THE EUROPEAN SOCIETY OF MEDICINE
Medical Research Archives, Volume 12 Issue 7

CASE REPORT

Wohlfahrtiimonas chitiniclastica bacteremia: First Documented Case in Morocco and North Africa

Ayoub Rafei[1], Hamza Oualhadj[1], Taoufik Ben Houmich[1], Asmae Lamrani Hanchi[1], Nabila Soraa[1]

[1] Laboratory of Microbiology, Mohamed VI University Hospital, Marrakesh, Morocco

OPEN ACCESS

PUBLISHED
31 July 2024

CITATION
Rafei, A., Oualhadj, H., et al., 2024. Wohlfahrtiimonas chitiniclastica bacteremia. Medical Research Archives, [online] 12(7). https://doi.org/10.18103/mra.v12i7.5430

DOI
https://doi.org/10.18103/mra.v12i7.5430

ISSN
2375-1924

ABSTRACT

Background: Wohlfahrtiimonas chitiniclastica is an emerging pathogen associated with severe infections, predominantly found in compromised individuals and often underestimated due to diagnostic challenges. This case report documents the first recorded instance of Wohlfahrtiimonas chitiniclastica bacteremia in Morocco and North Africa, arising from an infected external fixator.

Case Presentation: A 24-year-old male presented to the emergency department with signs of severe sepsis. He had been previously treated with an external fixator for an open leg fracture. Despite having no significant past medical history or high-risk lifestyle behaviors, he developed rapidly progressing symptoms including cutaneous necrosis and systemic infection markers. Laboratory tests confirmed hyperleukocytosis, elevated C-reactive protein, and raised procalcitonin levels. Blood and tissue cultures identified Wohlfahrtiimonas chitiniclastica, along with Providencia stuartii and Enterococcus faecalis. The patient was treated in the intensive care unit with broad-spectrum antibiotics initially, followed by targeted therapy based on susceptibility profiles, and underwent surgical debridement of the infection site.

Discussion: The identification of Wohlfahrtiimonas chitiniclastica in this case marks an important development in its epidemiological profile. Once thought to be limited to specific regions and vectors, it is now recognized globally, suggesting a wider ecological presence and varied transmission routes. This case notably links the bacterium's infections to breaches in skin integrity, like wounds and chronic ulcers, highlighting them as primary infection gateways. The use of MALDI-TOF mass spectrometry was crucial for the swift and precise identification of Wohlfahrtiimonas chitiniclastica, proving more effective than traditional biochemical methods. Additionally, 16S rRNA gene sequencing offered valuable insights into the organism's taxonomy and resistance patterns, underscoring the critical role of these advanced diagnostics in modern clinical microbiology. Despite the bacterium's broad susceptibility to antibiotics, vigilance is crucial due to the potential for emerging resistance. This risk is heightened by antibiotic use in chronic wound management, emphasizing the need for continual surveillance and rigorous antibiotic stewardship to prevent therapeutic failures and resistance proliferation.

Conclusion: This case highlights Wohlfahrtiimonas chitiniclastica's worldwide distribution and its link to compromised skin integrity. Advanced diagnostics like MALDI-TOF MS and 16S rRNA sequencing proved crucial in identifying this pathogen. The potential for antibiotic resistance necessitates ongoing surveillance and prudent management to control infections and curb resistance. This case reinforces the need to include W. chitiniclastica in differential diagnoses, especially in cases involving skin breaches.

Introduction

Wohlfahrtiimonas chitiniclastica, a Gram-negative, strictly aerobic, non-motile bacterium, was first isolated from the larvae of the obligate parasitic fly *Wohlfahrtia magnifica*, known for causing myiasis in mammals and humans through wound invasion [1]. Identified in 2008, this bacterium is characterized by its catalase and oxidase positive reactions, absence of urease, indole, and H2S production, and notable for its significant chitinase activity. Such characteristics suggest a symbiotic relationship with its vector and a pivotal role in the host's metamorphosis process [1].

The transmission vectors of W. chitiniclastica are not limited to W. *magnifica* but include other fly species such as *Chrysomya megacephala, Lucilia sericata, and Musca domestica*, which deposit larvae in open wounds [2].

The identification of W. chitiniclastica has been greatly enhanced by advanced diagnostic techniques. 16S rRNA sequencing offers rapid and precise identification directly from clinical samples, though its effectiveness depends on primer selection and is not universally available in all laboratories for routine diagnostics [3,4]. MALDI-TOF MS offers significant advantages in terms of speed and cost, which are highly prioritized in daily clinical practice, Although species-level identification limitations can arise due to missing spectra of unknown species in the database [5,6].

Clinical suspicion of W. chitiniclastica infection should be elevated in patients with chronic skin lesions, such as diabetic foot ulcers, particularly those residing in poor social and hygienic conditions. Chronic open skin wounds and comorbidities like diabetes are notable risk factors for infection [2]. While its complete pathogenic mechanisms remain to be fully elucidated, the literature documents various human diseases attributed to this zoonotic pathogen, ranging from localized infections to systemic diseases such as bacteremia and sepsis, indicating its potential for significant morbidity [7,8].

Here we present the first, to our knowledge, well documented case of Wohlfahrtiimonas chitiniclastica bacteremia, secondary to an osteosynthesis associated infection, in Morocco and North Africa.

Case Report:

A 24-year-old male was admitted to the emergency department with symptoms suggestive of sepsis. He had been treated for an open leg fracture with an external fixator, installed one month prior. His past medical history showed no diabetes or any other immunosuppressive condition. Patient lived in poor conditions in a rural area, but had no exposure to tobacco, alcohol or IV drugs. Over the past few days, he had noticed increasing pain and redness at the fracture site, which had rapidly progressed to cutaneous necrosis accompanied by swelling and erythema around the fixator. The patient reported experiencing chills and an intermittent fever which had spiked the morning of admission. He also mentioned increasing fatigue and confusion, prompting his visit to the hospital. Upon physical examination, the patient exhibited fever with a body temperature of 39.3°C (102.7°F), tachycardia with a heart rate of 110 bpm, and tachypnea with a respiratory rate of 28 breaths per minute. His blood pressure was noted to be low at 90/50 mmHg. The physical assessment also revealed reduced urine output and altered mental state.

Laboratory investigations were immediately conducted, revealing significant hyperleukocytosis with a white blood cell count of 28,6K/µL, predominantly neutrophilic (70%). A marked thrombocytopenia was also noted with a platelet count reduced to 70K /µL. Biochemical tests showed hyperkalemia and an elevated lactate level. C-reactive protein was significantly elevated at 280 mg/L, and procalcitonin levels were also raised.

Blood cultures processed in a BACTEC system showed positive results after 32 hours, identifying Gram-negative bacilli (fig. 1). Subsequent cultures on Sheep blood agar and MacConkey agar under a 5% CO2 atmosphere showed monomicrobial growth of mucoid, spreading, lactose-negative, oxidase-positive colonies (fig 2). MALDI-TOF mass spectrometry (Bruker Daltonics) identified these isolates as Wohlfahrtiimonas chitiniclastica with a score greater than 2.0. Additionally, necrotic tissue cultures revealed a polymicrobial infection comprising *W. chitiniclastica, Providencia stuartii, and Enterococcus faecalis*. The antimicrobial susceptibility profile was determined using the BD Phoenix M50 system, and was interpretated according to the PK/PD breakpoints (non-species related) described on the EUCAST 22.1, indicating that the W. chitiniclastica isolate was sensitive to all tested antibiotics except Fosfomycin (Table 1: antibiotic susceptibility).

Upon admission, given the severity of his symptoms indicative of severe sepsis, the patient was immediately transferred to the intensive care unit (ICU) for urgent management. Initial treatment included broad-spectrum intravenous antibiotics, with a combination of piperacillin/tazobactam and vancomycin, to cover a wide range of potential pathogens. Supportive care was initiated, and given the respiratory distress and potential for rapid deterioration, mechanical ventilation support was also prepared if needed.

After 72 hours, once the blood culture results and sensitivity profile were available, the treatment was adapted to cefepime and ciprofloxacin, which the combined isolates were shown to be sensitive to.

Once stabilized, the patient underwent surgical intervention to address the source of infection. The external fixator was removed, and thorough debridement and irrigation of the fracture site were performed to eradicate the infectious foci. This was critical to prevent recurrence and promote healing.

Following the surgical intervention, the patient's condition gradually improved, and he was closely monitored for signs of recurrent infection or other complications.

Upon discharge, the patient was scheduled for regular follow-up visits in the orthopedic clinic to monitor the healing process and manage the orthopedic hardware potentially needed after resolution of the infection.

Table 1: Antimicrobial susceptibility testing of W. chitiniclastica

Antibiotic	MIC (µg/ml)	Susceptible=S
Amoxicillin	<2	S
Amoxicillin-clavulanate	<2	S
Ceftriaxone	<1	S
Piperacillin-tazobactam	<8	S
Cefepime	<4	S
Gentamycin	<0.5	S
Amikacin	<1	S
Ciprofloxacin	<0.25	S
Levofloxacin	<0.5	S
Fosfomycine	>8	R

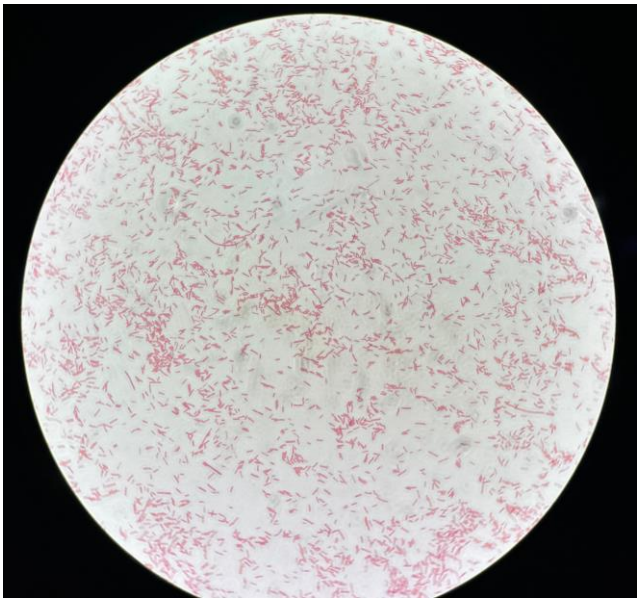

Fig. 1. Gram-negative rod from positive blood culture on microscopic examination (1000x).

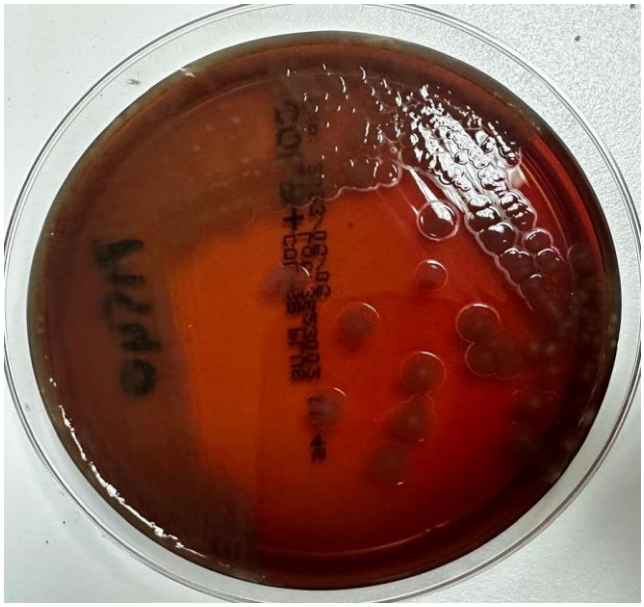

Fig. 2. Colonies growing on sheep blood agar revealing a characteristic mucoid morphology.

Discussion:

EPIDEMIOLOGY AND MODES OF TRANSMISSION:

In 2008, Tóth et al. first identified *Wohlfahrtiimonas chitiniclastica* after isolating it from *Wohlfahrtia magnifica* larvae. These larvae are a major vector of myiasis in humans and animals across Eastern Europe, the Mediterranean, and Central Asia [1,9,10]. This discovery highlighted the bacterium's role in disease transmission through contact of skin wounds or mucous membranes with infected larvae leading to myiasis [2,11]. Further investigations have revealed that *W. chitiniclastica* can be carried by fly species such as *Lucilia sericata*[12], *Lucilia illustris*[13,14], *Chrysomya megacephala*[15,16], and *Musca domestica*[17], indicating a range of carriers and adaptability in different environments. While most cases have been described in Europe[2,18–25], the presence of *W. chitiniclastica* infections in regions such as South America[26], Africa[27], Asia[28], and the United States [7,8,29–33] suggests its ability to thrive outside its habitats due to its expanded vector associations. Recent studies have demonstrated that *W. Chitiniclastica* is not limited to fly larvae but can also be found in arsenic-contaminated soils [34] and various food sources such as chicken meat [35] and fish-based food [36], suggesting a more complex ecological role than previously recognized. These discoveries point towards foodborne transmission pathways beyond traditional knowledge and emphasize the need for further research to comprehend the risks and mechanisms of infection thoroughly.

In the case study, although no larvae were specifically found with the patient, it is noteworthy that the patient returned to a rural area in Morocco after initial discharge following an open leg fracture intervention. In this region, both *Wolfahrtia magnifica* and *Musca domestica* are known to be common. This situation highlights the importance of considering epidemiological factors when assessing the transmission and risks associated with *W. Chitiniclastica* in regions where vectors are prevalent.

CLINICAL PROFILING:

Wohlfahrttiimonas chitiniclastica infection represents a rare but globally recognized clinical challenge. To date, 44 cases have been reported including ours [37], with no age-specific susceptibility as ages range from 17 to 90 years, with a mean age of onset of 62 years [37]. Critical risk factors contributing to acquiring this infection include compromised personal hygiene, poor living conditions, and lifestyle habits such as alcohol, tobacco, and drug use[2,18,26,37]. In addition, the presence of underlying health conditions such as diabetes, cardiovascular and osteoarticular diseases, but more importantly, those that affect the skin integrity, such as chronic necrotic wounds, significantly increase the risk profile for these infections.[7,19,20,22,26,30,38]

Clinical manifestations vary and include soft tissue infections, osteomyelitis, and bloodstream infections, indicating the bacterium's ability to cause serious health problems, particularly in immunocompromised patients[7,37]. Notably, the course and outcome of the

infection appear to be strongly influenced by the health status of patients at the time of hospitalization rather than the virulence of W. *chitiniclastica* itself[2]. Most patients responded well to antimicrobial treatment with beta-lactams[37]. This suggests that this microorganism remains susceptible to antibiotics, but due to the selection of resistant clones through antibiotic treatment of chronic wounds, it is important to monitor this trend[39,40]. Coexisting species with multiple resistance genes in the same ecological niche may promote multidrug resistance [39]. This scenario suggests a rapid adaptation to drug resistance, potentially making W. *chitiniclastica* a significant health risk.

MICROBIOLOGICAL IDENTIFICATION:

Identifying *Wohlfahrtiimonas chitiniclastica* in samples has been a challenge, due to the limitations of biochemical testing methods [24]. The organism is known for being non motile and a Gram-negative bacillus that grows best at temperatures between 28 and 37°C. although Toth[1] initially described the bacterium as being strictly aerobic, two strains have been reported to grow under anaerobic conditions[8,30]. It forms flat smooth colonies on blood agar plates (BAP) and chocolate agar (CHOC) while on MacConkey agar (MAC) it produces lactose negative colonies. Despite these growth characteristics the organism tests positive for catalase and oxidase but negative for urease, indole and hydrogen sulfide production adding complexity to its profile[24,37]

Common identification systems like the API system from bioMérieux, the BD Phoenix Gram Negative Panel and the VITEK 2 system have been known to provide false or misleading results[8,19,32]. For example both the BD Phoenix Gram Negative Panel and VITEK 2 systems have misidentified W. *Chitiniclastica* isolates as species, like *Acinetobacter lwoffii*, *Brevundimonas diminuta* and *Moraxella spp.* with misleadingly high confidence scores exceeding 96% [19,26].These misidentifications highlight the need, for diagnostic tools particularly considering the potential of W. *Chitiniclastica* to cause severe infections and the importance of distinguishing it from other skin flora or environmental contaminants.

On the hand advanced molecular techniques like MALDI TOF MS (Matrix Assisted Laser Desorption Ionization Time of Flight Mass Spectrometry) 16S rRNA gene sequencing and rpoB analysis have proven to be reliable and accurate in identifying *Wohlfahrtiimonas chitiniclastica* [2,7,18,24,26,28]. In our case MALDI TOF MS was used to identify the organism confirming its presence and aiding in clinical management. While the rpoB method is not widely used in diagnostics yet, MALDI TOF MS and 16S rRNA gene sequencing are becoming the gold standard for identifying this challenging organism[24]. These approaches overcome the limitations of tests by providing genetic insights that ensure accurate identification.

16S rRNA sequencing is an effective and rapid identification method for bacterial organisms directly from clinical samples. However, its diagnostic power heavily depends on the choice of primer, the amplicon length, and the coverage of variable regions [3,6,41]. Suboptimal primers can fail to detect specific species or groups, and no single region within the 16S rRNA gene can distinguish all bacteria. Therefore, careful selection of primer pairs is crucial for accurate identification [24].

MALDI-TOF MS is a well-established method in routine diagnostics, offering speed and cost-effectiveness[2]. Despite limitations at the species level due to incomplete databases, it remains a valuable tool for rapid identification. In the case of W. chitiniclastica infections, MALDI-TOF MS excels as a fast and inexpensive identification method [5,6]. However, combining MALDI-TOF MS with 16S rRNA gene sequencing can enhance reliability and accuracy, particularly in cases with ambiguous results [2].

It's important to recognize that W. *Chitiniclastica*'s prevalence and awareness may have been underestimated in the past due to the limitations of the conventional identification methods[22,24]. As scientific and medical communities enhance techniques, including W.*Chitiniclastica*'s reaction profile in automated databases and broader use of diagnostics are crucial, for better detection rates and appropriate clinical care.

ANTIBIOTIC PROFILING OF WOHLFAHRTIIMONAS CHITINICLASTICA:

Phenotypic resistance:

Wohlfahrtiimonas chitiniclastica is generally susceptible, to a range of antibiotics proving effective against beta lactam antibiotics like penicillins, cephalosporins and carbapenems which have been successful in treating infections in various documented cases [18,20,32,42]. In our case the strain demonstrated susceptibility to all tested antibiotics including beta lactams, fluoroquinolones, aminoglycosides and trimethoprim/sulfamethoxazole. However, it did show resistance to fosfomycin. Nonetheless interpreting susceptibility test results can be complex due to the lack of established guidelines for this bacterium in the EUCAST 23.1 standards making it challenging to determine resistance or susceptibility.

Resistances have been noted in instances to antibiotics such as piperacillin/tazobactam [28], moxifloxacin, ofloxacin and ciprofloxacin [25,28]. Aminoglycosides like amikacin, gentamicin and tobramycin also exhibit resistance patterns across studies rendering them less favorable for initial treatment (2,20,21,24). The effectiveness of tetracycline varies among strains. While a considerable number of isolates still shows sensitivity to it, there are increasing reports of emerging resistances[24,25,28,32]. Trimethoprim/sulfamethoxazole remains potent against strains despite reports of initial cases showing resistance in specific regions[25,27]. Macrolides such as azithromycin clarithromycin erythromycin demonstrate varying degrees of susceptibility, with up to now and to our knowledge, only one strain exhibiting resistance[7].

The organism's strong resistance to fosfomycin have been widely observed, even though this contradicts the lack of fosfomycin resistance genes found in studies [37].

Genotypic Resistance:

Genomic studies have not detected specific resistance genes for fluoroquinolones, nor betalactams suggesting a lack of genetic basis for resistance in many cases [24,37]. However, two cases reported resistance genes, including the blaVEB-1 [43,44] and blaOXA-1 gene cassettes[45], which

confer resistance to ceftazidime, ampicillin, and extend the spectrum to ESBL, affecting the efficacy against various antibiotic classes[46].

Research has pinpointed genes linked to resistance against aminoglycosides [*aph*(3″)-Ib and *aac*(6′)-Ib-cr] [37,45], tetracyclines [*tetC tetR tetA (H)*] [24,37,43,45] and Fosfomycin [*abaF*] [37]. Detection of macrolide efflux pump genes *macA* and *macB* suggests resistance to macrolides[37,47].

Conclusion:

This case report further elucidates the clinical and microbiological characteristics of Wohlfahrtiimonas chitiniclastica, underscoring its status as an emerging yet underrecognized human pathogen. The successful identification of W. chitiniclastica in our case, primarily using MALDI-TOF MS, highlights the pivotal role of advanced molecular techniques in the accurate diagnosis of this organism, which often eludes traditional biochemical methods. Our findings confirm the association of W. chitiniclastica with chronic wounds, particularly in environments of poor hygiene or in immunocompromised individuals, where it may also partake in polymicrobial infections, and underscores its ability to cause life-threatening infections.

The organism's general susceptibility to a broad range of antimicrobial agents provides a therapeutic advantage. However, the potential for developing resistance, coupled with its capability to thrive in synergistic microbial communities, necessitates vigilant monitoring and targeted research into its resistance mechanisms and virulence factors. The inclusion of W. chitiniclastica in differential diagnoses is crucial, especially in cases involving chronic wound infections and myiasis, to prevent overlooked infections and improve clinical outcomes.

Bibliography:

1. Toth EM, Schumann P, Borsodi AK, Keki Z, Kovacs AL, Marialigeti K. Wohlfahrtiimonas chitiniclastica gen. nov., sp. nov., a new gammaproteobacterium isolated from Wohlfahrtia magnifica (Diptera: Sarcophagidae). *International Journal Of Systematic And Evolutionary Microbiology*. 2008;58(4):976-981. Doi:10.1099/ijs.0.65324-0
2. Schröttner P, Rudolph Ww, Damme U, Lotz C, Jacobs E, Gunzer F. Wohlfahrtiimonas chitiniclastica: current insights into an emerging human pathogen. *Epidemiol Infect*. 2017;145(7):1292-1303. Doi:10.1017/S0950268816003411
3. Armougom F. Exploring Microbial Diversity Using 16S rRNA High-Throughput Methods. *J Comput Sci Syst Biol*. 2009;02(01). Doi:10.4172/jcsb.1000019
4. Klindworth A, Pruesse E, Schweer T, et al. Evaluation of general 16S ribosomal RNA gene PCR primers for classical and next-generation sequencing-based diversity studies. *Nucleic Acids Res*. 2013;41(1):e1. Doi:10.1093/nar/gks808
5. Timperio AM, Gorrasi S, Zolla L, Fenice M. Evaluation of MALDI-TOF mass spectrometry and MALDI BioTyper in comparison to 16S rDNA sequencing for the identification of bacteria isolated from Arctic sea water. *PLOS ONE*. 2017;12(7):e0181860. Doi:10.1371/journal.pone.0181860
6. Strejcek M, Smrhova T, Junkova P, Uhlik O. Whole-Cell MALDI-TOF MS Versus 16S rRNA Gene Analysis for Identification and Dereplication of Recurrent Bacterial Isolates. *Front Microbiol*. 2018;9:1294. Doi:10.3389/fmicb.2018.01294
7. Fenwick AJ, Arora V, Ribes JA. Wohlfahrtiimonas chitiniclastica: Two Clinical Cases and a Review of the Literature. *Clinical Microbiology Newsletter*. 2019;41(4):33-38. Doi:10.1016/j.clinmicnews.2019.01.006
8. Chavez JA, Alexander AJ, Balada-Llasat JM, Pancholi P. A case of Wohlfahrtiimonas chitiniclastica bacteremia in continental United States. *JMM Case Reports*. 2017;4(12). Doi:10.1099/jmmcr.0.005134
9. Hall MJR, Testa JM, Smith L, et al. Molecular genetic analysis of populations of Wohlfahrt's wound myiasis fly, *Wohlfahrtia magnifica* , in outbreak populations from Greece and Morocco. *Medical Vet Entomology*. 2009;23(s1):72-79. Doi:10.1111/j.1365-2915.2009.00780.x
10. Farkas R, Hall MJR, Bouzagou AK, Lhor Y, Khallaayoune K. Traumatic myiasis in dogs caused by *Wohlfahrtia magnifica* and its importance in the epidemiology of wohlfahrtiosis of livestock. *Medical Vet Entomology*. 2009;23(s1):80-85. Doi:10.1111/j.1365-2915.2008.00772.x
11. Robbins K, Khachemoune A. Cutaneous myiasis: a review of the common types of myiasis. *International Journal of Dermatology*. 2010;49(10):1092-1098. Doi:10.1111/j.1365-4632.2010.04577.x
12. Maleki-Ravasan N, Ahmadi N, Soroushzadeh Z, Raz AA, Zakeri S, Dinparast Djadid N. New Insights Into Culturable and Unculturable Bacteria Across the Life History of Medicinal Maggots Lucilia sericata (Meigen) (Diptera: Calliphoridae). *Front Microbiol*. 2020;11:505. Doi:10.3389/fmicb.2020.00505
13. Wang Y, Li LL, Wang JF, et al. Development of the green bottle fly Lucilia illustris at constant temperatures. *Forensic Sci Int*. 2016;267:136-144. Doi:10.1016/j.forsciint.2016.07.019
14. Iancu L, Necula-Petrareanu G, Purcarea C. Potential bacterial biomarkers for insect colonization in forensic cases: preliminary quantitative data on Wohlfahrtiimonas chitiniclastica and Ignatzschineria indica dynamics. *Sci Rep*. 2020;10(1):8497. Doi:10.1038/s41598-020-65471-6
15. Cao XM, Chen T, Xu LZ, et al. Complete Genome Sequence of Wohlfahrtiimonas chitiniclastica Strain SH04, Isolated from *Chrysomya megacephala* Collected from Pudong International Airport in China. *Genome Announc*. 2013;1(2):e00119-13. Doi:10.1128/genomeA.00119-13
16. Gabre R, Adham F, Chi H. Life table of Chrysomya megacephala (Fabricius) (Diptera: Calliphoridae). *Acta Oecologica-international Journal of Ecology - ACTA OECOL*. 2005;27. Doi:10.1016/j.actao.2004.12.002
17. Gupta AK, Nayduch D, Verma P, et al. Phylogenetic characterization of bacteria in the gut of house flies (Musca domestica L.). *FEMS Microbiol Ecol*. 2012;79(3):581-593. Doi:10.1111/j.1574-6941.2011.01248.x
18. Rebaudet S, Genot S, Renvoise A, Fournier PE, Stein A. *Wohlfahrtiimonas chitiniclastica* Bacteremia in Homeless Woman. *Emerg Infect Dis*. 2009;15(6):985-987. Doi:10.3201/eid1506.080232
19. De Dios A, Jacob S, Tayal A, Fisher MA, Dingle TC, Hamula CL. First Report of Wohlfahrtiimonaschitiniclastica Isolation from a Patient with Cellulitis in the United States. Munson E, ed. *J Clin Microbiol*. 2015;53(12):3942-3944. Doi:10.1128/JCM.01534-15
20. Campisi L, Mahobia N, Clayton JJ. *Wohlfahrtiimonas chitiniclastica* Bacteremia Associated with Myiasis, United Kingdom. *Emerg Infect Dis*. 2015;21(6):1068-1069. Doi:10.3201/eid2106.140007
21. Dovjak P, Kroißenbrunner M, Iglseder B. Myiasis absent Wohlfahrtiimonas chitiniclastica bacteremia in a lung cancer patient: a case report. *Eur J Med Res*. 2021;26:101. Doi:10.1186/s40001-021-00576-w
22. Kõljalg S, Telling K, Huik K, et al. First report of Wohlfahrtiimonas chitiniclastica from soft tissue and bone infection at an unusually high northern latitude. *Folia Microbiol*. 2015;60(2):155-158. Doi:10.1007/s12223-014-0355-x
23. Hladík M, Lipovy B, Kaloudova Y, et al. Human Infections by Wohlfahrtiimonas chitiniclastica: A Mini-Review and the First Report of a Burn Wound Infection after Accidental Myiasis in Central Europe. *Microorganisms*. 2021;9(9):1934. Doi:10.3390/microorganisms9091934
24. Kopf A, Bunk B, Coldewey SM, Gunzer F, Riedel T, Schröttner P. Identification and Antibiotic Profiling of Wohlfahrtiimonas chitiniclastica, an Underestimated Human Pathogen. *Front Microbiol*. 2021;12:712775. Doi:10.3389/fmicb.2021.712775
25. De Smet D, Goegebuer T, Ho E, Vandenbroucke M, Lemmens A. First case of Wohlfahrtiimonas chitiniclastica isolation from a patient with a foot ulcer infection in Belgium. *Acta Clinica Belgica*.

2023;78(3):245-247. Doi:10.1080/17843286.2022.2090770
26. Almuzara MN, Palombarani S, Tuduri A, et al. First Case of Fulminant Sepsis Due to Wohlfahrtiimonas chitiniclastica ▿ . *J Clin Microbiol*. 2011;49(6):2333-2335. Doi:10.1128/JCM.00001-11
27. Hoffman R, Fortuin F, Newton-Foot M, Singh S. First report of Wohlfahrtiimonas chitiniclastica bacteraemia in South Africa. *South African Medical Journal*. 2016;106(11):1062. Doi:10.7196/SAMJ.2016.v106i11.11449
28. Md Noor S, Zuraina N, Ahmad F, Rahman Z. Fatal Wohlfahrtiimonas chitiniclastica Bacteremia in an Immunocompromised Patient. *Clinical Microbiology Newsletter*. 2017;39. Doi:10.1016/j.clinmicnews.2017.07.003
29. Leeolou MC, Perrault DP, Sivaraj D, et al. A rare case of Wohlfahrtiimonas chitiniclastica infection in California. *JAAD Case Rep*. 2021;17:55-57. Doi:10.1016/j.jdcr.2021.09.022
30. Nogi M, Bankowski MJ, Pien FD. Wohlfahrtiimonas chitiniclastica Infections in 2 Elderly Patients, Hawaii, USA. *Emerg Infect Dis*. 2016;22(3):567-568. Doi:10.3201/eid2203.151701
31. Ahmad Y, Gaston DC, Gray J, et al. The Brief Case: The Fly Who Cried Wohlf. *J Clin Microbiol*. 2022;60(6):e0107321. Doi:10.1128/jcm.01073-21
32. Snyder S, Singh P, Goldman J. Emerging pathogens: A case of Wohlfahrtiimonas chitiniclastica and Ignatzschineria indica bacteremia. *IDCases*. 2020;19:e00723. Doi:10.1016/j.idcr.2020.e00723
33. Lysaght TB, Wooster ME, Jenkins PC, Koniaris LG. Myiasis-induced sepsis: a rare case report of Wohlfahrtiimonas chitiniclastica and Ignatzschineria indica bacteremia in the continental United States. *Medicine (Baltimore)*. 2018;97(52):e13627. Doi:10.1097/MD.0000000000013627
34. Sanyal SK, Mou TJ, Chakrabarty RP, Hoque S, Hossain MA, Sultana M. Diversity of arsenite oxidase gene and arsenotrophic bacteria in arsenic affected Bangladesh soils. *AMB Express*. 2016;6(1):21. Doi:10.1186/s13568-016-0193-0
35. Anjaria P, Koringa P, Bhavsar P, et al. Exploring the Hidden Microbial World of Market Chicken Meat: A Culture-Independent Analysis of Surface Microbiota. Published online April 11, 2023. Doi:10.2139/ssrn.4412769
36. Sami A. *The Sudabiome: Oral and Gut Microbiome Parameters of the Sudanese Population Including Dietary and Cultural [Toombak] Metagenomics*.; 2022. https://hdl.handle.net/10468/14479
37. Kopf A, Bunk B, Riedel T, Schröttner P. The zoonotic pathogen Wohlfahrtiimonas chitiniclastica – current findings from a clinical and genomic perspective. *BMC Microbiol*. 2024;24(1):3. Doi:10.1186/s12866-023-03139-7
38. Bonwitt JH, Tran M, Dykstra EA, et al. Fly Reservoir Associated with Wohlfahrtiimonas Bacteremia in a Human. *Emerg Infect Dis*. 2018;24(2):370-373. Doi:10.3201/eid2402.170913
39. Kalan LR, Brennan MB. The role of the microbiome in nonhealing diabetic wounds. *Ann N Y Acad Sci*. 2019;1435(1):79-92. Doi:10.1111/nyas.13926
40. Loesche M, Gardner SE, Kalan L, et al. Temporal Stability in Chronic Wound Microbiota Is Associated With Poor Healing. *J Invest Dermatol*. 2017;137(1):237-244. Doi:10.1016/j.jid.2016.08.009
41. Sune D, Rydberg H, Augustinsson ÅN, Serrander L, Jungeström MB. Optimization of 16S rRNA gene analysis for use in the diagnostic clinical microbiology service. *J Microbiol Methods*. 2020;170:105854. Doi:10.1016/j.mimet.2020.105854
42. Bueide P, Hunt J, Bande D, Guerrero DM. Maggot Wound Therapy Associated with Wohlfahrtiimonas chitiniclastica Blood Infection. *Cureus*. 2021;13(1):e12471. Doi:10.7759/cureus.12471
43. Guan J, Zhou W, Guo J, et al. A Wohlfahrtiimonas chitiniclastica with a novel type of blaVEB–1-carrying plasmid isolated from a zebra in China. *Front Microbiol*. 2023;14. Doi:10.3389/fmicb.2023.1276314
44. Zhang S, Cai Y, Meng C, et al. The role of the microbiome in diabetes mellitus. *Diabetes Research and Clinical Practice*. 2021;172. Doi:10.1016/j.diabres.2020.108645
45. Byarugaba DK, Erima B, Wokorach G, et al. Genome Sequence Analysis of a Wohlfahrtiimonas chitiniclastica Strain Isolated from a Septic Wound of a Hospitalized Patient in Uganda. *Microbiol Resour Announc*. 12(4):e00840-22. Doi:10.1128/mra.00840-22
46. Sugumar M, Kumar KM, Manoharan A, Anbarasu A, Ramaiah S. Detection of OXA-1 β-lactamase gene of Klebsiella pneumoniae from blood stream infections (BSI) by conventional PCR and in-silico analysis to understand the mechanism of OXA mediated resistance. *PLoS One*. 2014;9(3):e91800. Doi:10.1371/journal.pone.0091800
47. Yum S, Xu Y, Piao S, et al. Crystal structure of the periplasmic component of a tripartite macrolide-specific efflux pump. *J Mol Biol*. 2009;387(5):1286-1297. Doi:10.1016/j.jmb.2009.02.048

