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Abstract

(1) Background: Tungiasis is a cutaneous ectoparasitosis caused by the penetration of gravid female *Tunga penetrans* fleas into the epidermis. Although endemic in tropical and subtropical regions, it remains rare in Europe, where most cases are travel-associated and secondary household transmission is seldom documented. This study describes imported tungiasis in Greece and investigates possible secondary household transmission in a non-endemic setting. (2) Methods: Seven Greek men residing in Attica developed tungiasis following occupational exposure in Tanzania, together with one secondary case in a non-travelling household contact who had never travelled outside Greece. Diagnosis was based on clinical and dermoscopic findings and confirmed by amplification and sequencing of the mitochondrial cytochrome oxidase I (COI) gene. Household investigations were also performed. (3) Results: Eight male patients presented with painful plantar and/or subungual nodular lesions. Sequence analysis of COI demonstrated 657/662 bp (99%) identity with the *Tunga penetrans* reference sequence, and identical sequences were identified in all samples. All patients exhibited mild-to-moderate elevations of hepatocellular and cholestatic liver enzymes, which resolved within two weeks following treatment. Only one secondary household case was identified, and no infestation was detected among additional cohabitants or companion animals. (4) Conclusions: This report documents imported tungiasis with probable secondary household transmission in Greece and highlights the importance of clinical awareness and environmental assessment in non-endemic settings.

Keywords: *Tunga penetrans*; travel-associated infection; household transmission; dermoscopy; molecular identification; sub-Saharan Africa; Mediterranean region; zoonotic parasites; liver enzyme abnormalities

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1. Introduction

Tungiasis is a zoonotic parasitic disease affecting both animals and humans, caused by fleas of the genus *Tunga* (Siphonaptera: Tungidae). Of the 13 species currently described, most exhibit high host specificity and parasitize a single or a few closely related mammalian hosts, particularly rodents [1–4]. Among them, *Tunga penetrans* and *Tunga trimamillata* possess a broader host range and are the only species known to parasitize humans [5,6]. Both species are native to the Americas; however, *T. penetrans* has become widely established in sub-Saharan Africa following its historical introduction from Latin America [7].

Tungiasis is rare in Europe and North America but remains highly endemic in parts of sub-Saharan Africa, the Caribbean, and South America, where it represents significant public health concern. Infection is typically acquired through direct contact with infested sandy soil, often while walking barefoot in endemic environments such as beaches or peri-domestic areas [8,9].

Clinically, tungiasis is a cutaneous ectoparasitosis characterized by the penetration of fertilized female fleas into the host's epidermis, most commonly in the periungual or interdigital regions of the feet. Following penetration, the parasite undergoes hypertrophy (neosomy), with the abdomen increasing up to tenfold in size while producing up to 200 eggs. The embedded flea induces a localized inflammatory response, leading to painful nodular lesions that are frequently complicated by secondary bacterial infections. In endemic settings, repeated infestations may result in substantial morbidity, including chronic ulcerations, deformities, and impaired mobility [10].

In non-endemic regions such as Europe and North America, tungiasis is primarily diagnosed in travelers returning from tropical and subtropical areas. Reliable data on its true prevalence among travelers remain limited, as only a proportion of affected individuals seek medical attention or are referred to specialized centers. Nevertheless, available studies suggest that tungiasis is not uncommon among returning travelers. An airport-based survey of international tourists departing from Brazil reported a tungiasis prevalence of 3.2% [11], while a prospective study of 269 patients presenting with travel-associated dermatoses at a hospital in Paris identified tungiasis in 6% of cases [12].

The epidemiology of tungiasis reflects a complex interaction between human hosts, animal reservoirs, and environmental factors. In endemic settings, domestic and peridomestic animals, including dogs, cats, pigs, and rodents, play a key role in maintaining the parasite life cycle and sustaining environmental contamination [8,13,14]. The off-host developmental stages of *Tunga penetrans* occur in soil and are highly dependent on environmental conditions, including temperature, relative humidity, and substrate characteristics, which influence the survival and development of eggs, larvae, and pupae. Optimal development is generally associated with warm temperatures and moderate humidity, whereas excessive dryness or extreme heat may impair larval survival and disrupt the life cycle [13,15]. However, these ecological dynamics remain poorly characterized in non-endemic regions, where climatic conditions, housing environments, and host availability may differ substantially, potentially limiting sustained transmission.

Here, we report a case series of imported tungiasis in seven Greek men following occupational exposure in Tanzania, with subsequent involvement of a non-traveling household contact. This study highlights the potential for intra-household transmission in a non-endemic setting, underscores the importance of detailed travel history, clinical recognition, and dermoscopic evaluation, and describes the associated clinical and biochemical findings. In addition, environmental and household investigations, including assessment of companion animals and local climatic conditions, were conducted to explore possible transmission pathways. Molecular characterization of the isolated fleas through analysis of the mitochondrial cytochrome oxidase I (COI) gene further contributes to the limited molecular data available from imported cases in Europe.

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2. Materials and Methods

2.1. Patients and Clinical Evaluation

A case series of patients presenting with painful foot lesions compatible with tungiasis was identified among seven men who had worked in construction in Tanzania for approximately six months. All seven men returned to Greece in early June 2023. Two additional co-workers returned at the same time but did not report any symptoms and were therefore not clinically evaluated.

Among the seven male patients, one 51-year-old man cohabited with two non-traveling adult male partners (aged 42 and 40 years) in the same household. The 42-year-old cohabitant was subsequently evaluated after developing a compatible lesion approximately 30–35 days following the patient's return.

In total, eight male patients were included in the study. Clinical evaluation comprised detailed travel history, physical examination, and dermoscopic assessment. Dermoscopy was performed using a handheld dermoscope (DermLite DL4, 3Gen Inc., USA) at ×10 magnification under both polarized and non-polarized illumination, in accordance with established dermoscopic criteria for tungiasis [13,16].

The temporal sequence of clinical events and interventions is summarized in Table 1.

Table 1. Timeline of key clinical and environmental interventions in the case series.

Date	Event
3 June 2023	Return of seven workers from Tanzania to Greece
6-8 June 2023	Seven patients presented to the hospital, underwent clinical evaluation, and received treatment
13-17 June 2023	Application of antiparasitic spray in household environments, as reported by the patients
20-23 June 2023	Clinical follow-up of the seven patients at the hospital
10 July 2023	Presentation, clinical evaluation, and treatment of the eighth case (non-traveling household contact)
14 July 2023	First household visit to premises with outdoor areas; clinical assessment and antiparasitic treatment of companion animals
15 July 2023	Re-application of antiparasitic spray in the visited household environment
25 July 2023	Clinical follow-up of the eighth patient at the hospital
28 July 2023	Second household visit (follow-up) to premises with outdoor areas

2.2. Laboratory Investigations

All patients underwent routine laboratory testing at presentation, including complete blood count (CBC) and serum biochemical analysis. Hematological parameters were measured using an automated hematology analyzer (Sysmex XN-1000, Sysmex Corporation, Japan). Biochemical analyses, including liver function tests, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), and gamma-glutamyl transferase (γGT), were performed using an automated chemistry analyzer (Cobas 8000 modular analyzer series, Roche Diagnostics, Germany), following the manufacturer's standardized protocols.

Quality control procedures were performed daily using commercial control sera to ensure analytical accuracy. Follow-up laboratory testing was conducted 14 days after treatment to assess normalization of biochemical parameters.

2.3. Household Investigation

Household investigations were conducted for patients reporting residence in homes with outdoor areas (yards or surrounding land) and/or the presence of companion animals. These

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households were visited, and the domestic environment was assessed, including indoor-outdoor interfaces and peri-domestic conditions.

Meteorological data were derived from publicly available regional datasets and are presented as representative values for coastal Attica during the study period.

Cohabiting household members were clinically assessed at their residence on two occasions, 14 days apart, during July-August 2023 by a qualified dermatologist (T.F.). Companion animals were examined by an experienced veterinarian (G.C.) for the presence of ectoparasitic lesions consistent with tungiasis or other infestations.

2.4. Treatment and Follow-Up

Following clinical assessment, all patients underwent surgical extraction of the embedded parasites as part of routine clinical management. The procedure was performed under aseptic conditions and local anaesthesia (lidocaine HCl 1%) and involved careful enlargement of the central opening using a sterile needle or scalpel, followed by complete removal of the parasite and surrounding necrotic tissue, with care taken to avoid rupture and secondary inflammation. Parasite material obtained during extraction was collected under sterile conditions and preserved in 70% ethanol until molecular analysis.

Topical ivermectin (1% cream) was applied locally following extraction. In addition, a single oral dose of ivermectin (200 μg/kg body weight) was administered as adjunctive therapy, in accordance with previously reported management approaches [11,13].

Environmental control measures were recommended, including spraying of household and yard areas with a phoxim solution (0.05%) [17]. In households with companion animals, topical ivermectin (0.5% pour-on formulation) was applied percutaneously at a dose of 500 μg/kg body weight (1 mL/10 kg) [18].

Clinical follow-up of the patients was performed at 7 and 14 days post-treatment.

2.5. Molecular Analysis

Genomic DNA was extracted from parasite material using a phenol-chloroform protocol as described by Sambrook and Russell [19], with minor modifications. DNA concentration and purity were assessed using a NanoDrop 2000 spectrophotometer (Thermo Fisher Scientific, USA), and DNA integrity was verified by agarose gel electrophoresis.

A fragment of the mitochondrial cytochrome oxidase I (COI) gene was amplified by polymerase chain reaction (PCR) using the universal primers LCO1490 (5′-GGTCAACAAATCATAAAGATATTGG-3′) and HCO2198 (5′-TAAACTTCAGGGTGACCAAAAAATCA-3′), as originally described by Folmer et al. (1994). PCR reactions were performed in a total volume of 25 μL containing 1× PCR buffer, 2.0 mM MgCl2, 200 μM of each dNTP, 0.4 μM of each primer, 1 U Taq DNA polymerase (Invitrogen, USA), and 50–100 ng of template DNA.

Thermal cycling conditions included an initial denaturation at 94 °C for 5 min; followed by 35 cycles of denaturation at 94 °C for 30 s, annealing at 50 °C for 30 s, and extension at 72 °C for 1 min; with a final extension at 72 °C for 7 min.

PCR products were separated on a 1.5% agarose gel stained with ethidium bromide and visualized under UV illumination. Amplicons were purified using a commercial PCR purification kit (Qiagen, Germany) and sequenced bidirectionally (Eurofins Genomics, Germany). Forward and reverse sequences were assembled and manually edited using BioEdit software (version 7.2.5).

Species identification was performed using the BLAST algorithm against the GenBank database.

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2.6. Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients for diagnostic procedures, molecular analysis, and publication of anonymized clinical data and images. According to institutional policy, formal ethics committee approval was not required for this case series.

3. Results

All eight patients, including seven men with recent travel history to Tanzania and one non-traveling household contact, presented with painful plantar and/or subungual nodular lesions. The patients commonly reported moderate pruritus and a sensation of a foreign body in the affected area. Clinically, the lesions were typically yellowish and characterized by a central dark punctum surrounded by a mildly erythematous halo (Figure 1A–C). No lower limb edema or regional lymph node enlargement was detected during clinical examination.

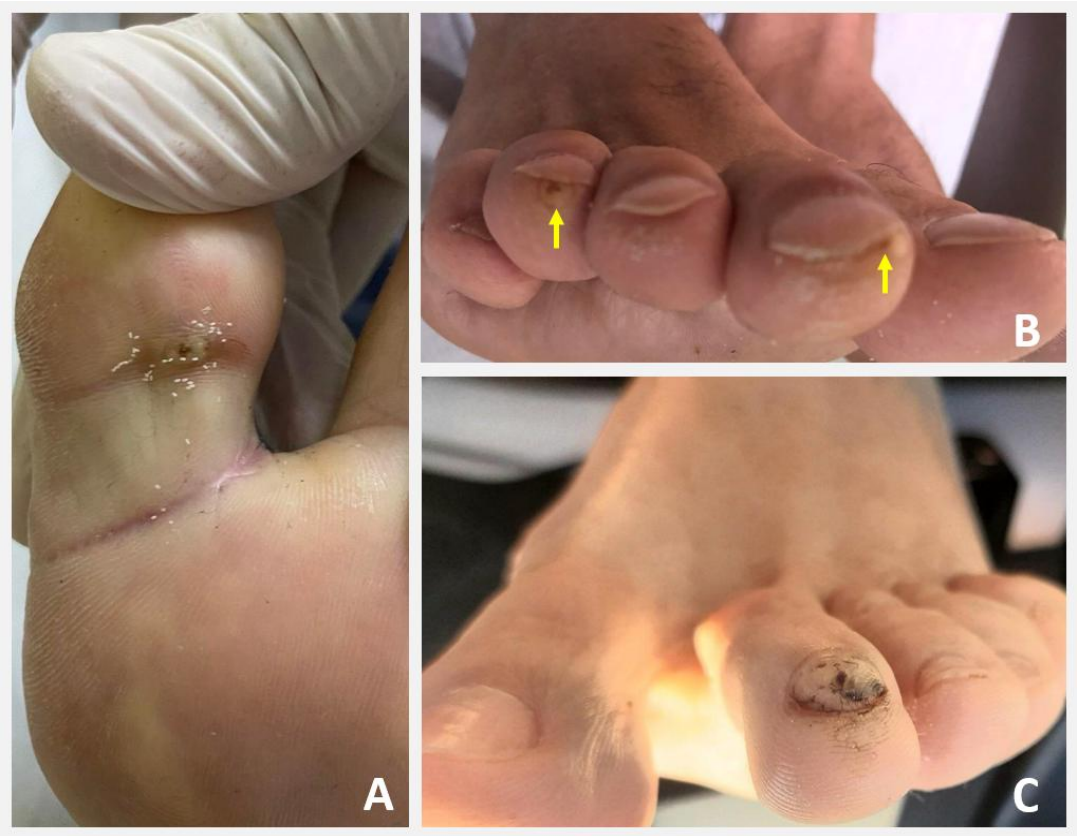

Figure 1. Clinical presentation of tungiasis lesions on the feet. (A) Single plantar lesion on the left hallux, with parasite eggs visible on the adjacent skin surface. (B) Periungual lesions affecting the 2nd and 4th toes of the right foot (yellow arrows). (C) Subungual lesion on the 2nd toe of the left foot.

Dermoscopy consistently revealed a central brown crateriform structure surrounded by a peripheral yellowish halo and a distinct pigmented ring. In several lesions, multiple whitish ovoid structures corresponding to parasite eggs were identified, further supporting the clinical diagnosis of tungiasis (Figure 2). Notably, in patients who had been wearing socks prior to clinical evaluation, a more pronounced accumulation of parasite eggs on the skin surface of the feet was observed. In our clinical experience, this finding facilitated both suspicion and confirmation of the diagnosis.

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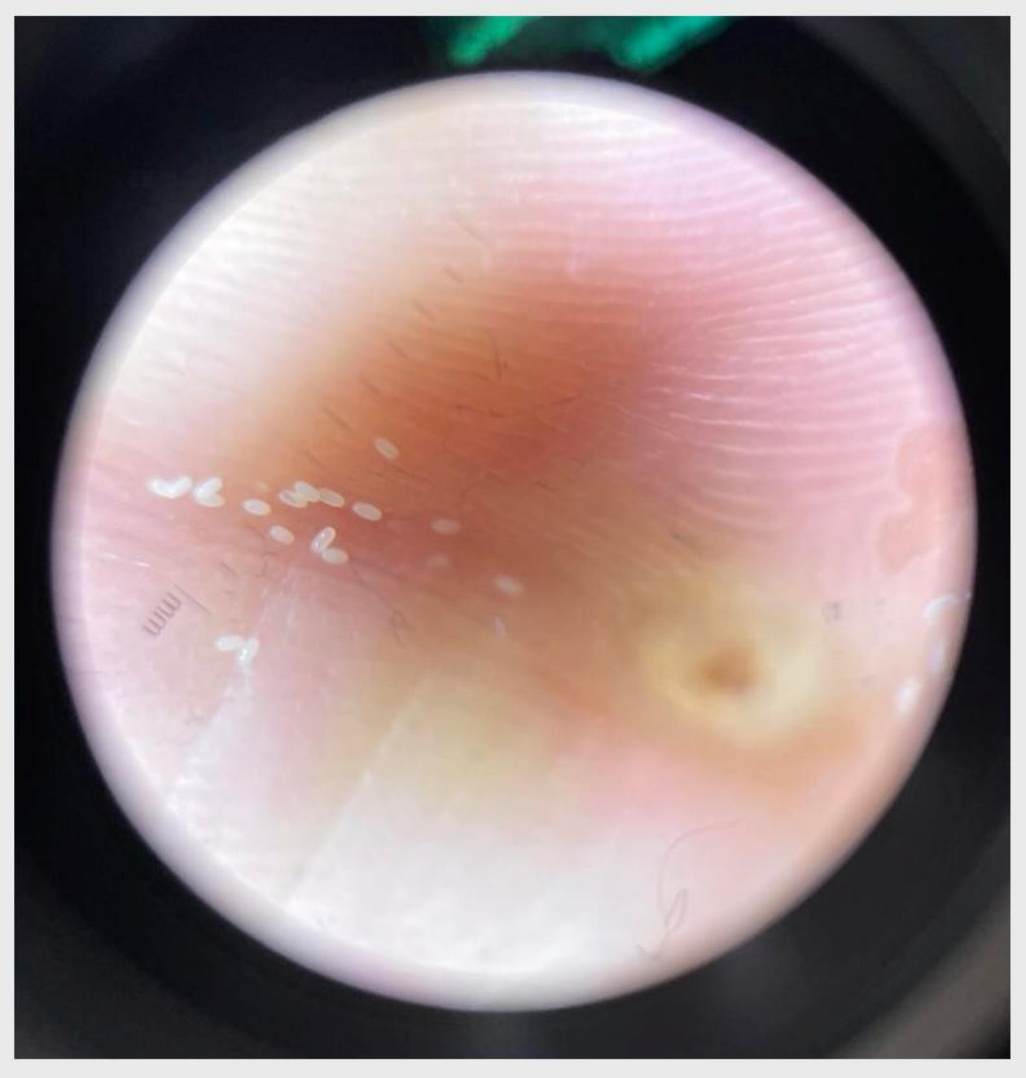

Figure 2. Dermoscopic appearance of a tungiasis lesion. A central brown crateriform structure is visible, surrounded by a peripheral yellowish halo and a distinct pigmented ring. Several parasite eggs are attached to the adjacent plantar skin surface.

In the non-traveling household contact, a single lesion was identified in the subungual region of the second toe of the left foot (Figure 1C). The absence of travel history, together with compatible clinical and dermoscopic findings, supports secondary household transmission.

Across the case series, lesions were confined to the feet, predominantly affecting plantar and periungual regions. The number and anatomical distribution of lesions per patient are summarized in Table 2.

Table 2. Distribution and number of lesions in male patients with imported tungiasis.

Patient	Age (years)	Travel history	Number of lesions	Anatomical location(s)
P1	55	Yes (Tanzania)	3	Left hallux (plantar); right foot, 2nd and 4th toes (subungual)
P2	60	Yes (Tanzania)	2	Plantar surface, right foot
P3	51	Yes (Tanzania)	1	Left hallux (subungual)
P4	18	Yes (Tanzania)	2	Plantar region, bilateral feet
P5	21	Yes (Tanzania)	1	Right foot, periungual region
P6	45	Yes (Tanzania)	2	Left foot, plantar and periungual regions

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P7	64	Yes (Tanzania)	1	Right hallux (subungual)
P8*	42	No	1	Left foot, 2nd toe (subungual)

*P8 represents the non-traveling household contact.

Routine laboratory testing revealed mild-to-moderate elevations of liver enzymes in all patients, involving both hepatocellular (AST, ALT) and cholestatic (ALP, γGT) parameters, without a consistent biochemical pattern. Complete blood count findings and other biochemical parameters remained within reference ranges. Detailed liver enzyme findings at presentation and follow-up are presented in Table 3. Notably, none of the patients exhibited fever or leukocytosis.

Table 3. Liver Enzyme Findings in Patients with Tungiasis at Presentation and Follow-up.

Patient	**AST (U/L)**		**ALT (U/L)**		**ALP (U/L)**		**γGT (U/L)**	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
P1	82	32	96	38	165	114	88	42
P2	68	30	74	35	140	105	52	40
P3	45	28	62	33	120	98	40	35
P4	95	36	110	62	180	120	102	50
P5	38	30	48	34	155	108	60	38
P6	72	34	85	37	135	102	70	41
P7	55	29	60	32	125	100	45	36
P8	50	27	58	34	115	110	85	35
Mean (SD)	63 (20)	31 (3)	74 (21)	38 (10)	142 (23)	107 (7)	68 (22)	40 (5)

Abbreviations: AST, aspartate aminotransferase; ALT, alanine aminotransferase; ALP, alkaline phosphatase; γGT, gamma-glutamyl transferase. **Reference ranges (adults):** AST: 10–40 U/L; ALT: 7–56 U/L; ALP: 44–147 U/L; γGT: 9–48 U/L. **Note:** Pre = at presentation; Post = 14 days after treatment.

Clinical follow-up at 7 and 14 days post-treatment demonstrated uncomplicated healing of the lesions, with no evidence of new lesions or secondary complications. Laboratory reassessment at 14 days confirmed normalization of the previously elevated liver enzyme levels (Table 3).

3.1. Molecular Findings

Eight samples, one from each patient, were subjected to molecular analysis. PCR amplification of the mitochondrial cytochrome oxidase I (COI) gene yielded a single amplicon of the expected size in all analyzed samples, while negative controls showed no amplification.

BLAST analysis demonstrated 657/662 bp (99%) nucleotide identity with the Tunga penetrans reference sequence (GenBank accession no. PV426769), confirming species identification. Identical sequences were obtained from all samples, suggesting a common source of infestation.

The representative sequence was deposited in GenBank under accession number PZ336383.

3.2. Household Investigation

Two of the seven male patients reported residing in houses with outdoor areas (backyards), including the patient associated with secondary household transmission. The same two patients also reported keeping companion animals.

Both households were in coastal areas of Attica. One was situated in the seaside area of Megara (western Attica), while the other -associated with secondary transmission- was in Porto Rafti, an Aegean coastal settlement in eastern Attica. Both settings were characterized by peri-domestic environments with direct contact between indoor and outdoor spaces.

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Environmental conditions during the study period (June-July 2023) were typical of the Mediterranean summer, with high ambient temperatures, moderate relative humidity, and minimal precipitation. Detailed meteorological data are presented in Table 4.

Table 4. Mean temperature and relative humidity in coastal Attica (Megara and Porto Rafti) during June–July 2023.

Month	Mean Temperature (°C)	Temperature Range (°C)	Mean Relative Humidity (%)	Humidity Range (%)	Precipitation (mm)
June 2023	28–30	20–34	50–55	35–70	~10
July 2023	31–33	24–42	40–50	25–65	~5–8

Source: Hellenic National Meteorological Service (HNMS) and National Observatory of Athens (meteo.gr), representative data for coastal Attica.

The first household consisted of a couple (the patient and his spouse) and two children aged 5 and 7 years. The household kept a single dog, which spent most of its time outdoors but had unrestricted access to indoor areas.

The second household, in which secondary transmission was observed, consisted of the patient and two adult male cohabitants. One dog and two cats were present in the household, all with unrestricted access to both indoor and outdoor areas.

Both premises consisted of modern residential houses of recent construction, built with concrete and cement materials and featuring cemented flooring. Each property included a surrounding outdoor area, part of which was landscaped and maintained as a flower garden.

All household members who did not present to the hospital (the spouse and two children in the first household and one adult male in the second household) were clinically examined during two visits conducted two weeks apart in July 2023. Similarly, all pets (two dogs and two cats) were examined at the same time points. No clinical evidence of tungiasis or other ectoparasitic infestation was observed in either humans or animals at either examination.

3.3. Treatment Outcome and Follow-Up

All patients underwent surgical extraction of the embedded parasites. Clinical follow-up demonstrated uncomplicated healing of the lesions, with no evidence of secondary infection or recurrence.

Liver enzyme abnormalities were transient, with all measured parameters returning to within reference ranges within two weeks following treatment (Table 3).

4. Discussion

Tungiasis remains an uncommon but increasingly recognized travel-associated dermatosis in non-endemic regions such as Europe [20–24]. In this context, the present case series highlights not only the occurrence of imported infection following travel to Tanzania, but also the potential for secondary household transmission under specific environmental conditions. These findings contribute to the limited evidence on the epidemiology and transmission dynamics of tungiasis outside endemic settings [13,25].

In non-endemic regions, tungiasis poses significant diagnostic challenges due to its rarity and the consequently low level of clinical suspicion, often leading to misdiagnosis as a bacterial infection, wart, or foreign body [11,13,22]. In the present series, the clinical manifestations were consistent with previous reports, with lesions predominantly localized to plantar and periungual regions and characterized by nodular morphology, a central punctum, and surrounding inflammation. Dermoscopy has substantially improved diagnostic accuracy by enabling visualization of

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characteristic features such as the central pore, pigmented ring, and whitish ovoid structures corresponding to parasite eggs, which are considered diagnostic hallmarks [10,13,26]. The consistent dermoscopic findings observed in our cases further support its value as a rapid and non-invasive diagnostic tool in non-endemic settings. In our study, the most prominent clinical feature of the infestation was the presence of parasite eggs, with a notably increased accumulation in the skin of the feet among patients who were wearing socks prior to clinical examination, a finding that facilitated clinical recognition.

This study further expands the epidemiological understanding of tungiasis in Europe by documenting probable secondary household transmission. Although *T. penetrans* is not transmitted directly between humans, eggs expelled from embedded fleas can contaminate the domestic environment. Under suitable environmental conditions, these eggs may develop into infective stages capable of reinfesting humans. While this transmission cycle is well established in endemic settings, it has not, to our knowledge, been documented in non-endemic regions, where most reported cases remain travel-associated [12,13,27]. The temporal relationship between the returning traveler and lesion development in the non-traveling cohabiting partner supports this indirect transmission mechanism.

Environmental conditions are key determinants of the off-host development of *Tunga penetrans.* The life cycle depends on warm temperatures and adequate soil humidity, with optimal development generally occurring at approximately 25–31 °C and moderate moisture levels that prevent desiccation of eggs and larvae [13,28]. Conversely, excessively dry conditions or extreme temperatures can impair the survival of immature stages and interrupt the life cycle [15,29].

In the present study, the household associated with secondary transmission was in a coastal area of Attica (Porto Rafti), where climatic conditions during June-July 2023 (Table 4) were characterized by high temperatures, moderate relative humidity, and minimal precipitation, including a heatwave period with temperatures exceeding 40 °C. These conditions may have been partially permissive for limited off-host development, particularly in sheltered peri-domestic microhabitats. However, extreme temperatures and reduced soil moisture likely constrained larval survival, limiting the establishment of a sustained environmental reservoir. In addition, the timely implementation of control measures, including the application of environmental antiparasitic spray and prophylactic treatment of companion animals, may have further reduced environmental contamination and interrupted the parasite life cycle. The combined effect of these environmental constraints and intervention measures may explain the occurrence of only a single secondary case, despite close and prolonged cohabitation among household members with comparable levels of environmental exposure, including shared use of living spaces and frequent contact with indoor surfaces. These findings further support evidence that microclimatic conditions, together with local intervention measures, rather than macroclimate alone, play a decisive role in transmission dynamics [13].

The household investigation provides additional insight into human-animal-parasite interactions in a non-endemic setting. Despite the presence of companion animals in two households, none of the examined pets (two dogs and two cats) showed clinical evidence of tungiasis. This finding is noteworthy, given that dogs, pigs, and rodents are recognized reservoirs in endemic regions [13,14]. The absence of infestation in pets, despite the lack of prior ectoparasite prophylaxis, suggests that under the observed environmental conditions, companion animals may not have played a significant role as hosts. This is encouraging, as it indicates that the conditions required for sustained transmission and endemic establishment are unlikely to be readily met in this setting.

Several factors may account for this observation. Environmental contamination may have been limited, thereby reducing exposure risk. In addition, behavioral factors, such as grooming habits and patterns of contact with infested substrates, may influence host susceptibility. Host preference may also vary according to ecological context, with humans potentially acting as more exposed hosts in peri-domestic environments in non-endemic areas [6]. Although these interpretations remain speculative due to the small sample size, they highlight the complexity of transmission dynamics outside endemic regions.

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Management in all cases consisted of surgical extraction combined with topical and systemic ivermectin, resulting in resolution without recurrence. Surgical removal remains the standard approach in cases with limited lesion burden, while adjunctive ivermectin may enhance parasite eradication and reduce the risk of residual infestation [11,13].

Molecular confirmation using COI gene sequencing further strengthened diagnostic accuracy. The obtained sequence demonstrated 99% identity with the reference T. penetrans mitochondrial genome (GenBank accession no. PV426769). Identical sequences among the analyzed samples support a common source of infestation and are consistent with intra-household transmission. The COI gene was selected as the standard DNA barcode marker for arthropod species identification, owing to its high interspecific variability and extensive representation in public databases [30–32]. Although COI data for *T. trimamillata* are not currently available in GenBank, differentiation from this species was not considered essential, given the epidemiological context of exposure in Tanzania, where T. penetrans is endemic, whereas *T. trimamillata* has been reported primarily in Latin America.

An additional finding of interest was the presence of mild-to-moderate elevations of both hepatocellular and cholestatic liver enzymes in all patients (Table 2). Given that tungiasis is a strictly cutaneous ectoparasitosis without known hepatic tropism, direct liver involvement appears unlikely. A more plausible explanation is a transient systemic inflammatory response. Pro-inflammatory cytokines, such as interleukin-6 and tumor necrosis factor-a, are known to influence hepatocellular function and bile secretion and may account for the observed biochemical abnormalities [33,34]. Similar transient enzyme elevations have been described in inflammatory conditions without primary liver disease [35]. The rapid normalization of liver enzyme levels following parasite removal supports a reversible, functional disturbance. To our knowledge, such alterations have not been systematically reported in tungiasis and may represent an underrecognized aspect of the host response.

Overall, this report underscores the importance of considering tungiasis in the differential diagnosis of nodular or subungual lesions in travelers returning from endemic regions. It also highlights the need to examine close household contacts and to consider environmental factors when evaluating potential secondary transmission.

5. Conclusions

Imported tungiasis remains an uncommon but clinically relevant parasitosis in Europe. This case series documents infection acquired in Tanzania, with subsequent secondary household transmission in Greece, confirmed by molecular identification.

In non-endemic settings, timely diagnosis relies on clinical awareness, detailed travel history, and the use of dermoscopy. Environmental conditions, particularly temperature and humidity, may permit limited local transmission but are unlikely to support sustained parasite establishment. In addition, timely intervention measures, including environmental disinfection and antiparasitic treatment of companion animals, may further reduce environmental contamination and interrupt the parasite life cycle.

Preventive measures, including the use of protective footwear and attention to environmental hygiene, remain essential. Further studies are needed to clarify the relative contributions of environmental factors, host-related characteristics, and intervention measures, including the role of domestic animals, in shaping transmission dynamics outside endemic areas.

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Institutional Review Board Statement: Ethical review and approval were waived for this study because it involved only patients who voluntarily presented to the hospital for routine clinical evaluation and treatment, without the application of additional experimental procedures or interventions beyond standard medical care. Clinical examination of companion animals was limited to routine non-invasive veterinary assessment and caused no distress or harm. All procedures involving human participants were conducted in accordance with the principles of the Declaration of Helsinki.

Informed Consent Statement: Written informed consent has been obtained from the patients to publish this paper.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

COI	Mitochondrial cytochrome oxidase I
AST	Aspartate aminotransferase
ALT	Alanine aminotransferase
ALP	Alkaline phosphatase
γGT	Gamma-glutamyl transferase

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