

BRIEF COMMUNICATION

Pseudomonas aeruginosa isolation from dog grooming products used by private owners or by professional pet grooming salons: prevalence and risk factors

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Abstract

Background: *Pseudomonas aeruginosa* is the most commonly isolated bacterium from skin lesions of dogs with post-grooming furunculosis (PGF). It is frequently found in human hair and skin care products, and may pose a health risk to consumers. Information regarding the prevalence of *P. aeruginosa* contamination of dog grooming products is lacking.

Objectives: To investigate the prevalence of *P. aeruginosa* contamination in nonmedicated dog grooming products after either home or professional use in pet grooming salons, and to identify risk factors that may be associated with contamination.

Materials and methods: Of 117 bottles of grooming products sampled for bacterial culture, 97 were used by pet grooming salons and 20 were used by private individuals. The following suspected risk factors were recorded: bottle size, relative remaining volume, content dilution, expiration date and ingredient list.

Results: *Pseudomonas aeruginosa* was isolated from 14 of 117 samples [11.97%, 95% confidence interval (CI) 6.97–19.3%]. Diluted products were contaminated significantly more often compared to undiluted products (odds ratio = 15.5, 95%CI 2.05–117.23; $P < 0.01$). None of the other variables was significantly associated with *P. aeruginosa* contamination.

Conclusions and clinical relevance: *Pseudomonas aeruginosa* contamination of dog grooming shampoos and conditioners was significantly associated with product dilution. Contaminated grooming products may predispose dogs to severe bacterial skin infections such as PGF.

INTRODUCTION

Pseudomonas aeruginosa is a pathogenic, Gram-negative bacterium, ubiquitously found in the environment. It is frequently found in human hair and skin care products.^{1,2} These contaminated products may pose a health risk to consumers.^{1,3} Skin infections caused by *P. aeruginosa* also have been reported in humans exposed to contaminated water.⁴

Post-grooming furunculosis (PGF) is a distinctive type of deep pyoderma described in dogs. Furunculosis is believed to be a sequel to follicular trauma caused by vigorous manipulation of the skin and coat (e.g. hand-stripping or traumatic brushing), followed by bathing with a contaminated product.⁵ *Pseudomonas aeruginosa* is the most commonly isolated bacteria from skin lesions of dogs affected with PGF.^{6,7} The source of bacterial contamination often is unknown. Shampoos

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contaminated with *P. aeruginosa* are suspected to play an important role in the pathogenesis of PGF in dogs, although cultures from bottles of dog grooming products are rarely performed.^{6–8} Bacterial culture from skin lesions of a single dog diagnosed with PGF yielded *P. aeruginosa* with an identical genetic fingerprint to the *P. aeruginosa* isolated from the shampoo bottle used before disease onset.⁹

The purpose of this study was to investigate the prevalence of *P. aeruginosa* contamination in nonmedicated dog grooming products, after either home or professional use at pet grooming salons, and to examine potential risk factors associated with contamination.

MATERIALS AND METHODS

Sixteen pet grooming salons and 18 pet owners (veterinary students) were enrolled in the study. Samples were collected by two investigators. Contact with the pet grooming salon operator was made by the investigators 2–48 h before visiting the facility. Verbal consent for participation in the study was obtained from all grooming salon operators. All the shampoo and conditioner bottles used on the day the investigator visited the facilities were sampled. In addition, 20 products used for home grooming by 18 veterinary students were brought directly to the main investigators for sampling. All of the home-use products were used for a single dog at least once during the month before sampling.

Samples were obtained using a sterile swab with transport media for bacterial culture (invasive sterile Eurotube collection swab with Stuart transport medium; Deltalab). Immediately before sampling, a small amount of the grooming product (approximately 0.5 ml) was squeezed through the opening of the bottle and discarded. A sterile swab then was placed at the opening of the bottles, gently rotated, left for a few seconds to moisten and then carefully withdrawn. All swabs were inserted directly into transport tubes and the lids were secured tightly. Within 2 h of collection the samples were stored at 4°C until processing the following day.

The following information was recorded for each bottle of grooming product sampled: (a) type of grooming product (shampoo or conditioner); (b) type of use (home use by dog owner or professional use at grooming salon); (c) bottle size (more or less than 1 L); (d) relative remaining volume in the bottle (a quarter or less, between a quarter and one half, between one half and three quarters, three quarters or more); (e) whether the contents were diluted with water or not; (f) expiration date printed on the bottle; and (g) list of ingredients.

Culture and species identification of samples

Samples were streaked onto MacConkey agar plates and incubated aerobically at 37°C overnight. Plates were examined for colonies resembling *P. aeruginosa*

morphology, which then were isolated and identified to species level by matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry with an Autoflex system (Bruker) using the direct protocol according to the manufacturer's instructions.

Statistical analysis

In order to test the association between categorical variables and a positive culture of *P. aeruginosa*, chi-square or Fisher's exact test was used, as appropriate. A multivariable logistic regression included those associations found to be significant on chi-square or Fisher's exact test, as well as the grooming establishment in order to adjust for clustering (more than one sample per establishment). Confidence intervals (95%) of proportions were calculated by Fisher's exact test (WINPEPI, DESCRIBE A, v3.18). Statistical significance was set at $p < 0.05$. Calculations were carried out using SPSS v25 and 27 (IBM).

RESULTS

A total of 117 bottles of dog grooming products were sampled from 34 establishments. Twenty samples were obtained from 18 private owners (two owners provided two samples each) and 97 samples were obtained from 16 grooming salons (Table 1). *Pseudomonas aeruginosa* was isolated from 14 of 117 samples (11.97%, 95%CI 6.97%–19.3%). Of the 14 positive samples, 12 were collected from grooming products used in seven grooming salons and two samples were collected from shampoo bottles used by two private owners (one sample each; Table 2).

Contamination was significantly associated with diluted products compared to undiluted products [odds ratio (OR) = 15.5, 95%CI: 2.05–117.23; $P < 0.01$]. No statistically significant association was found between the isolation of *P. aeruginosa* and the type of grooming product (i.e. shampoo versus conditioner), the type of usage (i.e. private versus professional), the size of the bottle, the relative amount remaining in the bottle, or the expiration date.

Information regarding the ingredients was available for 103 of the 117 products sampled (Table 3). No significant association was found between any of the ingredients and the isolation of *P. aeruginosa*. This organism was not isolated from any of the bottles lacking an ingredient list.

DISCUSSION

Nearly 12% of pet grooming products tested were contaminated with *P. aeruginosa*. This is consistent with previous culture of this organism from both dog and human shampoos.^{2,8,9} To the best of the authors' knowledge, this is the first publication examining the prevalence of *P. aeruginosa* contamination of grooming products on a larger scale.

Dilution of shampoo and conditioners with tap water is a common practice in pet grooming salons. In our study, all diluted products were diluted with tap water according to the manufacturer's instruction. Previous reports suggest that shampoos diluted with tap water may be a risk factor for contamination.⁷ The present study supports this assumption. The source of contamination may be the tap water itself, as outbreaks of *P. aeruginosa* associated with contaminated tap water have been reported.¹⁰

In previous publications reporting the isolation of *P. aeruginosa* from grooming products, the expiration date of the grooming products was not mentioned.^{8,9} In our study, of the 35 grooming products for which there was information regarding the expiration date,

six were expired, and *P. aeruginosa* was isolated from two of those. Although not statistically significant, it is important to further investigate this issue as the use of expired grooming products is a potentially common practice.

There was no association between individual ingredients and *P. aeruginosa* contamination. Aloe vera, one of the most common ingredients in dog grooming products, has been found to have in vitro antibacterial activity against *P. aeruginosa*.¹¹ Although aloe vera was present in over half of the products evaluated in this study, large variation in ingredient combinations and concentrations made it impossible to draw conclusions regarding any association between ingredients and *P. aeruginosa* contamination.

All pet grooming salons that participated in this study reported using the same bottle of shampoo for several dogs, while the private owners in this study used each shampoo bottle for one dog. The fact that no significant differences were found in the contamination rate between the products used in pet grooming salons and those used by the dog owners, suggests that the number of dogs for which the product was being used does not pose a greater risk of contamination with *P. aeruginosa*.

One study limitation is the advanced notice given to pet grooming salon operators before investigators arrived. Even though pet grooming salon operators stated they did not change the sampled bottles or take any disinfection measures before sampling, this possibility cannot be entirely excluded. Another limitation is the relatively small sample size that may contribute to the lack of statistical significance for some of the risk factors evaluated.

Overall, the prevalence of contamination of the grooming products in this study was surprisingly high. This contamination rate may expose dogs being groomed to contaminated products that increase the risk of developing bacterial skin infection. Furthermore, dilution of grooming products can increase the risk of contamination. Future studies

TABLE 1 The number of samples from each pet grooming salon and the number of positive samples by location

Commercial pet grooming salon	Number of samples	Number of positive samples
1	8	0
2	3	0
3	3	1
4	5	1
5	4	0
6	12	1
7	3	0
8	4	0
9	9	0
10	7	1
11	8	0
12	3	0
13	9	2
14	3	0
15	5	2
16	11	4

TABLE 2 Association between contamination of grooming products with *Pseudomonas aeruginosa* and suspected risk factors

Characteristics		Number of samples n (%)	Positive samples for <i>P. aeruginosa</i> n (%)
Type of grooming product	Shampoo	97 (82.9%)	10 (10.3%)
	Conditioner	20 (17.1%)	4 (20.0%)
Type of use	Professional use by pet grooming salon	97 (82.9%)	12 (12.4%)
	Private use by the dog owners	20 (17.1%)	2 (10.0%)
Size of grooming bottle product	>1 L	61 (47.9%)	5 (8.2%)
	<1 L	56 (52.1%)	9 (16.1%)
Relative amount remaining in the bottle	<¼	27 (23.1%)	3 (11.1%)
	¼–½	31 (26.5%)	5 (16.1%)
	½–¾	27 (23.1%)	2 (7.4%)
	>¾	32 (27.3%)	4 (12.5%)
Dilution	Diluted	18 (15.4%)	7 (38.9%)
	Not diluted	99 (86.6%)	7 (7.1%)
Expiration date	Expired	6 (5.1%)	2 (33.3%)
	In date	29 (24.8%)	3 (10.3%)
	No data	82 (70.1%)	9 (11.0%)

TABLE 3 Association between contamination with *Pseudomonas aeruginosa* and ingredients of grooming products

Ingredients	Number of samples containing the ingredient (% of total sampled); n (%)	Number of samples positive for <i>Pseudomonas aeruginosa</i> (% of positive samples of total number containing the ingredient); n (%)
Aloe	9 (8.7%)	3 (33.3%)
Aloe vera	38 (36.9%)	5 (13.2%)
Aloe barbadensis leaf juice	9 (8.7%)	3 (33.3%)
Cocamide DEA	19 (18.4%)	3 (15.8%)
Cocamidopropyl betaine	39 (37.9%)	6 (15.4%)
Coconut	21 (20.4%)	2 (9.5%)
Creatine	10 (9.7%)	2 (20.0%)
DMDM hydantoin	25 (24.3%)	3 (12.0%)
EDTA	15 (14.6%)	2 (13.3%)
Fragrance	57 (55.3%)	6 (10.5%)
Glycerin	23 (22.3%)	4 (17.4%)
Jojoba	24 (23.3%)	4 (16.7%)
Limonene	12 (11.7%)	3 (25.0%)
Panthenol	41 (39.8%)	8 (19.5%)
Phenoxyethanol	14 (13.6%)	3 (21.4%)
Purified water/deionised water	35 (34.0%)	3 (8.6%)
Sodium chloride	18 (17.5%)	2 (11.1%)
Sodium laureth sulfate	24 (23.3%)	3 (12.5%)
Tea tree oil	15 (14.6%)	3 (20.0%)
Vitamin A	20 (19.4%)	2 (10.0%)
Vitamin D	21 (20.4%)	2 (9.5%)
Vitamin E	47 (45.6%)	9 (19.1%)
Water	21 (20.4%)	4 (19.0%)

are warranted to examine the prevalence of contamination of grooming products with other bacteria isolated from skin of dogs with PGF such as *Staphylococcus pseudintermedius*, *Staphylococcus epidermidis*, *Enterobacter cloacae*, *Serratia marcescens*, *Staphylococcus hominis*, *Klebsiella oxytoca* and *Burkholderia cepacia*.^{6,8}

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CONFLICT OF INTEREST


No conflicts of interest have been declared.

AUTHOR CONTRIBUTIONS

Elad Perry: Conceptualization; data curation; investigation; methodology; project administration; visualization; writing – original draft; writing – review and editing. **Gila Sutton:** Formal analysis; methodology; writing – original draft; writing – review and editing. **Lotem Haggag:** Data curation; investigation; methodology; project administration; writing – review and editing. **Marcelo Fleker:** Methodology; resources; writing – review and editing. **Shlomo Blum:** Methodology; resources; writing – review and editing. **Ronnie Kaufmann:** Supervision; writing – review and editing.

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Résumé

Contexte - *Pseudomonas aeruginosa* est la bactérie la plus couramment isolée des lésions cutanées des chiens atteints de furunculose post-toilettage (PGF). On la trouve fréquemment dans les cheveux humains et les produits de soin de la peau et peut présenter un risque pour la santé des consommateurs. Les informations concernant la prévalence de la contamination par *P. aeruginosa* des produits de toilettage pour chiens font défaut.

Objectifs – Étudier la prévalence de la contamination par *P. aeruginosa* des produits de toilettage pour chiens non médicamenteux après un usage domestique ou professionnel dans les salons de toilettage pour animaux de compagnie, et identifier les facteurs de risque pouvant être associés à la contamination.

Matériels et méthodes – Sur 117 flacons de produits de toilettage prélevés pour culture bactérienne, 97 étaient utilisés par des salons de toilettage et 20 par des particuliers. Les facteurs de risque suspectés suivants ont été enregistrés : taille de la bouteille, volume restant relatif, dilution du contenu, date de péremption et liste des ingrédients.

Résultats – *Pseudomonas aeruginosa* a été isolé dans 14 des 117 échantillons [11,97 %, intervalle de confiance (IC) à 95 % 6,97–19,3 %]. Les produits dilués étaient significativement plus souvent contaminés que les produits non dilués (odds ratio = 15,5, IC à 95 % 2,05–117,23 ; $P < 0,01$). Aucune des autres variables n'était significativement associée à la contamination par *P. aeruginosa*.

Conclusions et pertinence clinique – La contamination par *Pseudomonas aeruginosa* des shampoings et après shampoings pour chiens était significativement associée à la dilution du produit. Les produits de toilettage contaminés peuvent prédisposer les chiens à de graves infections cutanées bactériennes telles que la PGF.

Resumen

Introducción- *Pseudomonas aeruginosa* es la bacteria más comúnmente aislada de las lesiones cutáneas de perros con furunculosis posterior al aseo (PGF). Se encuentra con frecuencia en productos para el cuidado de la piel y el cabello humano, y puede representar un riesgo para la salud de los consumidores. Falta información sobre la prevalencia de la contaminación por *P. aeruginosa* en los productos de aseo para perros.

Objetivos- investigar la prevalencia de la contaminación por *P. aeruginosa* en productos de aseo canino no medicados después del uso doméstico o profesional en salones de aseo de mascotas, e identificar los factores de riesgo que pueden estar asociados con la contaminación.

Materiales y métodos- de 117 botellas de productos de aseo muestreados para cultivo bacteriano, 97 fueron utilizados por salones de aseo de mascotas y 20 fueron utilizados por particulares. Se registraron los siguientes factores de riesgo sospechosos: tamaño de la botella, volumen restante relativo, dilución del contenido, fecha de caducidad y lista de ingredientes.

Resultados- se aisló *Pseudomonas aeruginosa* en 14 de 117 muestras [11,97 %, intervalo de confianza (IC) del 95 %: 6,97–19,3 %]. Los productos diluidos se contaminaron significativamente más a menudo en comparación con los productos sin diluir (odds ratio = 15,5, IC del 95 %: 2,05–117,23; $P < 0,01$). Ninguna de las otras variables se asoció significativamente con la contaminación por *P. aeruginosa*.

Conclusiones y relevancia clínica- la contaminación por *Pseudomonas aeruginosa* de los champús y acondicionadores de aseo para perros se asoció significativamente con la dilución del producto. Los productos de aseo contaminados pueden predisponer a los perros a infecciones cutáneas bacterianas graves como la PGF.

Zusammenfassung

Hintergrund – *Pseudomonas aeruginosa* ist das am häufigsten isolierte Bakterium aus Hautveränderungen bei Hunden mit einer Furunkulose nach einer Schur (PGF). Es wird häufig in menschlichen Haar- und Hautpflegeprodukten gefunden, und könnte ein Gesundheitsrisiko für die KonsumentInnen darstellen. Es gibt keine Information bezüglich der Prävalenz einer *P. aeruginosa* Kontamination in Pflegeprodukten für Hunde.

Ziele – Eine Untersuchung der Prävalenz einer Kontamination durch *P. aeruginosa* in nicht medizinischen Hunde Pflegeprodukten nach ihrer Verwendung zu Hause oder nach ihrer professionellen Verwendung in Kosmetiksalons für Hunde, sowie eine Identifizierung von Risikofaktoren, die mit einer derartigen Kontaminierung einhergehen könnten.

Materialien und Methoden – Von den 117 Flaschen mit Waschprodukten, von denen Proben zur bakteriellen Kultur entnommen wurden, waren 97 in Kosmetiksalons für Tiere im Einsatz und 20 wurden privat benützt. Es wurden die folgenden Risikofaktoren festgehalten: Flaschengröße, relativer Volumensrest, Verdünnung des Inhalts, Ablaufdatum und Zusammensetzung.

Ergebnisse – *Pseudomonas aeruginosa* wurde in 14 von 117 Proben isoliert [11,97%; 95% Konfidenzintervall (CI) 6,97-19,3%]. Verdünnte Produkte waren signifikant häufiger kontaminiert im Vergleich zu unverdünnten Produkten (Chancenverhältnis = 15,5; 95% CI 2,05-117,23; $P < 0,01$). Keine der anderen Variablen stand mit einer Kontaminierung durch *P. aeruginosa* signifikant im Zusammenhang.

Schlussfolgerungen und klinische Bedeutung – Eine Kontamination von Hundeshampoos und Pflegeprodukten durch *Pseudomonas aeruginosa* stand in einem signifikanten Zusammenhang mit der Verdünnung der Produkte. Kontaminierte Pflegeprodukte könnten Hunde zu schweren bakteriellen Hautinfektionen wie eine PGF prädisponieren.

概要

背景 - 緑膿菌はグルーミング後癬腫症(PGF)の犬の皮膚病変から最もよく分離される細菌である。また、ヒト用のヘアケア製品およびスキンケア製品からも頻りに検出され、消費者に健康リスクを与える可能性がある。犬用グルーミング製品の緑膿菌汚染の有病率に関する情報は不足している。

目的-本研究の目的は、家庭用またはペットグルーミングサロンでの業務用使用後の非薬用犬グルーミング製品における緑膿菌汚染の有病率を調査し、汚染と関連する危険因子を特定することである。

材料および方法 - 細菌培養のためにサンプリングされたグルーミング製品 117 本のうち、97 本がペットグルーミングサロンで使用されたもの、20 本が個人で使用されたものであった。ボトルサイズ、相対的残量、内容物の希釈度、有効期限、成分表など、リスク要因と思われるものを記録した。

結果 - 117 サンプル中 14 サンプルから緑膿菌が分離された [11.97%, 95% 信頼区間 (CI) 6.97-19.3%]。希釈した製品は、希釈していない製品と比べて有意に多く汚染されていた(オッズ比 = 15.5, 95%CI 2.05-117.23; $P < 0.01$)。他のどの変数も緑膿菌の汚染と有意な関連はなかった。

結論および臨床的意義 - 犬用グルーミングシャンプーおよびコンディショナーの緑膿菌汚染は、製品の希釈度と有意に関連していた。汚染されたグルーミング製品は、犬を PGF のような重篤な細菌性皮膚感染症にさせる可能性がある。

摘要

背景-从洗澡后疔病(PGF)患犬的皮肤病变中最常分离出的细菌是铜绿假单胞菌。它常见于人的头发和护肤品中,可能给消费者带来健康风险。缺乏关于犬洗浴产品中铜绿假单胞菌污染流行率的信息。

目的-研究在家庭中或宠物美容店的专业使用后,非药用犬洗浴产品中铜绿假单胞菌污染的流行率,并确定可能与污染相关的风险因素。

材料和方法-117瓶洗浴产品用于细菌培养,其中宠物美容店使用的97瓶,私家用的20瓶。记录了以下可疑风险因素:瓶大小、相对剩余体积、内容物稀释度、失效日期和成分列表。

结果-117份样本中有14份分离出铜绿假单胞菌[11.97%, 95%置信区间(CI)6.97-19.3%]。与未稀释产品相比,稀释产品的污染显著增加(比值比 = 15.5, 95%CI 2.05-117.23; $P < 0.01$)。其他变量均与铜绿假单胞菌污染无显著相关性。

结论和临床相关性-犬洗浴香波和护毛素的铜绿假单胞菌污染与产品稀释显著相关。污染的洗浴产品可能使犬易患重度细菌性皮肤感染,如PGF。

Resumo

Contexto - *Pseudomonas aeruginosa* é a bactéria mais frequentemente isolada de lesões cutâneas de cães com furunculose pós-banho (FPB). É frequentemente encontrada em cabelos humanos e cosméticos e pode causar malefícios à saúde dos consumidores. Informações sobre a prevalência de contaminação de produtos de banho caninos por *P. aeruginosa* são escassas.

Objetivos – Investigar a prevalência de contaminação de cosméticos de banho não medicamentosos para cães por *P. aeruginosa* após uso caseiro ou profissional em pet shops, e identificar os fatores de risco que podem estar associados à contaminação.

Materiais e métodos – Dos 117 frascos de cosméticos testados por cultura bacteriana, 97 foram utilizados por pet shops e 20 foram de uso doméstico individual. Os seguintes fatores de risco foram registrados: tamanho do frasco, volume remanescente relativo, diluição do conteúdo, data de validade e lista de ingredientes.

Resultados - *Pseudomonas aeruginosa* foi isolada de 14 das 117 amostras [11,97%, 95% intervalo de confiança (IC) 6,97–19,3%]. Produtos diluídos apresentaram contaminação significativamente mais frequentemente, comparado a produtos não diluídos (odds ratio = 15,5; 95% IC 2,05–117,23; $P < 0,01$). Nenhuma das outras variáveis foi significativamente associada à contaminação por *P.aeruginosa*.

Conclusões e relevância clínica – A contaminação de shampoos e condicionadores caninos por *Pseudomonas aeruginosa* foi significativamente associada à diluição do produto. Cosméticos veterinários contaminados podem predispor cães a infecções cutâneas bacterianas como a FPB.