

Bioaerosols and their risks to environmental health in a pet shop

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ABSTRACT

Research carried out in pet stores has indicated microbiological contamination of the air through exposure to bioaerosols. This study aimed to analyze the presence of microorganisms in bioaerosols from a pet shop in Fernandópolis/SP. Air samples were collected on November 21, 23, and 25, 2022, by exposing Petri dishes containing culture media, open for 30 min at 1.5 m from the floor in the central part of the workroom, before, during, and after dog bathing, grooming, and drying procedures. The dishes were incubated at 37 °C for 24–48h for the growth of bacteria and yeasts, after which colony-forming units were counted and identified using conventional biochemical methods. The microbial community during the bathing and grooming of animals was quantitatively higher and qualitatively different from that at the beginning and end of the procedure, a fact that was repeated on the three days of analysis. The results indicated resistance of *Staphylococcus aureus* to the antibiotics ceftazidime, tobramycin, penicillin, oxacillin, and erythromycin higher than 80% and 100% sensitive to amikacin. Therefore, bioaerosols from the evaluated pet shop present high contamination by microorganisms (*Candida albicans*, *Staphylococcus aureus*, *Micrococcus* sp., *Bacillus* sp., and *Escherichia coli*) produced mainly during bathing, grooming, and drying of dogs, which raises concerns regarding the risk of disease transmission by these pathogens to the animals and humans who are on site and under direct contact with bioaerosols and work equipment.

KEYWORDS: Microorganisms. Contamination. Air quality. Veterinary clinic.

1. INTRODUCTION

Bioaerosols or biological contaminants are microparticles suspended in the air, composed of living animal or vegetable microorganisms. These biological pollutants consist of bacteria, viruses, fungi, parasites, arthropods, pollen, algae, and mites or substances derived from them, which invade the human and animal body via the air, oral, and transcutaneous routes, and can be harmful to health, with great capacity to remain suspended in the air for long periods (SIVAGNANASUNDARAM et al., 2019).

According to Decree No. 40,400/95 of the State of São Paulo, a pet shop is a store whose purpose is to sell animals and products for veterinary use and provide services to pets, such as grooming and bathing (BRASIL, 1995). Moreover, they must have the minimum facilities necessary for operation, such as impermeable surfaces, space for grooming, bathing, drying, and styling, and space to house animals intended for sale, separate from other facilities, among others. Importantly, the application of vaccines and exams must be carried out in the veterinary office.

The presence of bioaerosols in pet shops can be attributed to other infected animals that transmit these contaminants through the air. Transmission generally occurs when microbial pathogens are passed from an infected animal to another vulnerable animal through salivation, licking, sneezing, and barking, among others (SETLHARE et al., 2014). These microorganisms are capable of affecting the health of store employees and customers and can also result in disease outbreaks among pets.

Bioaerosols have been studied to determine the sources of contamination of epidemic diseases, as their inhalation is related to infectious diseases, allergies, cancer, and acute poisoning, which makes them a possible weapon for bioterrorism. The particles that make up aerosols can deposit in different parts of the respiratory system. The microbial load of these particles in closed environments, such as hospitals, is influenced by the number of occupants, nature, degree of activity, ventilation, and other environmental factors (VANETTI et al., 2020).

Regular monitoring of bioaerosols in the internal environments of pet shops due to the high concentrations of bacteria and fungi that can be pathogenic is recommended to minimize the airborne transmission of opportunistic microorganisms and their major impact on animals. Microbiological analyses are necessary to determine the possibility of the existence of causes or sources of contaminants that are difficult to detect (PAGALILAUAN; PARAOAN; VITAL 2018). However, most epidemiological evidence on sensitization/allergy in relation to exposure to dog and cat allergens requires further evaluation.

The environment of veterinary institutions and the performance of duties by veterinarians or employees in pet shops are related to exposure to harmful biological agents (GRZYB; PAWLAK, 2021). Especially direct contact between veterinarians and sick animals is associated with the risk of biological contamination. In veterinary practice, not only animals are sources of contamination by microorganisms but also people or components of the internal environment.

The literature has some studies available describing the problem of microbiological air contamination in small animal veterinary clinics, veterinary hospitals, and pet shops, with an average fungal aerosol concentration of 700 to 8,068 CFU m⁻³ (BULSKI; FRACZEK, 2021).

People who work in this type of environment are more frequently exposed to dermatological diseases caused by *Microsporum* sp., *Trichophyton* sp., and *Blastomyces dermatitidis* (WEESE; PEREGRINE; ARMSTRONG, 2002). These and other microorganisms not only harm the health of store employees and customers but can also result in disease outbreaks among pets.

There are numerous proposals for determining maximum acceptable values (MAV) or sets of values that classify environmental conditions in terms of epidemiological markers (fungi and bacteria) through standards or norms, indicated by government agencies or even research projects, professional experience, or scientific consensus. However, these proposals are not uniform, suggesting the possibility of variations resulting from macrogeographic, climate, and even socioeconomic and technological variables (RAO; BURGE; CHANG, 1996).

In Brazil, the National Environment Council, through Resolution No. 3, of June 1990, establishes air quality standards in external environments, which could affect the health, safety, and well-being of the population if exceeded. Regarding inhalable particles, primary and secondary standards have an average annual concentration of 50 mg m⁻³ and a concentration of 150 g m⁻³ day⁻¹, which should not be exceeded more than once a year (BRASIL, 1990). The levels of biological contaminants in indoor air, which vary enormously depending on time and space, have no widely accepted methods and standards in Brazil.

In this context, this study aimed to analyze the presence of microorganisms in bioaerosols from a pet shop in Fernandópolis/SP. We sought to evaluate the hypothesis that the composition of the cultivable community of bacteria and yeasts in bioaerosols varies before, during, and after dog bathing, grooming, and drying procedures, with a growing increase in abundance from the beginning to the end of the procedures.

2 METHODOLOGY

This is a qualitative-quantitative analytical study of an applied nature to generate knowledge about bioaerosols inside a dog bathing, grooming, and drying room in a pet shop to quantify and identify the microorganisms present and their respective resistance to antimicrobials.

The research was carried out on the 21st, 23rd, and 25th of November 2022 in a pet shop located in the municipality of Fernandópolis/SP. The passive sedimentation technique described by Kalwasińska, Burkowska, and Wilk (2012) and Hayleeyesus and Manaye (2014) was used to capture air samples from the bathing and grooming room. Petri dishes with different culture media, namely tryptone soya agar (TSA, OXOID®) and eosin-methylene blue (EMB, OXOID®) for the cultivation of bacteria and Sabouraud dextrose agar (SAB, OXOID®) for yeasts, were opened in the central part of the room at a height of 1.5 m from the floor for 30 min. This procedure was carried out before, during, and after bathing, grooming, and drying dogs on the three described dates. Sampling was carried out in duplicate.

The dishes were capped, identified by date and culture medium, and packaged separately to avoid possible cross-contamination. They were safely transported to the Laboratory of Microbiology of a university in isothermal boxes containing ice to maintain an internal temperature of 10 °C.

The dishes were incubated at 37 °C for 24-48 hours for bacteria. Counting was carried out after this period with a manual counter and the characteristics of the colonies were evaluated relative to shape, size, and color. The gram-staining methodology was used to identify gram-positive and gram-negative bacteria that developed in the medium.

A colony was taken and inoculated in a 4% Sabouraud dextrose agar slant tube (yeasts) and nutrient agar (bacteria) to obtain pure cultures.

Once the pure cultures were obtained, the gram-negative bacterial species were characterized using the Api 20E system to identify enterobacteria, while the catalase, coagulase, DNase, oxidase, and hemolysis tests were performed to characterize the gram-positive bacterial species.

Macroscopic and microscopic morphological characteristics were used to identify the yeasts. The evaluation of results followed the reference standards of Resolution RE No. 09, of 01/16/2003 (BRASIL, 2003).

The modified Kirby Bauer method was used to assess the in vitro antimicrobial susceptibility, as recommended by the Clinical Laboratory Standard Institute – CLSI (CLSI, 2020). Dishes containing Mueller-Hinton agar were previously inoculated with the individually isolated bacterial suspension and discs impregnated with antimicrobials were distributed on the surface. The dishes were incubated at 37 ± 1 °C for 24 hours. The following antimicrobials were evaluated: gentamicin, sulfamethoxazole/trimethoprim, chloramphenicol, ceftazidime, ampicillin, amikacin, tobramycin, tetracycline, ciprofloxacin, vancomycin, penicillin, oxacillin, cephalothin, erythromycin, and clindamycin. The results were interpreted according to protocols established by CLSI (CLSI, 2022).

The obtained data was compiled into a spreadsheet in Microsoft Excel® format filled with the identification of the microorganisms, the community composition, and the count of colony-forming units (CFU). These results allowed performing the occurrence analysis of each of the identified microorganisms according to the day and moment of evaluation. The relevance of

this approach was to observe whether there were significant differences in the quantity and identity of different microorganisms relative to the day and time of collection.

Descriptive statistics (mean, standard deviation, and median), the Kruskal-Wallis test, and principal component analysis (PCA) (multivariate approach) were used to verify the relationship between the day, times of collection, and types of microorganisms. PCA was performed using the CANOCO 5.0 software (Biometrics, Wageningen, NL). Analysis of similarity (ANOSIM) was performed with the PRIMER 6.0 program (Plymouth Marine Laboratory, Primer E, UK) to evaluate the similarity of groups revealed by cluster analysis from the count and community composition data.

3 RESULTS AND DISCUSSION

Table 1 shows the percentage of occurrence of microorganisms at different times of collection, that is, at the beginning of the working day (BW), during bathing, grooming, and drying (DBG), and at the end of the working day (EW) in three days of evaluation.

The microorganism *Staphylococcus aureus* showed the highest occurrence at all collection times and evaluation days, except for day 1 in BW, when *Candida albicans* stood out over the others. Still in absolute terms, the number of microorganisms present in DBG and EW bioaerosols was higher than in BW, as well as on the third day of evaluation, when there was a large increase in environmental contamination by *Staphylococcus aureus* compared to the first and second days (Table 1).

Table 1 – Percentage of occurrence of microorganisms identified at different times during the working hours and evaluation days of a pet shop.

Microorganism	DAY 1					
	(BW)		(DBG)		(EW)	
	N	%	N	%	N	%
<i>Candida albicans</i>	36,000	98.9	334,667	12.8	306,683	12
<i>Escherichia coli</i>	0	0.0	3,200	0.1	3,218	0.1
<i>Staphylococcus aureus</i>	210	0.6	2,266,743	86.9	2,233,553	87.7
<i>Bacillus</i> sp.	170	0.5	3,187	0.1	3,338	0.1
<i>Micrococcus</i> sp.	0.0	0.0	2,967	0.1	2,567	0.1
Microorganism	DAY 2					
	(BW)		(DBG)		(EW)	
	N	%	N	%	N	%
<i>Candida albicans</i>	0.0	0.0	866,667	35	866,733	38
<i>Escherichia coli</i>	0.0	0.0	320	0.01	422	0.02
<i>Staphylococcus aureus</i>	1,667	67.9	1,633,767	65	1,433,383	62
<i>Bacillus</i> sp.	773	31.5	1,867	0.1	1,870	0.08
<i>Micrococcus</i> sp.	14	0.6	1,172	0.05	867	0.04
Microorganism	DAY 3					
	(BW)		(DBG)		(EW)	
	N	%	N	%	N	%
<i>Candida albicans</i>	420	11.5	366,777	0.846	293,413	0.676
<i>Escherichia coli</i>	5	0.1	645	0.002	610	0.002
<i>Staphylococcus aureus</i>	3,233	88.4	43,668,333	99.15	43,333,967	99.32
<i>Bacillus</i> sp.	0.0	0.0	280	0.001	227	0.001
<i>Micrococcus</i> sp.	0.0	0.0	337	0.001	280	0.001

N – Number (m^{-3}).

Source: The authors.

Hospital environments and places where there is intense animal traffic, such as exhibitions, pet shops, fairs, and animal shelters, are important sources of infections for a wide variety of microorganisms, which can be responsible for superficial and systemic infectious diseases (PANAGOPOULOU et al., 2002), and studies have shown that pet stores have a high concentration of bioaerosols (LU et al., 2018).

In this experiment, the air of pet shops showed high contamination by microorganisms, with *Staphylococcus aureus* being the bacteria with the highest occurrence in the three collection times and evaluation days. The presence of microorganisms was higher in DBG and EW, probably due to the handling of animals during grooming, bathing, and drying their hair, exposing microorganisms, and increasing the concentration of contaminants in bioaerosols (Table 1).

The presence of microorganisms in bioaerosols in pet shops is considered common due to the large flow of animals, which have bacteria, such as staphylococci and streptococci, among others, naturally resident on their skin and hair (TEIXEIRA; BARBOZA; PEREIRA, 2019). However, one must be alert, as gram-positive bacteria, mainly *S. aureus*, may be related to the proliferation of diseases such as pneumonia, endocarditis, erysipelas, impetigo, and boils, among other infectious diseases (ENGELKIRK; DUBEN-ENGELKIRK; BURTON, 2012).

Exposure to biological agents has been the subject of investigations that aim to correlate the impact on health with the type of occupational environment under study. Many of the organisms transported through the air flow are parasites and trivially inhabit the surface of the skin, and can be transported to nearby areas, promoting the phenomenon of cross-contamination (CLARK; CALCINA-GOFF, 2009).

Table 2 shows descriptive statistics related to the results of the occurrence of microorganisms present in the pet shop relative to the time of business and the day of evaluation. The results indicate that there were no significant differences in the quantification of each microorganism regarding the day of evaluation, as all *p*-values were higher than the test significance level, except for *Bacillus* sp. values ($p = 0.02$), which showed less contamination on day 3.

In this context, there were no significant differences regarding microbial contamination on the different days of analysis, that is, contamination occurs regardless of the working day, and there is no cumulative effect of the occurrence of microorganisms.

In turn, the Kruskal-Wallis test indicated significant differences for all microorganisms at the time of the working day in which the evaluation was carried out ($p < 0.01$), with bathing, grooming, and drying (DBG) showing the highest values. Grooming instruments in a veterinary clinic and pet shop environments are known to be the most shared and least sanitized equipment in the range of use between individuals (TEIXEIRA; BARBOZA; PEREIRA, 2019). In addition, the use of dryers, brushes, and the animals' movement, salivation, sneezing, and barking end up exposing microorganisms to the air, increasing the concentration of bioaerosols.

Table 2 – Descriptive statistics of the occurrence of different microorganisms at different times during the working day and day of evaluation in a pet shop.

Microorganism	Day	Beginning of the working day		During bathing and grooming		End of the working day		p-value
		Mean±SD	Md	Mean±SD	Md	Mean±SD	Md	
Bacillus sp.	1	170±17	160	3,187±2,629	4900	5,000±141	14	0.02
Bacillus sp.	2	773±142	800	1,867±839	2400	2,800±3,300	10	
Bacillus sp.	3	0.0±0.0	0.0	280±255	340	227±113	0.0	
p-value		<0.01						
C. albicans	1	36,000±14,731	44,000	334,667±254,883	440,000	460,000±84,853	40	0.61
C. albicans	2	0.0±0.0	0.0	866,667±750,555	1,300,000	866,733±433,463	195	
C. albicans	3	420±82	440	366,777±335,875	440,000	293,413±146,827	240	
p-value		<0.01						
E. coli	1	0.0±0.0	0.0	3,200±3,020	3,600	4,800±1,697	21	0.85
E. coli	2	0.0±0.0	0.0	320±315	600	615±600	27	
E. coli	3	5±0.2	5	645±554	950	910±870	11	
p-value		<0.01						
Micrococcus sp.	1	0.0±0.0	0.0	2,967±2,815	4,400	2,567±2,290	0.0	0.50
Micrococcus sp.	2	14±3.8	16	1,172±1,142	1,400	867±467	0.0	
Micrococcus sp.	3	0.0±0.0	0.0	337±292	500	280±113	0.0	
p-value		<0.01						
S. aureus	1	210±20	210	2,266,743±2,802,287	5,300,000	2,233,553±2,746,245	700	0.10
S. aureus	2	1,667±473	1,500	1,633,767±1,456,438	2,200,000	1,433,383±733,420	130	
S. aureus	3	3,233±1,980	2,500	43,668,333±37,816,861	65,000,000	43,333,967±21,668,000	2,000	
p-value		<0.01						

Source: Research data.

The Kruskal-Wallis test also indicated that the number of each of the microorganisms evaluated in the air samples from this pet shop showed no significant differences relative to the day of evaluation, except for *Bacillus* sp., that is, contamination occurs regardless of the working day, with no cumulative effect of microorganisms. However, a significant increase in the number of microorganisms was observed during the DBG period.

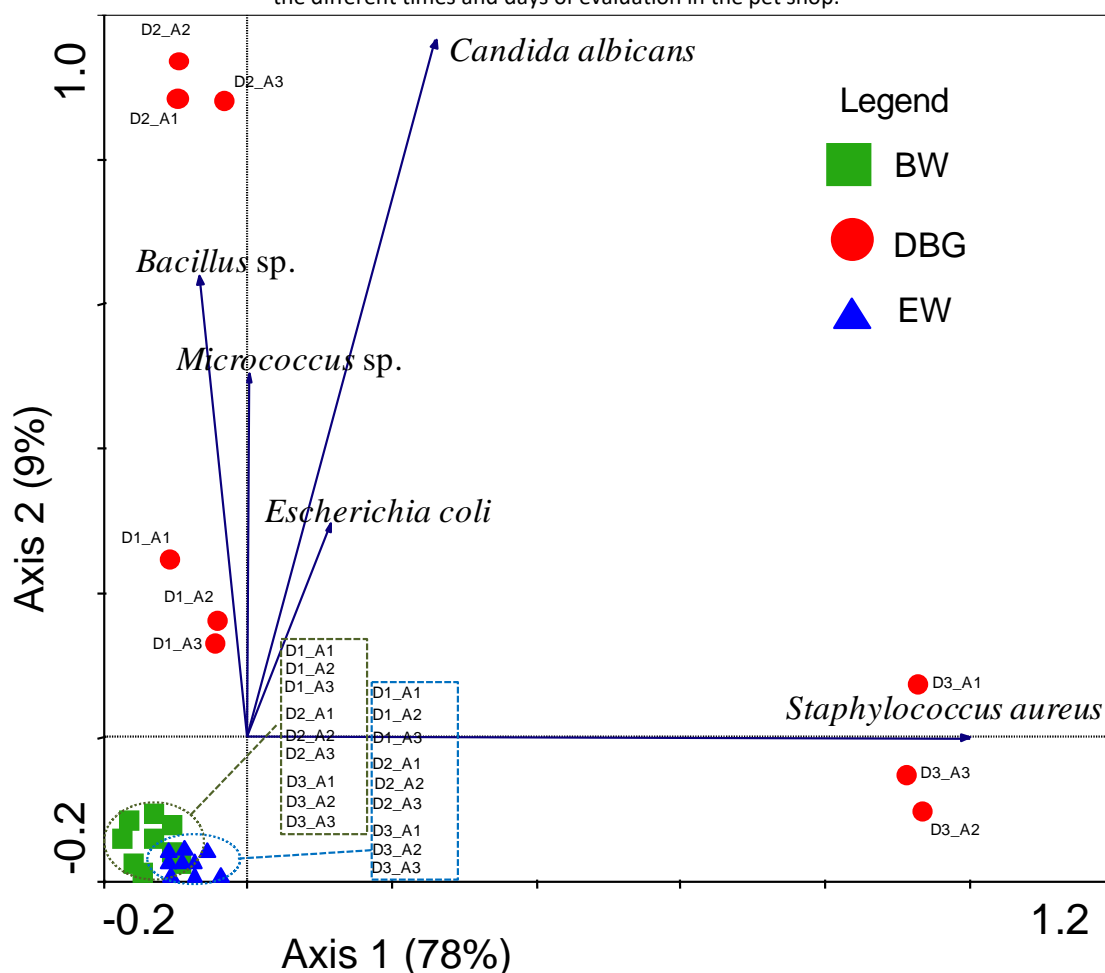
Surface moisture and ambient temperature favor the development of pathogenic microorganisms. Animal grooming machines, bathtubs, towels, and sponges allow the fixation of liquids, microorganisms, and mites, which can be transmitted from one animal to another if there is no correct and frequent cleaning (COELHO et al., 2010). The devices may remain damp even after cleaning. Cases in which there are clusters of bacteria in these areas may stimulate the biofilm formation process as a form of survival, making them more resistant to sanitization or disinfection due to the generated extracellular matrix (KASNOWSKI et al., 2010).

Poorly maintained artificial ventilation systems may elevate the concentration of microorganisms in the environment, while natural ventilation plays a crucial role by inducing an air dilution effect, effectively lowering the microbial load (STOCKWELL et al., 2019). The filters of refrigeration devices in hospital rooms retain bioaerosols together with humidity, favoring microbial proliferation and the formation of biofilms, constituting a continuous source of contamination (AFONSO et al., 2004). Furthermore, there is low air renewal in hospitals, increasing the number of viral particles by up to 100,000 times. Nebulizers and humidifiers used in the hospital environment can also be sources of pathogens, as well as the surfaces of sinks, drains, and washbasins, which have the potential for bacterial growth after contamination by the deposition of bioaerosols (SILVA, 2013).

Thus, a multivariate approach is appropriate, as it systematically analyzes the data with precision and conciseness. Principal component analysis (PCA) aims to analyze interrelationships between the numerous variables collected. In this study, we examined the correlation between the presence of various microorganisms and the specific days and times during the working days. The aim was to derive insights into the stages of dog bathing that were more likely to exhibit higher or lower occurrences of specific microorganisms or groups of microorganisms.

PCA revealed that the microbial community recovered by the culture-dependent approach was similar before (BW) and after dog bathing and grooming, that is, in EW, but differed from that recovered during bathing and grooming (DBG). This difference was revealed for the three sampling days (Figure 1).

Figure 1 – Principal component analysis (PCA) showing the relationship between the identified microorganisms and the different times and days of evaluation in the pet shop.



Source: Research data.

In this study, given the extensive array of collected variables, a multivariate approach was employed to comprehensively explore and analyze their interrelationships. This approach revealed that the microbial community in DBG differs significantly from those in BW and EW consistently across all three days of sampling. These findings suggest a dynamic capability of the

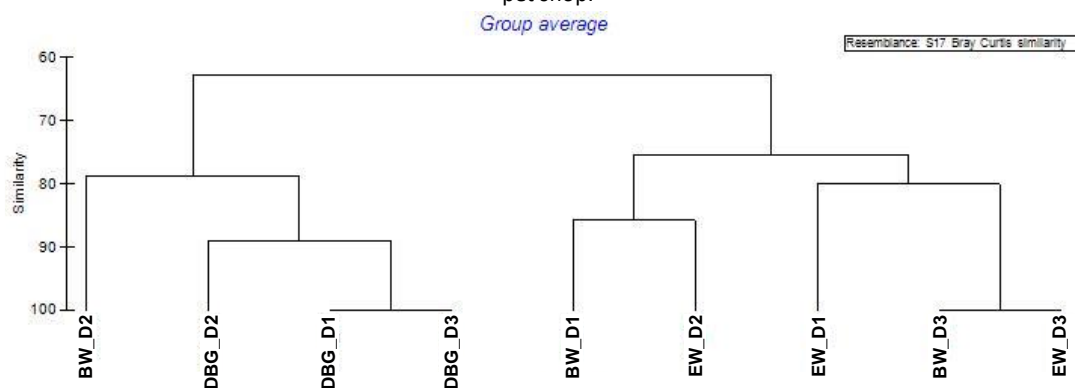
microbial community to vary, depending on the diverse animals served in the commercial establishment.

Similarity analysis between the microbial communities recovered on the surface of the culture medium arranged in the Petri dish was also performed. The results revealed separate groups for communities in BW and DBG ($R = 0.967$), as well as for DBG and EW ($R = 1.0$), but with overlap for communities recovered in BW and EW ($R = 0.253$). This result confirms the grouping in the PCA ordering space and reinforces that the microbial community in the pet shop room during the bathing and grooming procedure involving dogs is quantitatively altered, returning to a condition similar to the initial one after the end of the working day.

From a qualitative perspective—relying on identification data of microorganisms retrieved from the cultivation medium on Petri dishes positioned at the center of the pet shop’s bathing and grooming room—the microbial community composition exhibited distinctions between DBG and EW ($R = 0.593$). However, similarities were observed between BW and DBG ($R = 0.148$).

The dendrogram illustrates this result of the similarity analysis, with the microbial community in BW on the second day of sampling clustered close to the DBG-revealed communities (Figure 2).

Figure 2 – Clustering dendrogram relative to the days and times of the microbiological analysis of air quality in the pet shop.



Source: Research data.

Studies have shown that the accumulation of microorganisms is particularly serious in the internal environments of pet shops due to the housing, treatment, and hygiene of animals (LEHTONEN; REPONEN; NEVALAINEN, 1993; ACGIH, 1999). These microorganisms not only harm the health of store employees and customers but can also result in disease outbreaks among pets.

Bulski and Fraczek (2021) evaluated the mycological air quality in a veterinary clinic in Krakow during the summer of 2017. The highest fungal aerosol concentration was observed in the treatment room five hours after the veterinary practice opened. The analysis of the bioaerosol particle distribution showed that fungi isolated from the air can reach the throat, trachea, and primary bronchi regions in the human respiratory tract, with *Penicillium* and *Cladosporium cladosporioides* predominant, in addition to *Microsporum canis* and *Trichophyton verrucosum*, which can cause dermatophytosis.

Certain fungi and bacteria have the potential to cause severe and even fatal infections when inhaled. Due to their ability to be easily dispersed through the air and dust particles, it is crucial to conduct microbiological monitoring of the air and implement control measures during renovation activities within enclosed hospital environments. *Staphylococcus aureus* exemplifies a pathogenic bacterium capable of airborne transmission through dust (SILVA et al., 2002). This study revealed a notable incidence of *Staphylococcus aureus*.

According to Renström et al. (2011), one-third of pet shop workers in Sweden reported airway symptoms at work or were sensitized to allergens. Therefore, increasing awareness of potential health risks, implementing effective allergen prevention measures, and developing rigorous disinfection protocols to promote the overall well-being of pet shop employees and customers are essential.

Occupational exposure to cats and dogs can cause respiratory symptoms in veterinarians (SUSITAIVAL et al., 2003), and their prolonged exposure can be a health risk, also causing allergic problems or dermatophytosis. Proper maintenance of the environment where animals remain, with disinfection and sterilization procedures, is adequate to protect people from diseases caused by biological factors. Furthermore, a high-performance mechanical ventilation system or an air-conditioning system with adequate microbiological control must be introduced to ensure air quality. Monitoring air quality is also very important for evaluating exposure to potentially pathogenic microorganisms (BULSKI; FRACZEK, 2021).

Lu et al. (2018) assessed the efficacy of disinfection using gaseous chlorine dioxide on the air quality within a pet shop in Taiwan. Their findings led to the conclusion that this method proved beneficial in safeguarding the health of both employees and visitors, as well as the well-being of the animals.

Finally, an antibiogram was carried out in this experiment to evaluate the resistance or sensitivity of *Staphylococcus aureus* to certain antibiotics. The choice of antibiotics followed the routine standards of the laboratory of microbiology (Chart 1).

Chart 1 – Antibiogram of *Staphylococcus aureus*.

Antibacterial	DAY 1						DAY 2						DAY 3						% resistance
	BW		DBG		EW		BW		DBG		EW		BW		DBG		EW		
	1*	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
Gentamicin	R	S	R	R	S	S	S	R	S	S	S	S	S	S	R	S	S	S	27.8
Sulfamethoxazole/trimethoprim	S	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	11.1
Chloramphenicol	S	S	R	R	R	S	R	R	R	R	S	S	R	S	R	S	R	R	61.1
Ceftazidime	R	R	R	S	R	S	R	R	R	R	R	R	R	R	R	R	R	R	88.9
Ampicillin	S	R	R	S	S	S	S	S	R	R	R	S	R	S	R	S	R	R	50.0
Amikacin	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	0.0
Tobramycin	R	S	R	R	R	R	R	R	R	R	R	S	R	S	R	R	R	R	83.3
Tetracycline	R	R	R	R	R	R	S	R	R	R	S	S	S	S	R	R	R	S	66.7
Ciprofloxacin	S	S	R	R	R	R	S	R	R	R	R	S	S	S	R	R	S	S	55.5
Vancomycin	R	R	R	R	R	S	S	R	R	R	R	S	R	S	R	R	R	R	77.8
Penicillin	R	R	R	R	R	S	S	R	R	R	R	S	R	R	R	R	R	R	83.3
Oxacillin	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	100
Cephalothin	S	S	S	S	S	R	R	S	R	R	S	S	S	S	S	S	S	S	22.2
Erythromycin	R	S	R	R	R	S	R	R	R	R	R	R	R	S	R	R	R	R	83.3
Clindamycin	S	S	R	R	R	S	S	R	R	R	S	S	R	S	R	S	S	R	50.0

*R: resistant S: sensitive.

Source: Research data.

The results showed the percentages of *S. aureus* resistant to the studied antibiotics according to the time of working day and collection day, indicating a resistance of more than 80% to the antibiotics ceftazidime, tobramycin, penicillin, oxacillin, and erythromycin, and 100% sensitivity to amikacin.

In general, the days and times of evaluation did not affect the resistance/sensitivity of *S. aureus* to different antibiotics.

Therefore, this case study opens up space for the evaluation of other pet shops at other times of the year.

Finally, increasing awareness of potential health risks and effective measures to avoid allergens among pet shop employees and developing rigorous disinfection protocols to promote the general well-being of both employees and store customers are essential.

The National Institute for Occupational Safety and Health of America and the American Conference of Governmental Industrial Hygienists (ACGIH) have determined that the total number of indoor bioaerosol particles should not exceed 1,000 CFU m⁻³, while the total culturable bacterial count should not exceed 500 CFU m⁻³ (NIOSH, 1998; ACGIH, 1989; AIHA, 1996). Furthermore, the Taiwan Environmental Protection Administration (EPA) stated that the concentration of bacteria in indoor public spaces should not exceed 1,500 CFU m⁻³, while the concentration of fungi should not exceed 1,000 CFU m⁻³ (CHEN et al., 2016; BULSKI; FRACZEK, 2021). However, the fungal concentration limit <1000 CFU m⁻³ does not apply when the internal/external fungal concentration ratio is lower than or equal to 1.3 (LU et al., 2018).

Therefore, similar measures are necessary in Brazil, and it is up to the health sectors to develop these protocols.

4 CONCLUSION

Based on the applied methodology and the obtained results, it is evident that the bioaerosols in the examined pet shop exhibit significant contamination by pathogenic microorganisms, including *Staphylococcus aureus*, *Candida albicans*, *Micrococcus* sp., *Bacillus* sp., and *Escherichia coli*.

In quantitative terms, the microbial community present in bioaerosols in the pet shop during the bathing, grooming, and drying of dogs is altered, returning to a condition similar to the initial one after the end of the working day. In qualitative terms, the microbial community differed during bathing, grooming, and drying and at the end of the working day but was similar between the beginning of the working day and during bathing, grooming, and drying. In general, *S. aureus* presented the highest occurrence in the three collection times and evaluation days.

The presence of pathogenic microorganisms in bioaerosols in pet shops raises concerns about the possibility of transmission to the animals and humans who are in direct contact with the work equipment.

This study is expected to alert professionals and employees of pet shops regarding the need to implement stricter protocols and adopt routine measures to control infections and sanitize the equipment used in these establishments.

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