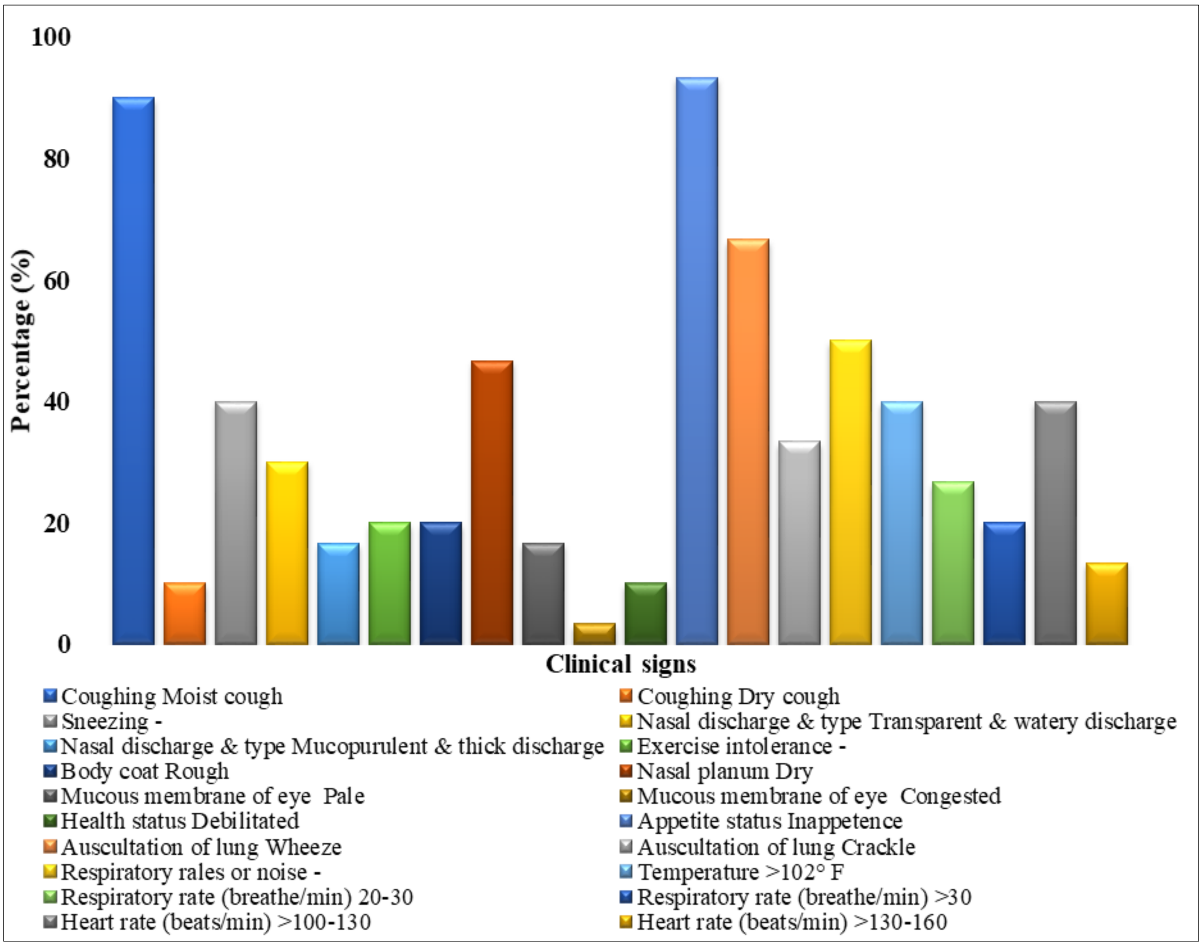


Fig 1: Bar diagram showing clinical findings observed in bacteria associated respiratory tract infection in dogs

Isolation and identification of bacteria

In the current study different bacterial species of the clinically affected dogs were isolated from the nasal swab and presented in the Fig 2, Fig 3, Fig 4 and Fig 5. Under the category of multiple isolates, (30.00%) samples were positive for *Staphylococcus* spp. concurrently with *Escherichia coli* and similarly (23.33%) for *Staphylococcus* spp. concurrently with *Klebsiella pneumoniae* (13.33%) for *Staphylococcus* spp. concurrently with *Escherichia coli* and *Klebsiella pneumoniae*, (13.33%) for *Staphylococcus* spp. concurrently with *Bacillus* spp. and (6.67%) positive for the presence of *Staphylococcus* spp. Concurrently with *Pseudomonas* spp. Under single organism the samples were found to be positive for *Escherichia coli* (10.00%) and *Staphylococcus* spp. (3.33%). Identification of *Staphylococcus* spp. and *Bacillus* spp. were executed based on the Gram's staining properties. Microscopically, *Staphylococcus* spp. were resembled like an irregular clusters on the other hand *Bacillus* spp. were rod-shaped purple colour in appearance. In mannitol salt agar all the isolates of *Staphylococcus* spp. produce a small yellow-coloured colony. In biochemical test all the isolates of *Staphylococcus* spp. and *Bacillus* spp. showed a catalase positive reaction. *Escherichia coli* were confirmed based on colony characteristics on MacConkey agar (bright pink colour colonies) and metallic sheen were observed in EMB agar. The further confirmatory diagnosis was done by biochemical test *i.e.* IMViC test. *Escherichia coli* showed a positive reaction for the indole and methyl red test. *Klebsiella pneumoniae* on Gram's staining showed gram-negative rods and produced lactose fermenting mucoid colony on MacConkey agar. On biochemical test, organisms showed positive reaction for Voges-proskauer and Citrate utilization test. *Pseudomonas* spp. on Gram's staining showed gram-negative rods. Further confirmation was done by IMViC test and in the result, the Citrate utilization test revealed a positive reaction whereas all other exhibited a negative reaction.

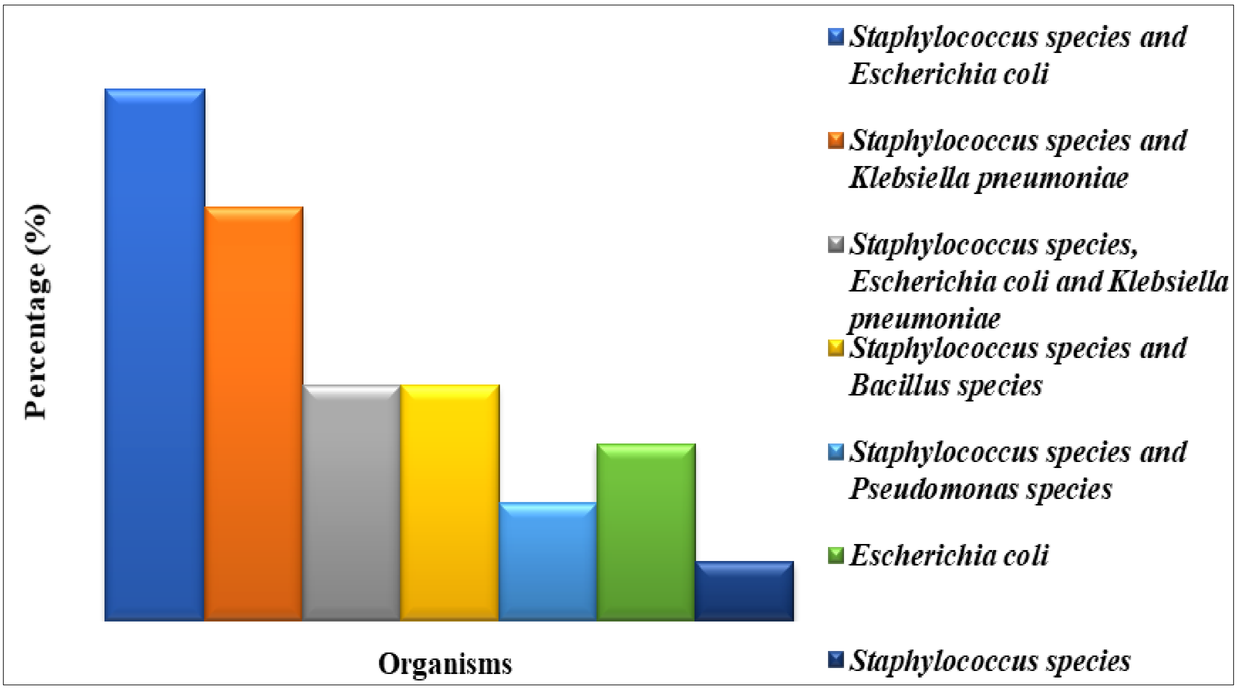
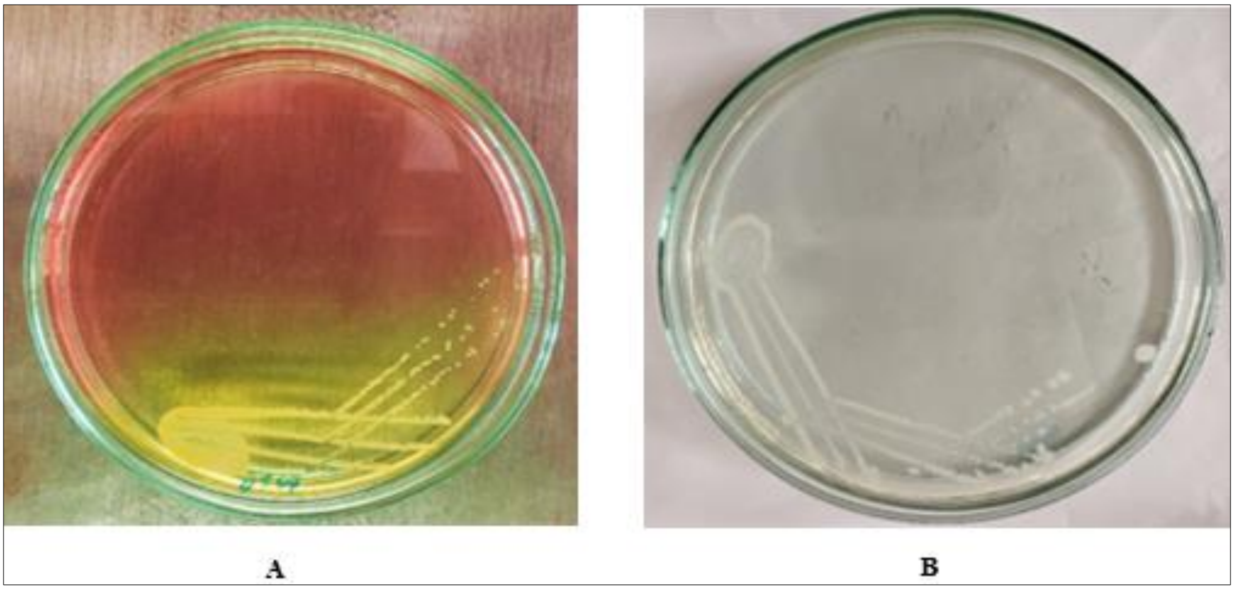


Fig 2: Bar diagram indicating the percentage of bacterial isolates in the respiratory tract infected dogs



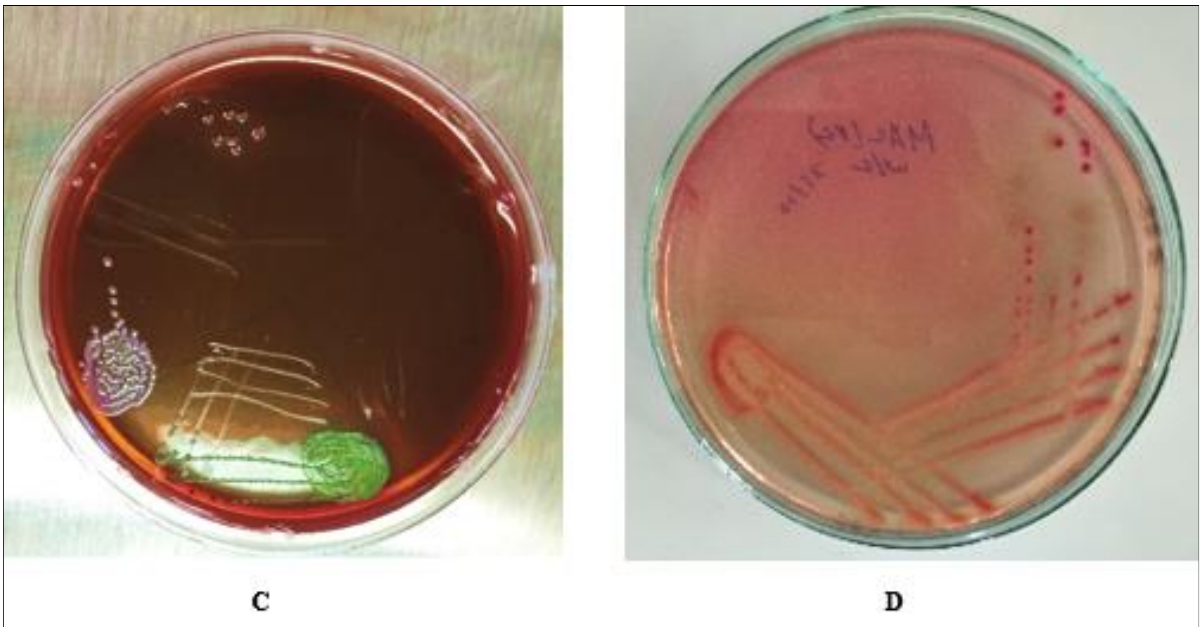


Fig 3: Photograph showing growth of Staphylococcus species on MSA (A), Bacillus species on Nutrient Agar (B), E. coli; K. pneumoniae on EMB agar (C) and E. coli on MLA (D)

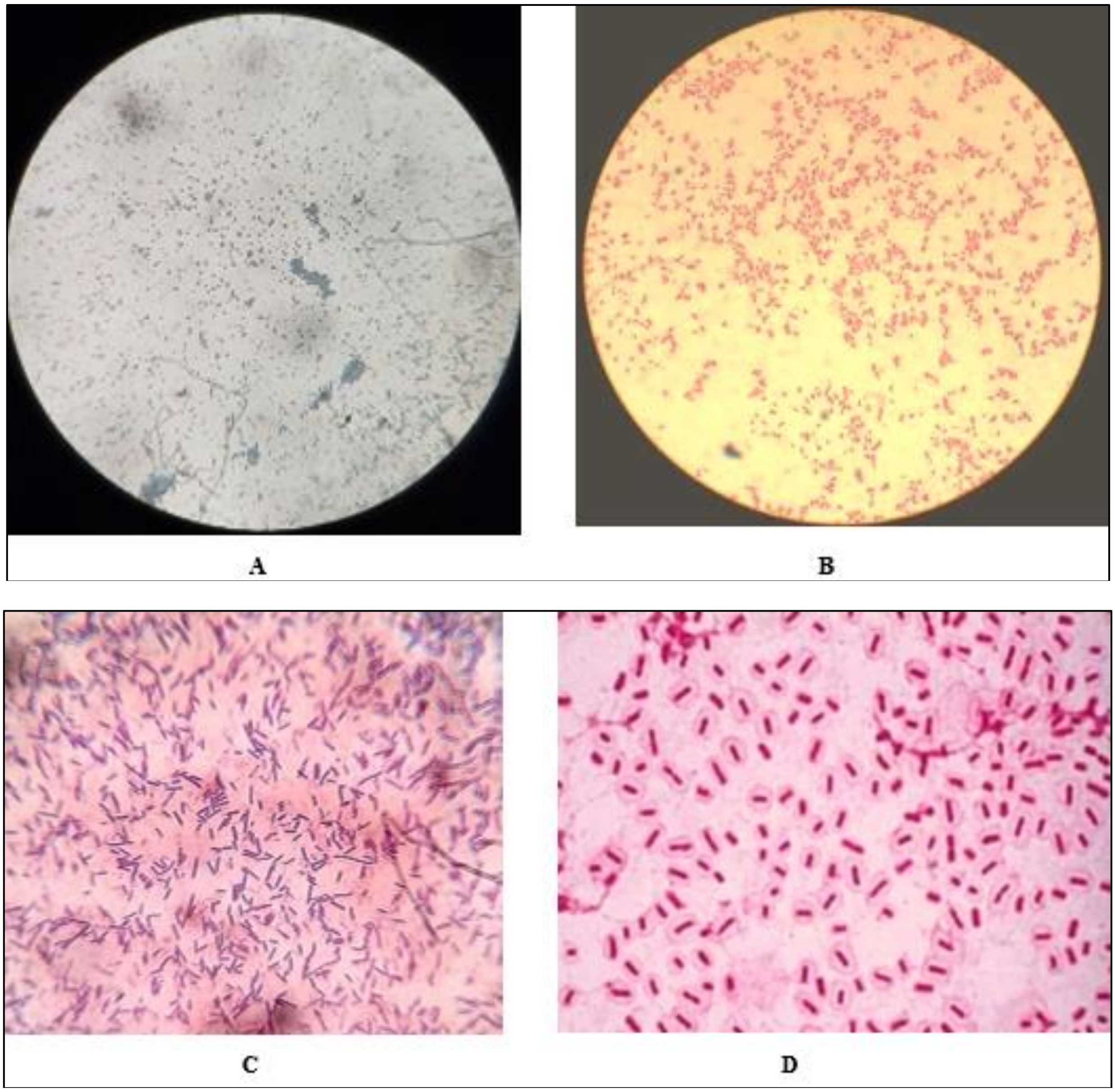


Fig 4: Photomicrograph showing Staphylococcus species (A), E. coli (B), Bacillus species (C) and (D) K. pneumoniae after gram's staining

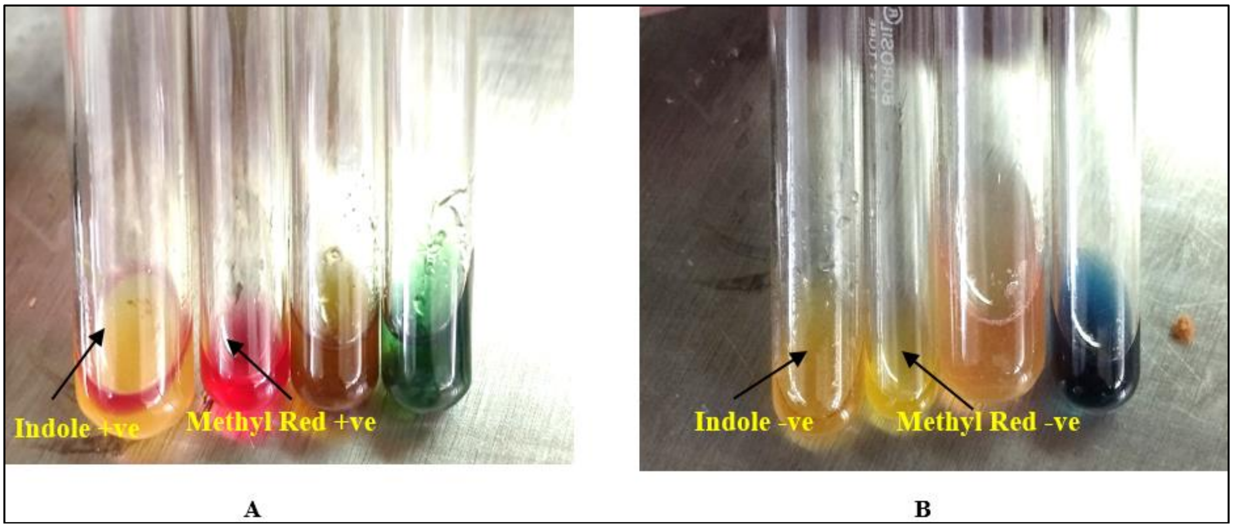


Fig 5: Photograph showing IMVIC test for E. *coli* (A) and K. pneumoniae (B)

***In-vitro* Antibiotic Sensitivity Test (ABST)**

In the recent study, an antibiotic sensitivity test was done by disc diffusion technique in Mueller Hinton Agar (Fig 6 and Fig 7). In the result, for *Staphylococcus* spp. the highest sensitivity was observed on Ceftriaxone (100%) followed by Enrofloxacin (81.48%), Doxycycline (77.77%), Ceftriaxone potentiated with tazobactam (11.11%) and Gentamicin (11.11%) but found resistant to Amoxicillin potentiated with clavulanic acid. Antibiotic sensitivity test for *Escherichia coli* revealed the highest sensitivity towards Doxycycline (62.50%) followed by Enrofloxacin (56.25%), Ceftriaxone (50.00%) and Gentamicin (37.50%) but found resistant to Ceftriaxone potentiated with tazobactam and Amoxicillin potentiated with clavulanic acid. *Klebsiella pneumoniae* was found highest sensitive to Ceftriaxone (90.91%) followed by Doxycycline (72.73%), Enrofloxacin (36.36%) and Ceftriaxone potentiated with tazobactam (18.18%) but found resistant to Gentamicin and Amoxicillin potentiated with clavulanic acid respectively. An antibiotic sensitivity test was done on isolates of *Pseudomonas* spp. ABST revealed (100.00%) sensitivity to Ceftriaxone, Doxycycline, Enrofloxacin and Ceftriaxone potentiated with tazobactam and (50.00%) sensitivity to Gentamicin but found resistant to Amoxicillin potentiated with clavulanic acid. *Bacillus* spp. was found to be the highest sensitivity to Doxycycline (100.00%) and Ceftriaxone (100.00%) followed by Enrofloxacin (75.00%) but found resistant to Ceftriaxone potentiated with tazobactam, Gentamicin and Amoxicillin potentiated with clavulanic acid.

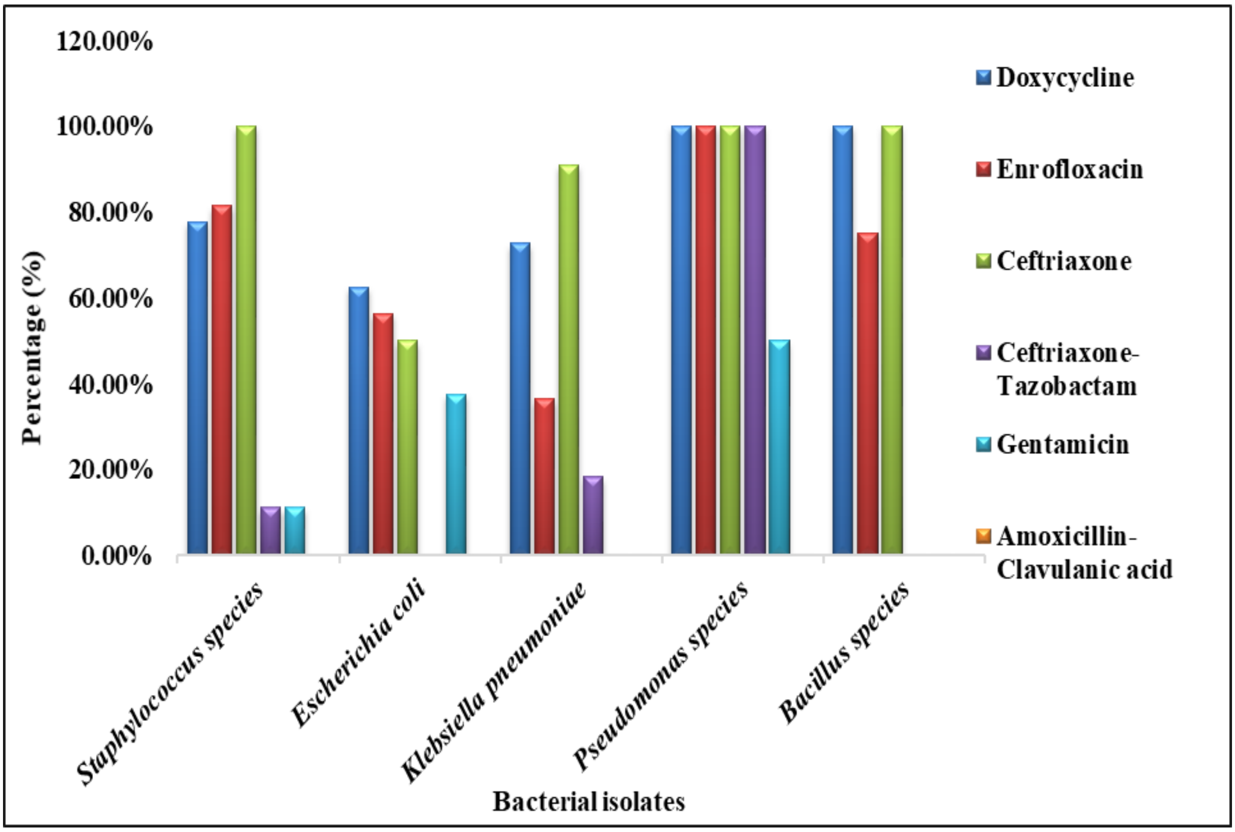


Fig 6: Bar diagram showing antibiotic sensitivity of isolates in bacteria associated respiratory tract infection in dogs

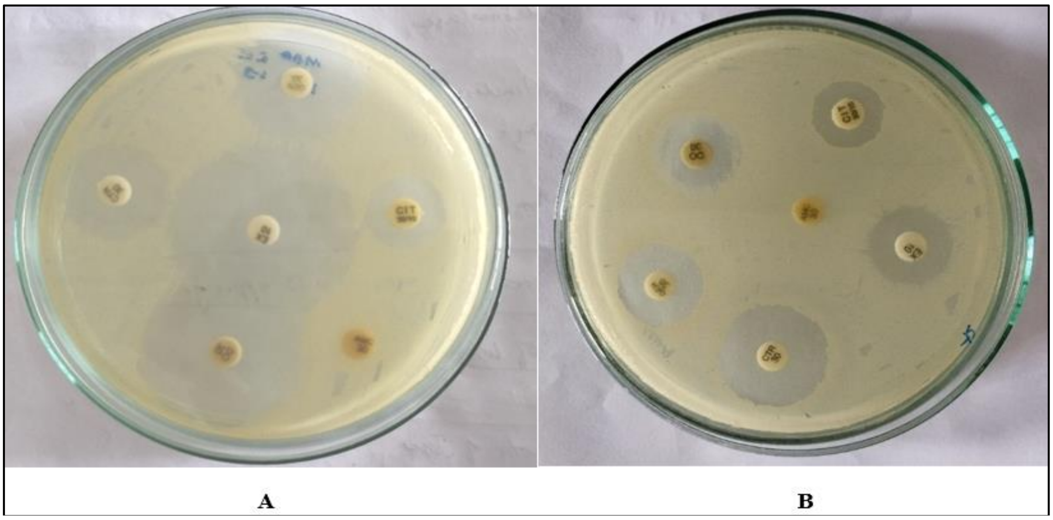


Fig 7: Photograph showing (A) and (B) *in-vitro* antibiotic sensitivity test

Therapeutic Management: The post-treatment clinical evaluation of signs and symptoms was done for 10 days. On the basis of an *in-vitro* antibiotic sensitivity test, three antibiotics namely Doxycycline hydrochloride, Enrofloxacin and Ceftriaxone sodium were administered to the animals along with supportive therapy for the treatment of bacteria-associated respiratory tract infections in dog. Overall recovery is illustrated in the Fig 8, Fig 9 and Fig 10. In Group B, ten dogs were treated with pantoprazole, 20% mannitol, furosemide and vitamin supplements. Among ten dogs parenteral administration of Doxycycline hydrochloride was given to eight dogs and the remaining two dogs were treated with oral administration of Doxycycline hydrochloride. One dog was given ramipril, pimobendan and a cardio-supportive drug. Four dogs were given imidocarb along with atropine sulphate at 14 days intervals. Haematinic was given to four dogs. Liver supportive and pheniramine maleate was given in two dogs. Prednisolone was given parenterally in six dogs for 5 days. Meloxicam was also given parenterally in one dog for 3 days. Nebulization was performed in three dogs.

In Group B two dogs recovered on 5th day, five dogs recovered on 7th day and another two dogs recovered on 10th day for respiratory tract infection and remission of clinical signs. In Group C, ten dogs were treated with 20% mannitol, furosemide, pantoprazole and vitamin supplements parenterally. Among ten dogs eight dogs were treated with parenteral administration of Enrofloxacin and two dogs were given Enrofloxacin tablet orally. Homeopathic medicine rhus toxicodendron, vitamin C, canine distemper immunoglobulin and nervine tonic were given to one dog. Pheniramine maleate was given in one dog and nebulization was performed in five dogs. In Group C, two dogs recovered on 5th day, four dogs recovered on 7th day and three dogs recovered on 10th day. In Group D, ten dogs were treated with 20% mannitol, furosemide, Ceftriaxone sodium and vitamin supplements parenterally. Meloxicam tablet was given orally to two dogs. Pimobendan and cardio-supportive drugs were given orally in two dogs. Ramipril was given in three dogs through the oral route. Fructodex in saline was given to one dog through the parenteral route. Prednisolone was given through parenterally in three dogs for 5 days and liver supportive and hematinic were given in two dogs. Nebulization was performed in three dogs. In Group D, only one dog recovered on 5th day, six dogs recovered on 7th day and three dogs recovered on 10th day.

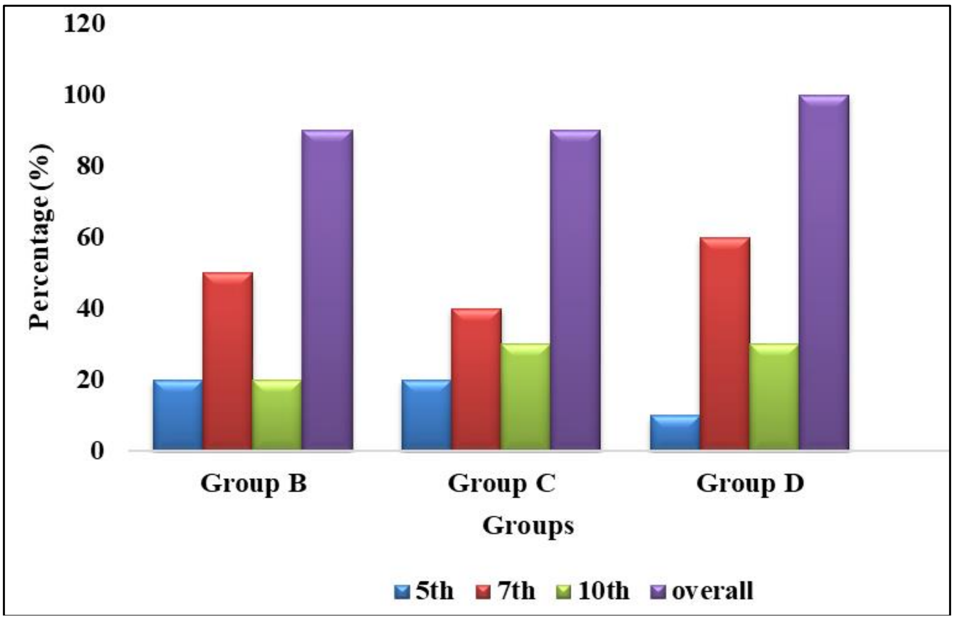


Fig 8: Bar diagram showing therapeutic response between groups

Fig 9: Photograph showing presence of mucopurulent nasal discharge in pre-treatment period

Fig 10: Photograph showing disappearance of mucopurulent nasal discharge in recovery period

Discussion

In the present study, the most common clinical findings observed in dogs were analogous to Elgalfy *et al.* (2022) [8], Arsevska *et al.* (2018) [2], Ellis *et al.* (2016) [9], Sanchez-Viscaino *et al*. (2016) [24], Dear (2014) [7], Ayodhya *et al.* (2013) [3], Vieson *et al.* (2012) [26] and Peeters *et al.* (2000) [19]. Whenever the causative organisms enter in to the respiratory tract by inhalation, they invade the mucosal layer and multiply in the epithelium. As a result of this different types of inflammatory mediators, bacterial toxins and enzymes release and lead to inflammation and copious exudates production as well as a rise of body temperature. There is a loss of mucociliary movement because of the destruction of respiratory epithelium and followed by sloughing off. In the later stage, necrotic material oozes out with a mucopurulent consistency (Baron, 1996) [4]. Finally, to evacuate the exudates from the tract cough is generated in the affected dogs.

In the current study, different bacteria were isolated from the samples and similar observations were also recorded by various researchers Menard *et al.* (2022) [14], Moon *et al.* (2022) [15], Elgalfy *et al.* (2022) [8], Yadav *et al*. (2020) [28], Ayodhya *et al.* (2013) [3], Moonsun *et al.* (2004) [16], Moyaert *et al.* (2019) [17] and Köse *et al.* (2021) [11]. *Staphylococcus* spp., *Escherichia coli* and *Bacillus* spp. are present as a normal flora in the respiratory tract in the dog according to Ajuwape *et al.* (2006) [1]. Due to immunodeficiency or other stress factor organisms may flare up and leads to respiratory tract infection in dogs as mentioned by Lappin *et al*. (2017) [12]. *Pseudomonas* spp. and *Klebsiella pneumoniae are* gram negative opportunistic bacteria in dogs. Infections mainly develop when the animal is immune compromised or normal barriers are breached as described by Nielsen *et al*. (2022) [18] and Zhang *et al.* (2022) [29].

In the recent study, *Staphylococcus* spp. isolates were sensitive to Ceftriaxone (100.00%) followed by other antibiotics *in-vitro* antibiotic sensitivity test. These observations were in accordance with Moyaert *et al.* (2019) [17], Yadav *et al.* (2019) [27] and Rheinwald *et al.* (2015) [23]. *Klebsiella pneumoniae* isolates were sensitive to Ceftriaxone (90.91%) followed by other antibiotics and these observations were in accordance with Köse *et al.* (2021) [11] and Yadav *et al.* (2019) [27]. The present finding revealed *Escherichia coli* had the highest sensitivity towards Doxycycline (62.50%) followed by Enrofloxacin, Ceftriaxone and Gentamicin. Similar observations were also recorded by Moyaert *et al.* (2019) [17], Yadav *et al.* (2019) [27] and Rheinwald *et al.* (2015) [23]. *Pseudomonas* spp. was found to be 100.00% sensitivity to Ceftriaxone, Doxycycline, Enrofloxacin and Ceftriaxone potentiated with tazobactam and 50.00% sensitivity to Gentamicin. These observations were in accordance with Yadav *et al.* (2019) [27] and Rheinwald *et al.* (2015) [23]. *Bacillus* spp. isolates were highest sensitive to Doxycycline and Ceftriaxone followed by Enrofloxacin and resistant to Ceftriaxone potentiated with tazobactam, Gentamicin and Amoxicillin potentiated with clavulanic acid. These findings were similar to Yadav *et al.* (2019) [27]. High and moderate level of resistance was exhibited by the isolates to Amoxicillin potentiated with clavulanic acid, Ceftriaxone potentiated with tazobactam and Gentamicin in the present study might be due to indiscriminate and over use of antibiotics in the treatment of animal (Mavrides *et al.*, 2021) [13].

Three groups of dogs, Groups B, C and D comprising 10 dogs in each group were treated with Doxycycline hydrochloride, Enrofloxacin and Ceftriaxone sodium respectively along with supportive therapy. A similar report on the administration of antibiotic therapy in bacteria associated respiratory tract infection was made by Lappin *et al*. (2017) [12]. The antibiotic therapy should be chosen based on antimicrobial susceptibility tests (Vieson *et al.*, 2012) [26]. Carbone *et al.* (2001) [5] reported that the clinical efficacy of different antibiotics may vary from *in-vitro* antibiotic sensitivity test results.

Conclusion

The most common clinical sign observed was moist cough (90.00%). *Staphylococcus* spp. concurrently with *Escherichia coli* (30.00%) were common isolates. In *in-vitro* antibiotic sensitivity test *Staphylococcus* spp., *Klebsiella pneumoniae*, *Pseudomonas* spp. and *Bacillus* spp. showed highest sensitive to Ceftriaxone. *Escherichia coli* and *Bacillus* spp. showed highest sensitive to Doxycycline. Ceftriaxone sodium was found 100.00% effective followed by Doxycycline hydrochloride and Enrofloxacin (90.00%).

Acknowledgement

The acknowledge HOD of the department of Veterinary Clinical Medicine, Ethics and Jurisprudence, College of Veterinary Science, Assam Agricultural University, Khanapara, Guwahati for furnishing facilities which help in successfully completion of research work and there is no conflict of interest related to the work.

References

1. Ajuwape ATP, Oyebanji MO, Adetosoye AI. Bacteriological examination of normal upper respiratory tract of puppies with particular reference to Staphylococci. Veterinarski Arhiv. 2006;76(2):179-184.
2. Arsevska E, Priestnall SL, Singleton DA, Jones PH, Smyth S, Brant B, *et al.* Small animal disease surveillance: respiratory disease. Veterinary Record. 2018;182 (13):369-373.
3. Ayodhya S, Rao DST, Reddy YN, Sundar NS, Kumar VG. Isolation and characterization of bacteria from canine respiratory diseases in and around Hyderabad city, Andhra Pradesh, India. Veterinary World. 2013;6(9): 601-604.
4. Baron S. Infections of the Respiratory System. Chapter 93, Medical Microbiology. 4th edition. Galveston (TX): University of Texas Medical Branch at Galvestone; c1996. https://www.ncbi.nlm.nih.gov/books/NBK8142.
5. Carbone M, Pennisi MG, Masucci M, De Sarro A, Giannone M, Fera MT. Activity and post antibiotic effect of marbofloxacin, enrofloxacin, difloxacin and ciprofloxacin against feline *Bordetella bronchiseptica* isolates. Vet Microbiol. 2001;8(1):79-84.
6. Clinical and laboratory standard institute guidelines. Antibiotic Sensitivity test. 2022;7(1):1-21.
7. Dear JD. Bacterial Pneumonia in Dogs and Cats. Veterinary Clinics: Small Animal Practice. 2014;44(1):143-159.
8. Elgalfy GE, Abd-El-Raof YM, Ghanem MM, El-Khaiat HM. Clinical, Hematological, Acute phase proteins and Radiographic changes in different respiratory affections in dogs and cats. Benha Veterinary Medical Journal. 2022;42:80-85.
9. Ellis JA, Gow SP, Waldner CL, Shields S, Wappel S, Bowers A, Lacoste S, *et al*. Comparative efficacy of intranasal and oral vaccines against *Bordetella bronchiseptica* in dogs. The Veterinary Journal. 2016;212:71-77.
10. Freedman A, Wayne RK. Deciphering, the Origin of Dogs: From Fossils to Genomes. Annu. Rev. Anim. Biosci. 2017;5:281-307.
11. Köse SI, Maden M, Sayin Z. Clinical and bacteriological analysis of respiratory tract infections in sheltered dogs and determination of antibacterial treatment options. J Hellanic. Vet Med Soc. 2021;72(4): 3491-3502.
12. Lappin MR, Blondeau J, Boothe D, Breitschwerdt EB, Guardabassi L, Lloyd DH, et al. Antimicrobial Use Guidelines for Treatment of Respiratory Tract Disease in Dogs and Cats: Antimicrobial Guidelines Working Group of the International Society for Companion Animal Infectious Diseases. Journal of Veterinary Internal Medicine. 2017;31(2):279-294.
13. Mavrides DE, Morgan AL, Na JG, Graham PA, McHugh TD. Antimicrobial resistance profiles of bacteria associated with lower respiratory tract infections in cats and dogs in England. Veterinary Record. 2021;190(4):e779. DOI: 10.1002/vetr.779.

14. Menard J, Porter I, Lerer A, Robbins S, Johnson PJ, Goggs R. Serial evaluation of thoracic radiographs and acute phase proteins in dogs with pneumonia. Journal of Veterinary Internal Medicine. 2022;36(4):1430-1443.
15. Moon DC, Choi JH, Boby N, Kang HY, Kim SJ, Song HJ, *et al*. Bacterial Prevalence in Skin, Urine, Diarrheal stool and Respiratory Samples From Dogs. Microorganisms. 2022;10(8):1668.
16. Moonsun K, Jongtae J, Taeyoung K, Youngmin Y, Jumyeong L, Dusik L, *et al*. Antibiotic resistance of bacterial isolates from nasal discharges of dogs with respiratory diseases. Journal of Veterinary Clinics. 2004;21(2):133-139.
17. Moyaert H, Jong AD, Simjee S, Rose M, Youals M, Garch FE, *et al*. Survey of antimicrobial susceptibility of bacterial pathogens isolated from dogs and cats with respiratory tract infections in Europe: Com Path. Journal of Applied Microbiology. 2019;127:29-46.
18. Nielsen SS, Bicout DJ, Calistri P, Canali E, Drewe JA, Garin-Bastuji B, et al. Assessment of listing and categorization of animal diseases within the framework of the Animal Health Law Regulation (EU No 2016/429): antimicrobial-resistant *Pseudomonas aeruginosa* in dogs and cats. European Food Safety Authority journal. 2022;20(5):e07310. DOI: 10.2903/j.efsa.2022.7310.
19. Peeters DE, Mckiernan BC, Weisiger RM, Schaeffer DJ, Clercx C. Quantitative Bacterial Cultures and Cytological Examination of Bronchoalveolar Lavage Specimens in Dogs. J Vet. Intern. Med. 2000;14:534-541. DOI: https://doi.org/10.1111/j.1939-1676.2000.tb02272.x.
20. Pescini SM, Schaebs FS, Gaugg A, Meinert A, Deschner T, Range F. The Role of Oxytocin in the Dog-Owner Relationship. Animals. 2019;9(10):792.
21. Qekwana DN, Naidoo V, Oguttu JW, Odoi A. Occurrence and Predictors of Bacterial Respiratory Tract Infections and Antimicrobial Resistance Among Isolates From Dog Presented With Lower Respiratory Tract Infections at a Referral Veterinary Hospital in South Africa. Frontiers in Veterinary Science. 2020;7:304.
22. Quinn PJ, Markey BK, Leonard FC, Fitzpatrick ES, Fanning S, Hartigan PJ. Pathogenic Bacteria, Veterinary Microbiology and Microbial Disease. 2nd Ed; c2011. p. 179-405.
23. Rheinwald M, Hartmann K, Hähner M, Wolf G, Straubinger RK, Schulz B. Antibiotic susceptibility of bacterial isolates from 502 dogs with respiratory signs. Veterinary Record. 2015;176(14):357-357.
24. Sanchez-Viscaino F, Daly JM, Jones PH, Dawson S, Gaskell R, Menacere T, et al. Small animal disease surveillance: respiratory disease. Veterinary Record. 2016;178(15):361-364.
25. Vientòs-plotts AI, Masseau I, Reinero CR. Comparison of Short-Versus Long-Course Antimicrobial Therapy of Uncomplicated Bacterial Pneumonia in Dogs: A Double-Blinded, Placebo-Controlled Pilot Study. Animals. 2021;11(11): 3096.
26. Vieson MD, Pineyro P, LeRoith T. A review of the pathology and treatment of canine respiratory infections. Vet Med (Auckl). 2012;3:25-39.
27. Yadav N, Rana YS, Charya G, Agnihotri D. Antibiogram of bacterial isolates associated with respiratory infection in dogs. Indian J Vet. Med. 2019;39:11-17.
28. Yadav N, Rana YS, Charya G, Jain VK, Agnihotri D. Isolation of Bacterial Pathogens Associated With Canine Respiratory Disease. Haryana Vet. 2020;59(1):51-54.
29. Zhang Z, Zhang L, Dai H, Zhang H, Song Y, An Q, et al. Multidrug-Resistant *Klebsiella pneuoniae* complex from clinical dogs and cats in China: Molecular Characteristics, Phylogroups and Hypervirulence-Associated Determinants. Front. Vet. Sci. 2022;9:816415.
DOI: https://doi.org/10.3389/fvets.2022.