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Dermanyssus gallinae in non-avian hosts: A case report in a dog and review of the literature

Barbara Moroni [a,*], Alessandra Barlaam [b,c], Ambra Lisa Misia [d], Andrea Peano [a], Luca Rossi [a], Annunziata Giangaspero [b]

[a] Department of Veterinary Sciences, University of Turin, Largo Braccini 2, 10095 Grugliasco, Italy
[b] Department of Agriculture, Food, Natural Resources and Engineering (DAFNE), University of Foggia, 71121, Italy
[c] Faculty of Veterinary Medicine, University of Teramo, 64100 Teramo, Italy
[d] Department of Veterinary Science, University of Perugia, Via S. Costanzo 4, 06126, Perugia, Italy

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ABSTRACT

Non-avian attacks of the worldwide distributed mite *Dermanyssus gallinae* are occasionally reported. However, it is widely accepted that their occurrence is underestimated. The present study aims to describe the first Italian case of dermanyssosis in a dog, to molecularly characterize the mites collected from the patient and the animal enclosure, where poultry and dog were confined, and to review the current literature on the non-avian attacks by *D. gallinae*. The dog was successfully treated with an oral sarolaner-based product, followed by a spot-on formulation of imidacloprid and moxidectin. The infestation source was likely attributable to poultry and confirmed by molecular identification of *D. gallinae sensu strictu*.

Ten articles on non-avian *D. gallinae* attacks in domestic animals and wildlife were retrieved, pointing out the need for more awareness amongst practitioners. The therapeutic effect of available antiparasitic drugs, currently used off-label, should also be better explored in non-avian hosts.

1. Introduction

Dermanyssus gallinae, also known as the poultry red mite (PRM), is a worldwide distributed blood-sucking ectoparasite affecting primarily farmed birds (*e.g.*, chickens, turkeys, and ducks), but also wild and synanthropic birds (*e.g.*, pigeons, sparrows, starlings, doves). However, non-avian attacks of the PRM have been described in several mammals, including humans [1]. This parasitosis is commonly referred to as dermanyssosis or gamasoidosis [2].

Hosts are found by chemical, mechanical and temperature-dependent signals [3,4], and all warm-blooded animals are considered attractive preys. Nonetheless, the role of *D. gallinae* as primary parasitic agent in mammals is debated.

Cross-transmission between birds and mammals is generally deemed as an occasional event reported in rural areas where poultry live in proximity of other farmed animals [5], or as an accidental encounter between household pets and synanthropic birds living in the eaves of the roofs or nearby the windows [6], mostly in urban contexts.

Recently, two cases of severe *D. gallinae* infestation with chronic anemia have been described in domestic cats [6], and PRM-related dermatitis was also recorded in domestic dogs [7,8]. Moreover, IgE sensitization towards *D. gallinae* was reported in dogs with no clinical signs, living close to PRM-infested poultry pens [9]. These findings stress the need to increase awareness about the role of the PRM in domestic mammals. Interestingly, recent molecular investigations have revealed that *D. gallinae* is a species complex including at least two cryptic species, associated respectively to poultry (*D. gallinae sensu strictu*) and to synanthropic birds (*D. gallinae* L1) [10–12]. However, only few cases of infestation in non-avian hosts were characterized at a molecular level [13,14].

This article aims to: i) describe the first case of avian dermatitis in a dog from Italy; ii) report the molecular characterization of the collected mites; iii) review the literature on PRM infestation in non-avian animal hosts.

2. Materials and methods

In May 2020, a 3-year-old male, non-neutered Maremmano

* Corresponding author.
E-mail addresses: barbara.moroni@unito.it (B. Moroni), alessandra.barlaam@unifg.it (A. Barlaam), ambralisa@hotmail.it (A.L. Misia), andrea.peano@unito.it (A. Peano), luca.rossi@unito.it (L. Rossi), annunziata.giangaspero@unifg.it (A. Giangaspero).

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sheepdog was referred to a private clinic in Marsciano, in the province of Perugia, Italy, for a generalized severe pruritus and skin lesions. The dog lived in a rural area on a family-owned hobby poultry farm and had been regularly vaccinated and seasonally treated with an antiparasitic spot-on.

During the dog clinical examination, an extensive erythematous lesion on the lumbosacral and tail/limb areas was recorded, and numerous (from white to red) mites were distinctly noticed crawling on the dog fur (Fig. 1). No other ectoparasites were seen on the dog.

Because of the aggressive attitude of the dog, the veterinarian was only able to collect one mite from the dog's fur through an adhesive tape. No blood samples or further clinical investigations were possible.

The veterinarian prescribed a single oral administration of a sarolaner-based product (Simparica®, Zoetis, Louvain-la-Neuve, Belgium) and, after two weeks, a spot-on formulation of imidacloprid and moxidectin (Advocate, Bayer). Moreover, an oral amoxicillin-clavulanic acid 20 mg/kg once a day for one week was also prescribed to control possible secondary bacterial infections.

A direct inspection of the site, where the infestation occurred, showed that the dog-kennel, and the poultry pen were adjacent and located in a single animal enclosure, only separated by a wire mesh fence (Fig. 2).

The mites were collected in the animal enclosure by sticky bands placed in the poultry pen and the adjacent dog kennel, for 24 h.

The mite collected from the dog and eight of the mites collected from the animal enclosure were placed in 70% ethanol and sent to the Parasitology laboratory of the Department of Agriculture, Food, Natural Resources and Engineering (DAFNE), University of Foggia, Italy. In the laboratory, the mite from the infested dog and the other eight mites collected were first observed under a stereomicroscope (Zeiss Discovery V12, Germany); then, one of the mites collected from the animal enclosure was placed in lactophenol at 45 °C on hot plate and after one week was put on a slide and observed under the light microscope (Axio Zeiss Imager A1, Germany). The specimen was morphologically examined using the identification keys by Di Palma [15] with a magnification of up to 10×.

The mite collected from the dog and four uningorged mites collected in the animal enclosure were molecularly tested.

Genomic DNA was extracted using the Nucleospin Tissue kit (Macherey-Nagel, Amsterdam, The Netherlands) according to the manufacturer's instructions. The DNA was stored at −20 °C pending further molecular testing.

A conventional PCR assay was used to amplify a 710-bp gene fragment of the *CO1* (cytochrome *c* oxidase subunit I) gene-based DNA barcode using the primers LCO1490 (5′-GGTCAACAAATCATAAAGATATTGG-3′) and HCO2198 (5′-TAAACTTCAGGGTGACCAAAAAATCA-3′) [16].

All PCR amplifications were performed in a 2720 Thermal Cycler T3000 (Applied Biosystems, Foster City, California, USA). Reactions were performed in a final volume of 25 µl containing 10 µl of DreamTaq Green PCR Master Mix (Thermo Fisher Scientific, Waltham, MA, USA), 1 µl of each primer (10 pmol/µl), 5 µl of extracted DNA and 8 µl of sterile water. One negative control (PCR grade water) was included in each experiment.

The PCR protocol was as follows: 1 min at 94 °C followed by five cycles of 94 °C for 1 min, 45 °C for 1.5 min, and 72 °C for 1.5 min followed by 35 cycles of 94 °C for 1 min, 50 °C for 1.5 min, and 72 °C for 1 min with a final extension step of 72 °C for 8 min [31].

The PCR products were run on 2% agarose gel stained with SYBR Safe DNA Gel Stain (Thermo Fisher Scientific, Waltham, MA, USA) and visualized under a UV transilluminator.

Purification and sequencing of PCR products with the described universal primers (in both forward and reverse directions) were performed by Eurofins MWG Operon (Ebersberg, Germany). The sequences generated were edited and aligned manually using Geneious version 2020.0.5 (https://www.geneious.com) and compared with *D. gallinae* DNA barcode sequences available in GenBank database using Nucleotide BLAST (http://blast.ncbi.nlm.nih.gov/Blast.cgi).

The most representative sequence obtained from the mite collected from the dog was submitted to GenBank.

A literature review was performed searching and selecting relevant research papers through three electronic databases (Scopus, Web of Science and Google Scholar) until January 2021 with no time and language limits. The search strategy included the key terms: *Dermanyssus gallinae*, Poultry Red Mite, dermanyssosis, gamasoidosis AND dog, cat, horse, livestock, animals, mammals, non-avian attacks, wildlife. Publications were also obtained *via* Web and interlibrary services. We screened titles and abstracts, and identified articles for their relevance to the present topic. Articles on experimental infestation were excluded.

3. Results

Itch and dermatitis were solved entirely in two weeks after the treatment, and no further mites were seen on the dog's fur.

Collected mites measured between 0.7 and 1.1 mm in length and, based on the main morphological features - the anal shield roughly D-shaped, with the anal opening in the lower half and surrounded by three setae and the dorsal shield posteriorly tapering, with a truncate margin - all the observed mites were identified as *Dermanyssus gallinae*.

Two samples (the mite isolated on the dog and one out of the four mites collected in the animal enclosure) gave clear bands that matched with the estimated PCR product sizes on the agarose gel, and the

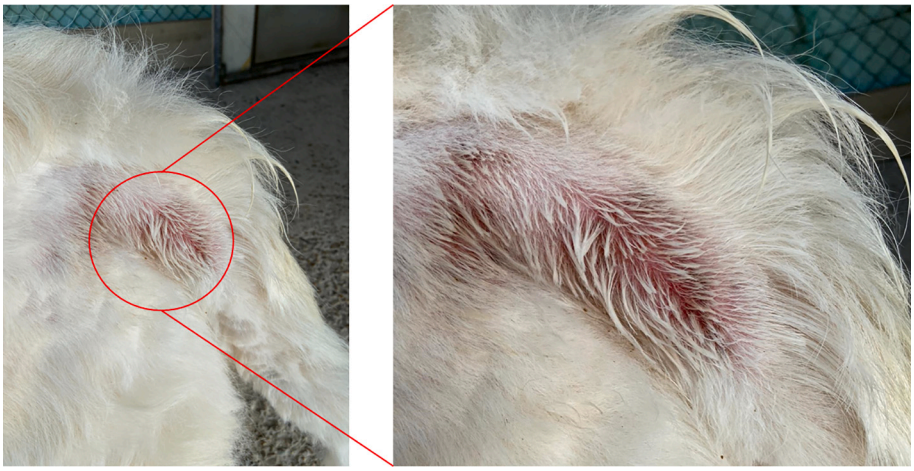

Fig. 1. Skin lesions on the tail/limb area with a closer view on the erythematous area.

Fig. 2. View of the animal enclosure: on the left, the poultry pen, and on the right, the dog-kennel.

molecular BLASTn analysis showed that the sequences matched with *D. gallinae sensu strictu*. The other three mites gave positive results, however, the bands on the agarose gel were weak and non-interpretable sequences were obtained from these samples.

The most representative *D. gallinae* sequence belonging to the dog was deposited in GenBank under accession number: MW315199.

As to the literature, ten publications on non-avian *D. gallinae* attacks in domestic animals, wildlife or livestock were found. Seven publications were on pet animals, one on goats, one on house mice and one on captive coypu (see Table 1).

4. Discussion

There is a broad consensus on the host-specificity of obligatory

Table 1
Reported cases of non-avian *Dermanyssus gallinae* attacks in animals.

Host species	Country	Skin lesions and sites	Blood-feeding activity	Source	Molecular identification	Transmission to humans	Treatment	Reference
Dog (*Canis lupus*)	Italy	(++) lumbosacral, tail	(+)	Poultry	*D. gallinae sensu strictu*	No	Oral sarolaner	Present study
Dog (*Canis lupus*)	Brazil	(+) lumbosacral	NA	Pigeons	NP	No	Topic fipronil /prednisone	Friesen et al. [24]
Dog (*Canis lupus*)	Belgium	(++) Head, lumbosacral, tail	(+)	Poultry	NP	No	Acaricide shampoo	Declercq and Nachtegaele [8]
Dog (*Canis lupus*)	New Zealand	A	(−)	Poultry or quail hunting	NP	No	Maldison powder dusting	Ramsay et al. [7]
Cat (*Felis catus*)	Italy	A	(+)	Poultry	NP	No	Selamectin solution (6%)	Di Palma et al. [6]
Cat (*Felis catus*)	Italy	(++) abdomen, around mammae	NA	[31]Pigeons	NP	No	Selamectin solution (6%) - 2 times/oclacitinib 1 mg/kg orally	Di Palma et al. [6]
Cat (*Felis catus*)	USA	NA	NA	NA	NP	Yes	Selamectin	Guin [30]
Horse (*Equus caballus*)	Belgium	(++) muzzle, forehead, hind legs	A/ NA	Poultry	NP	No	2% permethrin solution spraying	Mignon and Losson [22]
Pet gerbil (*Meriones unguiculatus*)	Colorado, USA	A	NA	Poultry	NP	Yes	Acaricide fumigation of the house	Lucky et al. [2]
Coypu (*Myocastor coypus*)	Poland	(++) axilla	NA	Wild birds	NP	No	NP	Gibasiewicz [25]
House mice (*Mus musculus*)	Iran	Generalized	NA	poultry	NP	NA	NP	Allymehr et al. [27]
Goat (*Capra hircus*)	Malaysia	NA	NA	NA	NP	NA	NP	Dorny et al. [26]

Skins lesions were classified in severe (++), mild (+) and absent (A), and the localization was also specified. The blood-feeding activity of the mite was classified in documented (+), none (−) or not available (NA). The source of the infestation is intended as the avian host species primarily involved. Molecular identification of the mites was also recorded, when applicable. NP: not provided.

parasitic mites, including most of the 25 *Dermanyssus* species [17]. Nevertheless, some mite species show a variable level of plasticity and host-jumps have been reported under specific circumstances, such as the simultaneous presence of multiple potential host species in the same environment [18–20].

Such occurrence is deemed as the most common for non-avian attacks of *D. gallinae*, and cases of host "switching" from poultry/synanthropic birds to domestic animals, or humans have been described throughout the last decade [1,5].

In the present study, the dog infestation source would seem associated with the immediate proximity of the dog-kennel to the poultry pen. However, at first, we could not exclude a different avian source of infestation. Indeed, *D. gallinae s.s.* has been associated with several bird orders, such as Anseriformes, Columbiformes, Coraciiformes, Galliformes, Passeriformes and Strigiformes [21]. On the contrary, *D. gallinae* L1 has shown a much more restricted host spectrum and it is currently exclusively associated with pigeons [10].

In the present case report, the mite retrieved on the dog (*D. gallinae s.s*) and the ones collected from the animal enclosure molecularly match and belong to the same lineage, thus corroborating the likely source of the infestation at the genetic level. To the best of our knowledge, this is the first molecular report of *D. gallinae s.s.* collected from a dog.

Dermanyssus gallinae is the most damaging ectoparasite of laying hens particularly in Europe and it is considered "endemic" in poultry houses, regardless of the farming system (caged, sheds and free-range, traditional and organic), and in both, industrial and rural farms, including hobby farms. In these settings, the PRM live in cracks and crevices of the walls, cages, roosts, bird nests, where it can easily hide in the daytime, and attacks the host during the night for a blood meal [4].

The temporary activity of the parasite on non-avian hosts may generate frequent misdiagnosis and clinical relapse of symptoms, as it is not uncommon for both human and vet clinicians to examine patients with skin pruritic papules in the absence of the mites [1,2,22].

Despite previous studies have hypothesized only a marginal role of *D. gallinae* in mammals [23], in the present study, the presence of several blood-engorged mites on the dog's fur, indicate an active and primary infestation rather than an adventitious feeding, as similarly reported in the highly infested kittens by Di Palma [6]. Moreover, the absence of other ectoparasites (such as fleas, ticks, lice) is also a plausible clue for the major pathogenic role played by *D. gallinae* on the dog. On the other hand, the skin lesions and the intense pruritus are consistent with previous reports of dermanyssosis in dogs [8,24]. However, it cannot be excluded that the dermatitis caused by mites' attacks might have been worsened by the dog's itch, consequent self-inflicted injuries and microbial contamination.

Of the reviewed articles, nine out of twelve cases reported the infection in pet animals (including a horse) (Table 1). The remaining regarded livestock and wildlife, with *D. gallinae* reported only as an accidental finding, lacking in essential details such as the possible source of infection, treatment (if applied), clinical course and localization of the skin lesions [25–27]. Considering the diversity and the randomness of the mammal hosts affected by *D. gallinae* – as shown in this review study - we expect that the host range may be remarkably broader. This aspect points out that, in non-avian hosts, several cases of dermanyssosis may remain undetected, especially in rural areas at higher risk of exposure, or in developing countries where access to veterinary facilities may be impracticable or neglected.

Furthermore, the majority of the reviewed articles were published after 2000, suggesting raising awareness of vet practitioners/researchers on the PRM and improved surveillance capacities.

The reviewed studies highlight the importance of a correct and early diagnosis of skin conditions compatible with dermanyssosis in pets, and the crucial role played by veterinarians in tracing the source of this neglected parasitosis to avoid reinfestation and adopt all the strategies to prevent the PRM attacks. In particular, as to the case reported in this study, it might be beneficial for poultry farmers to avoid the placement of other domestic animals in the space around the poultry house and instruct poultry workers and visitors to access the premises and the poultry house after wearing suitable protective clothing. Moreover, not only in the poultry industry but also in smaller and hobby farms, control strategies against the PRM, such as an adequate downtime between flocks, periodical mechanical and sanitary cleaning and application of acaricide products, *i.e.*, phoxim-based (organophosphates) spray product or the fluralaner-based (isoxazolines), mainly used in water, are highly recommended [28] in the light of the negative economic and sanitary impact of the PRM, and of its zoonotic interest [1].

Gamasoidosis misdiagnosis in pets can easily cause frustration for the owner and be perceived as a failure for the veterinarian, as the repeated treatments may not lead to a successful and complete recovery of the patient, as reported in some cases [22].

Even in studies confirming *D. gallinae* as the cause of the animal pruritus and skin lesions, successful treatments were often associated with a correct management of poultry and a complete eradication of environmental mites: less than once monthly applications of 2% permethrin solution over the body surface of a 16-year-old domestic horse during winter (when the horse was stabled close to the chickens) resulted in relapse of clinical symptoms [22], while a single 6% selamectin solution application completely resolved clinical signs in two kittens that have been likely removed from the poultry pen where they originally lived [6]. Moreover, resistance to pyrethroids has been widely proved across Europe, thus more targeted treatment should be developed to achieve maximum treatment benefits [29].

It is interesting to notice that in the two confirmed zoonotic cases (from a cat and a pet gerbil to their owners) [2,30], while the owners presented multiple papular skin lesions, their pets did not show any clinical symptoms, or, at least, not yet. It was thanks to the veterinarian, who carefully inspected the fur of the animals and retrieved the avian mites, previously acquired by infested birds, that the source of infestation for humans was identified and extinguished.

In passing, it is worth noting that sarolaner in dog, selamectin in cats and permethrin in horses have been administered off-label, as no registered products are currently present for dermanyssosis in mammals. Further, *in vivo* experiments are needed to assess the real therapeutic effect of these drugs in targeted animal species.

5. Conclusions

In conclusion, we urge more awareness of vet practitioners on avian mite-dermatitis diagnosis in companion animals and livestock, not only to protect animal health and welfare but also to prevent diseases in pet owners and farm operators in line with the One-Health approach.

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Availability of data and material

The datasets used and analyzed during the present study are included in this article. Raw data are available from the first and corresponding author upon reasonable request.

Author contribution

BM, AB, LR, AP and AG conceived and designed the study. AM visited the dog and prescribed treatments and BM collected mites from the animal enclosure. AB performed molecular analyses. BM wrote the first draft of the manuscript, all the authors contributed in shaping and revising the manuscript.

Ethics approval

Not applicable.

Consent for publication

The owner of the dog has consented to the submission of the case report to the journal.

Declaration of Competing Interest

The authors declare there are no conflicts of interest.

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