



## Cutaneous epitheliotropic T-cell lymphoma in a donkey — a case report

Jevgenija Kondratjeva, Florie Julien, Céline Coutelier, Louis Humeau, Fabien Moog, Daniel Combarros, Isabelle Fourquaux, Charline Pressanti, Maxence Delverdier, Peter F. Moore, et al.

### ► To cite this version:

Jevgenija Kondratjeva, Florie Julien, Céline Coutelier, Louis Humeau, Fabien Moog, et al.. Cutaneous epitheliotropic T-cell lymphoma in a donkey – a case report. BMC Veterinary Research, 2022, 18 (1), pp.267. 10.1186/s12917-022-03365-7 . hal-03752722

**HAL Id: hal-03752722**

**<https://hal.inrae.fr/hal-03752722>**

Submitted on 17 Aug 2022

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.




Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

CASE REPORT

Open Access



# Cutaneous epitheliotropic T-cell lymphoma in a donkey – a case report

Jevgenija Kondratjeva<sup>1</sup>, Florie Julien<sup>2</sup>, Céline Coutelier<sup>1</sup>, Louis Humeau<sup>1</sup>, Fabien Moog<sup>1</sup>, Daniel Combarros<sup>1,3</sup>, Isabelle Fourquaux<sup>4</sup>, Charline Pressanti<sup>1,3</sup>, Maxence Delverdier<sup>5,6</sup>, Peter F. Moore<sup>7</sup> and Marie Christine Cadiergues<sup>1,3\*</sup> 

## Abstract

**Background:** Cutaneous epitheliotropic T-cell lymphoma is a malignant tumour of the skin already reported in humans, dogs, cats, horses, and other species, but not previously in donkeys. The standard diagnosis is based on clinical, morphological and immunophenotypic data. Differentiation of malignant versus benign proliferation of lymphocytes is crucial; in ambiguous cases T-cell receptor gamma (TRG) molecular clonality should be tested. In the present paper, we report a case of mycosis fungoides diagnosed in a donkey whose diagnosis was based on clinical, histological and immunohistochemical aspects and a positive TRG clonality test.

**Case presentation:** A twenty-five-year-old donkey gelding was referred with a mildly pruritic, generalised and severe exfoliative dermatosis. Otherwise, the animal was clinically healthy, though mildly underweight. Dermatological examination revealed severe generalised alopecic and exfoliative dermatitis, occasionally eroded, with high number of large, thin, greyish scales. All mucocutaneous junctions except the hoofs were affected. Ectoparasites and dermatophytes were ruled out. The complete blood count and blood smear evaluation revealed mild normocytic normochromic anemia. The biochemistry panel showed mild hyperproteinemia with albumin within the normal range. Protein electrophoresis showed moderate polyclonal hypergammaglobulinemia. Histological findings were characterised by interface dermatitis with massive exocytosis in the epidermis of a homogenous population of lymphoid cells showing atypia. Clusters of neoplastic cells were present within the epidermis forming Pautrier “micro-abscesses”. These findings are consistent with cutaneous epitheliotropic lymphoma. Immunohistochemical staining revealed uniform labelling of the neoplastic cells for CD3, and lack of expression of CD20 (a B cell lineage associated marker). Molecular clonality PCR (PARR) was performed using equine TRG primers; this revealed a clonal rearrangement in a heavy polyclonal background. Transmission electronic microscopy showed multiple lymphocytes with convoluted or cerebriform nuclei.

**Conclusions:** This case report provides the first evidence of clinical, histopathological, immunophenotypic features, electron microscopy findings and molecular analysis of a cutaneous epitheliotropic T-cell lymphoma (mycosis fungoides) in a donkey. Our observations suggest that cutaneous T-cell lymphoma should be included in the differential diagnoses of exfoliative dermatitis, even those progressing in a chronic pattern and/or with few or no pruritus.

**Keywords:** *Equus asinus*, Donkey, Skin, Cutaneous T-cell lymphoma, Clonality test

## Background

Cutaneous lymphomas originating from T- or B-lymphocytes are uncommon in humans, dogs, cats, horses, and other species [1–3]. They are subdivided into

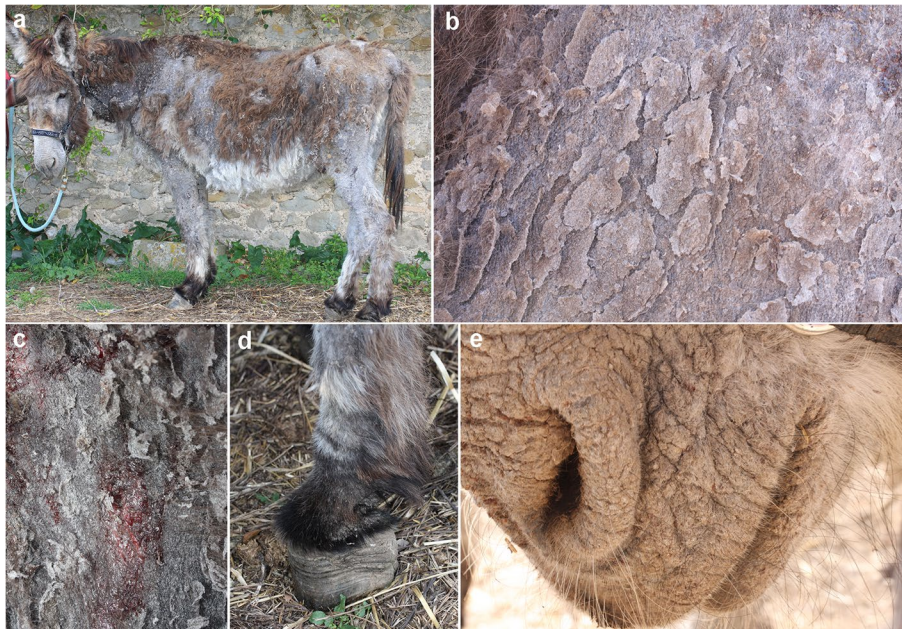
\*Correspondence: marie-christine.cadiergues@envt.fr

<sup>1</sup> Small Animal and Equine Hospital, ENVT, Université de Toulouse, Toulouse, France

Full list of author information is available at the end of the article



© The Author(s) 2022. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.



**Fig. 1** Initial physical examination. A 25-year-old donkey in poor body condition with severe generalised alopecic and exfoliative dermatitis (a); close up of the skin, which was generally thin, covered by large quantities of large, thin, greyish scales (b), occasionally eroded with sero-haemorrhagic exudate (c). The hoofs were not affected (d). The lips and muzzle were very scaly (e)

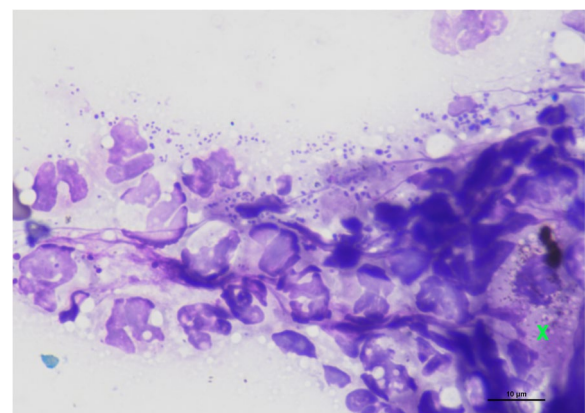
epitheliotropic and non-epitheliotropic types. Epitheliotropic lymphomas are typically of T-lymphocyte origin [2, 4–6] and have a variety of clinical presentations and morphological features [2, 4, 7, 8]. Amongst the three sub-forms of T-cell epitheliotropic lymphoma encountered in veterinary medicine—mycosis fungoides (MF), Sezary syndrome and pagetoid reticulosis—only the first two have been reported in horses [2, 9, 10]. The most common clinical presentation of MF in horses is exfoliative dermatosis, nodules, or ulcerations with or without pruritus, associated with infiltration of neoplastic T-lymphocytes with a specific tropism in the epidermis and adnexal structures, and oral mucosa [2, 8].

In donkeys, skin tumours are among the skin disorders reported in reviews [11, 12] or retrospective studies [13–15]. The most common neoplasia are sarcoid tumours [11–15]. To the best of our knowledge, no case of cutaneous epitheliotropic lymphoma has been described in the donkey to date. Here we report the clinical, histopathological, immunophenotypic features and positive clonality testing of a cutaneous epitheliotropic T-cell lymphoma (MF) in a donkey.

### Case presentation

A twenty-five-year-old donkey gelding was referred with a several-year history of mildly pruritic, generalised and severe exfoliative dermatosis, with exacerbation over the preceding three months. The donkey had lived in Southern France the last ten years and was kept outdoors

permanently with two other donkeys in a fenced field (250 m<sup>2</sup> with a 10 m<sup>2</sup> cover) and occasionally with several horses from the same area; none of the in-contact animals had ever displayed a dermatological disease. The paddock was located next to a water canal where rodents were regularly seen as well as biting insects during the summer months. The owner did not report any signs of systemic illness, except mild underweight. No treatment had been given, except occasional topical applications



**Fig. 2** Cytological examination. A direct skin smear was taken from eroded lesions on the lateral thorax. Degenerate neutrophils, phagocytized cocci and keratinocytes (green cross) were observed. (Stained with RAL®555, RAL Diagnostics; Site Montesquieu-Martillac, France. Magnification × 1000, bar = 10 µm)



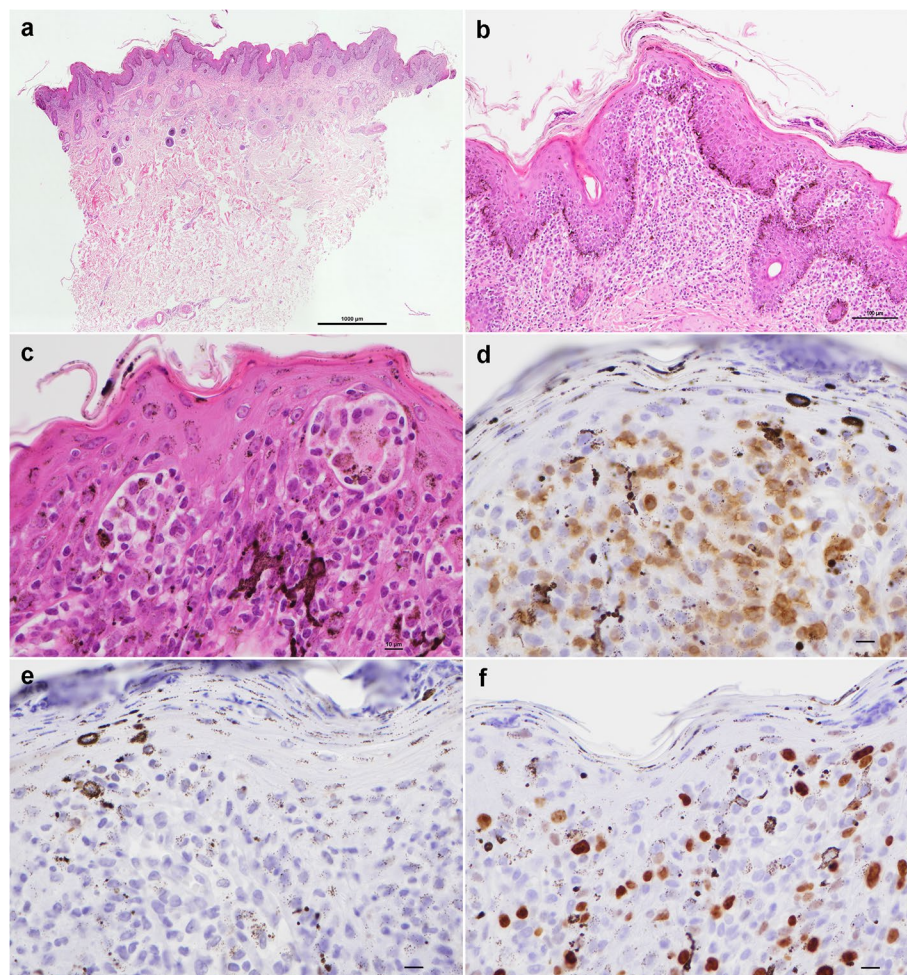
of povidone iodine and recent topical application of deltamethrin (Butox 7.5% pour-on, MSD, Beaucouzé, France – 10 mL) following skin scrapings shown to be positive for *Ornithonyssus bacoti* mites.

Physical examination on admission revealed an alert, responsive donkey with poor body condition (body score 2/5). Dermatological examination revealed severe generalised alopecic and exfoliative dermatitis (Fig. 1a). The skin was generally thin, covered by high number of large, thin, greyish scales, giving a laminated appearance upon close examination (Fig. 1b). Occasional erosions with sero-haemorrhagic exudate were present (Fig. 1c). All mucocutaneous junctions except the hoofs were affected (Fig. 1d and e).

The initial differential diagnoses included ectoparasites, dermatophytosis, pemphigus foliaceus, sarcoidosis,

zinc responsive dermatosis, generalised primary seborrhoea and epitheliotropic lymphoma.

Microscopic examination of skin scrapings collected from dorsum and flanks did not reveal any remaining mites. Cytological examination of direct skin smears from eroded lesions (RAL<sup>®</sup>555, RAL Diagnostics; Site Montesquieu-Martillac, France) revealed keratinocytes, degenerate neutrophils and phagocytized cocci (Fig. 2). Bacterial culture from an exudative lesion yielded multiple colonies of *Staphylococcus hyicus* and *Streptococcus dysgalactiae*, both sensitive to all the antibiotics tested, except for *S. dysgalactiae*, which was not sensitive to gentamicin. Fungal culture of scaling material and hair shafts was negative. The complete blood count and blood smear evaluation only revealed mild normocytic normochromic anemia ( $4.34 \times 10^6$  cells/ $\mu\text{L}$ , RI 4.4–7.1  $10^6/\mu\text{L}$  [16]).



**Fig. 3** Histopathological examination of biopsies taken from the lateral thorax. Interface dermatitis (a) with massive exocytosis in the epidermis of a homogenous population of lymphoid cells showing atypia (b). Clusters of neoplastic cells were present within the epidermis forming Pautrier microabscesses (c); [H&E staining, magnification  $\times 40$  (a),  $\times 200$  (b) and  $\times 400$  (c), bars = 1000  $\mu\text{m}$  (a), 100  $\mu\text{m}$  (b) and 10  $\mu\text{m}$  (c)]. Immunohistochemical staining for CD3 showed uniform labelling of the neoplastic cells for CD3 (d), whereas staining for CD20 was negative (e). The Ki-67 labelling fraction was hard to quantify in the epidermis as the background labelling of basal epithelial cells was prominent, but by comparing the labelling fraction in the superficial dermis, it was estimated at less than 20% (f). (Magnification  $\times 400$ , bar = 10  $\mu\text{m}$ )

The biochemistry panel showed mild hyperproteinaemia (78.7 g/L, RI 58–76 g/L [16]) with albumin in the normal range (29.8 g/L, RI 21.5–31.6 g/L [16]). Protein electrophoresis showed moderate polyclonal hypergammaglobulinemia (39.1%, RI 8–15.8%). Coproscopic examination revealed large numbers of strongyle (1 600 eggs per gram, modified McMaster technique).

Microscopic lesions in three 8-mm skin biopsy specimens from the lateral thorax were characterised by interface dermatitis (Fig. 3a) with epidermotropic lymphocytes (Fig. 3b) showing atypia in the epidermis. Clusters of neoplastic cells were present within the epidermis forming Pautrier “microabscesses” (Fig. 3c).

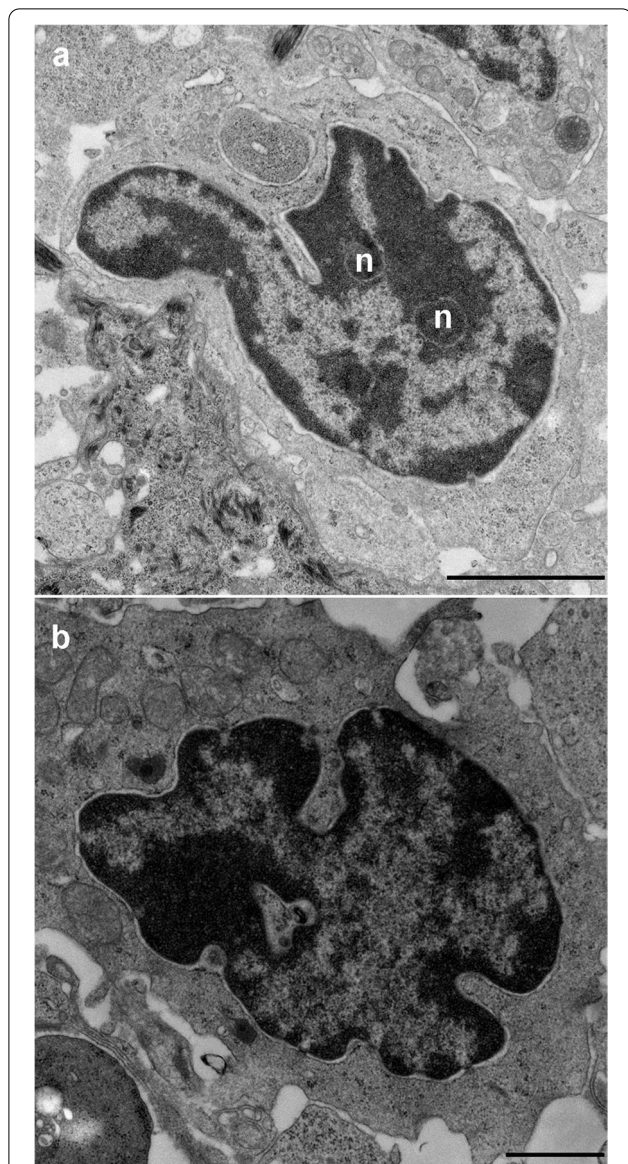
Immunohistochemical staining for CD3 (réf M7254, clone F7.2.38, dilution 1/50, Agilent Technologies, Les Ulis, France), CD20 (réf PA5-16,701, polyclonal, dilution 1/600, Invitrogen, Thermofisher Scientific, Waltham, Massachusetts, USA) and Ki-67 (réf M7240, clone mib1, dilution 1/50, Agilent Technologies, Les Ulis, France) revealed uniform labelling of the neoplastic cells for CD3 (Fig. 3d), and lack of labelling for CD20 (Fig. 3e). The Ki-67 labelling fraction was hard to quantify in the epidermis as the background labelling of the basal epithelial cells was prominent, but the labelling fraction in the superficial dermis was estimated at less than 20% (Fig. 3f).

Electron microscopic examination of lesional skin revealed multiple lymphocytes with convoluted (Fig. 4a) or cerebriform (Fig. 4b) nuclei. Prominent nucleoli were observed (Fig. 4a).

Molecular clonality PCR (PCR for antigen receptor rearrangement, PARR) was performed using equine primers (UC Davis Leukocyte Antigen Biology Laboratory proprietary) as no primer was available for donkeys. The DNA extracted from the blood from a normal 8-month old donkey (Fig. 5a) and from the buffy coat smears of the donkey’s peripheral blood (Fig. 5b), which served as polyclonal controls for TRG, produced a symmetrical polyclonal amplicon. In the skin of the donkey with mycosis fungoides, clonal rearrangements of TRG were observed in a heavy polyclonal background (Fig. 5c). Clonal peaks were at 76 bp and 80 bp.

Taken together, the clinical appearance, the histological findings, the immunophenotypical features and the positive T-cell clonality test, confirmed our hypothesis of a cutaneous epitheliotropic T-cell lymphoma (MF).

As the donkey was considered comfortable enough, the owners did not wish to attempt any specific treatment. Only skin care, alternating kerato-modulatory (Douxo®S3 Seb, CEVA, Libourne, France) and anti-septic (Douxo®S3 Pyo, CEVA, Libourne, France) once weekly shampooing was recommended after

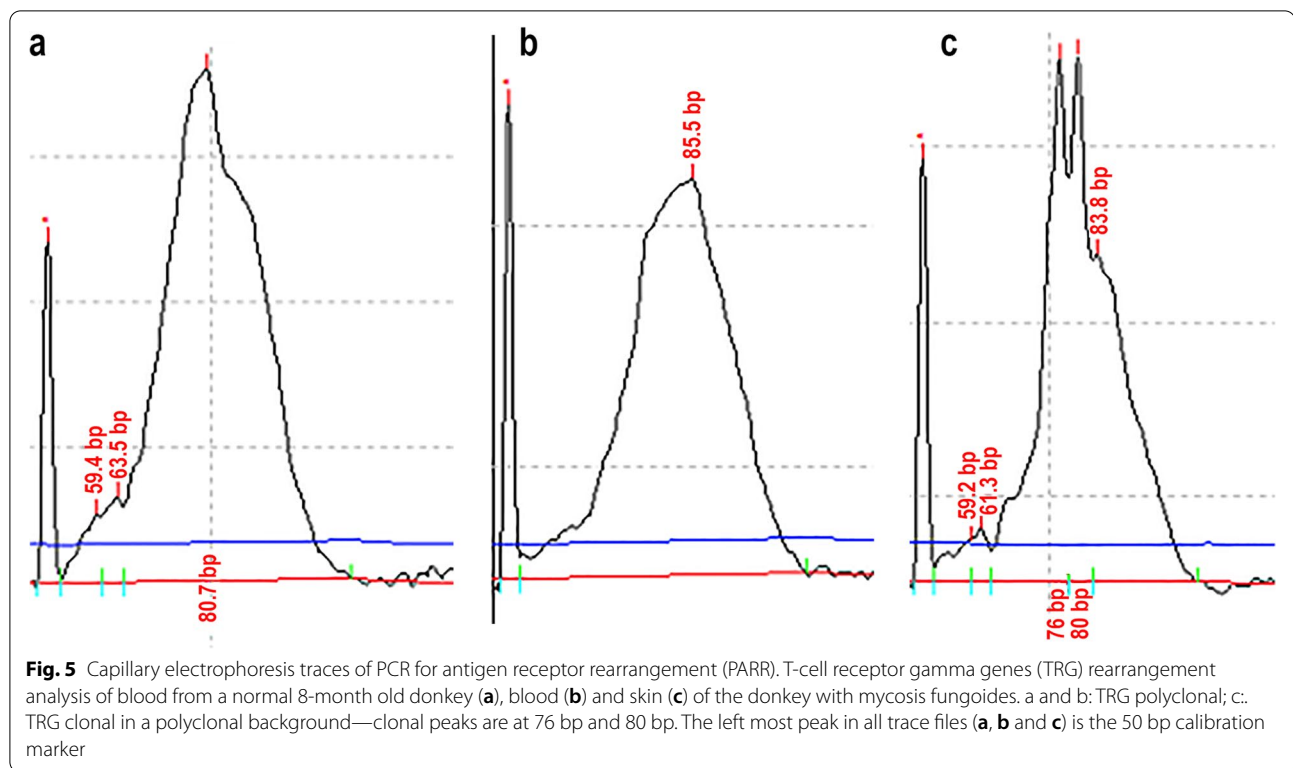


**Fig. 4** Electron microscopy of a skin biopsy taken from the lateral thorax showing multiple lymphocytes with convoluted (a) or cerebriform (b) nuclei. Prominent nucleoli were observed in the nucleus (n). Scale bars = 1  $\mu$ m

clipping the non-alopecic areas. A fortnightly application of delamethrin (Deltanil®10 mg/mL, Virbac, Carros, France—10 mL) was prescribed to (i) limit fly populations and the possible development of myiasis on the eroded zones and (ii) prevent *O. bacoti* reinfestations. Fenbendazole (Panacur pâte, MSD, Beaucauzé, France) was given orally to the two other donkeys at the manufacturer’s recommendation dosage.

One year after diagnosis, at the time of writing, the donkey is still alive, and the lesions appear to be stable.





## Discussion and conclusion

Progression of the cutaneous disease over several years had been reported by the owner. Although the animal had been examined several times by veterinarians, no further investigation had been undertaken except recent skin scrapings which had revealed *O. bacoti* infestation. Hence, the speed of progression of the condition is difficult to evaluate. In humans and dogs, MF typically progresses through several distinct or overlapping clinical stages consisting of patch and plaque formation, followed by subsequent progression to the tumour stage with potential for metastasis to regional lymph nodes and visceral organs [3, 4]. The progression of MF to fatal disease in humans may take years or even decades [17]. In a retrospective study of 30 cases in dogs, the mean time between the first onset of lesions and the final diagnosis of cutaneous epitheliotropic T cell lymphoma was 5.5 months [4]. Slowly progressive disease has also been reported in cats [5]. Previous persistent antigenic stimulation or chronic inflammation might predispose to development of MF in both humans and animals, diagnoses such as atopic dermatitis, psoriasis or infections have been implicated, but this link remains the subject of debate [1, 4, 18, 19].

The accurate distinction between reactive and neoplastic lymphoid proliferations and the differentiation of T- and B-lymphocytes can be challenging, all the

more so since in horses, the most frequent cutaneous malignant lymphomas are T-cell-rich B-cell lymphomas [9, 10, 20]. Molecular clonality assays, assessing clonality of T- or B-cells through PARR can effectively complete clinical, morphologic, and immunophenotypic assessments [21, 22]. Clonality assays are species-specific and in veterinary medicine, are currently only available for dogs, cats, and horses [21–23]. In the present case, the test was performed using primer sets for equine PARR on formalin-fixed paraffin-embedded tissue. To the authors' knowledge, this is the first documented use of PARR in donkeys.

At the time of diagnosis, mild normocytic normochromic anemia was observed. This abnormality is not reported in MF without lymph node involvement in humans, or in animals [5, 10, 17, 24–26]. The recent infestation by tropical rat mites possibly explains the mild anemia as these mites are hematophagous and in case of a heavy infestation, can cause anemia [27].

Skin-directed and systemic treatments of MF are clearly described in human medicine, depending on the stage, the areas affected and systemic involvement. Treatments include topical steroids, phototherapy, electron beam therapy, radiation, retinoids, monoclonal antibodies, single and multiagent chemotherapy [28, 29]. In horses, data concerning T-cell lymphoma are limited to one horse with a nodular form which was

treated with intralesional injections of betamethasone associated with megestrol acetate tablets in addition to surgical removal of ulcerated lesions [30].

In conclusion, this case report provides the first evidence of clinical, histopathological, immunophenotypical features, electron microscopy findings and molecular analysis of a cutaneous epitheliotropic T-cell lymphoma (mycosis fungoides) in a donkey. Cutaneous T-cell lymphoma should be included in the differential diagnoses of exfoliative dermatitis, even with a prolonged time course and little or no pruritus.

#### Abbreviations

CD: Cluster of differentiation; TRG: T-cell receptor gamma genes; RI: Reference interval; PARR: PCR for antigen receptor rearrangement; DNA: Deoxyribonucleic acid; MF: Mycosis fungoides; bp: Base pairs.

#### Acknowledgements

We would like to acknowledge D. Goodfellow for editing the English.

#### Authors' contributions

JK, FJ, CC, LH, FM, DC, CP and MCC dealt with the case, MD oversaw the histopathology and electron microscopy examination, IF dealt with the electron microscopy procedures, PFM performed the clonality tests. JK and MCC drafted the manuscript and DC, FJ, CC, LH, FM, DC, IF, CP, MD, PFM and MCC read, reviewed the manuscript, and approved submission of the final manuscript.

#### Authors' information

Jevgenija Kondratjeva, DVM, ECVD resident; Florie Julien, DVM, Céline Coutelier, DVM; Louis Humeau, DVM; Fabien Moog, DVM, ECVD resident; Daniel Combarros, DVM, Dipl. ECVD; Isabelle Fourqueaux, laboratory technician; Charline Pressanti, DVM, Dipl. ECVD; Maxence Delverdier, DVM, PhD, Dipl. ECVF; Peter F Moore, DVM, PhD; Marie Christine Cadiergues, DVM, PhD, Dipl. ECVD.

#### Funding

The Dermatology Unit of ENVT funded all complementary analyses. The funding body had no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

#### Availability of data and materials

The data generated, and/or used during the work-up of this case cannot be made publicly available in the interests of retaining patient confidentiality but are available from the corresponding author on reasonable request.

#### Declarations

##### Ethics approval and consent to participate

All diagnostic and therapeutic procedures were performed by licensed veterinarians in the course of routine veterinary health management.

##### Consent for publication

The owner of the donkey gave her consent for publication.

##### Competing interests

The authors declare that they have no competing interests.

##### Author details

<sup>1</sup>Small Animal and Equine Hospital, ENVT, Université de Toulouse, Toulouse, France. <sup>2</sup>Selarl Hippovet Aude, Laure Minervois, France. <sup>3</sup>INFINITY, Université de Toulouse, CNRS, UPS, InsermToulouse, France. <sup>4</sup>Centre de Microscopie Electronique Appliquée À La Biologie, Université de Toulouse, Toulouse, France. <sup>5</sup>Basic Sciences Department, Université de Toulouse, ENVT, Toulouse, France. <sup>6</sup>IHAP,

Université de Toulouse, INRAE, ENVT, Toulouse, France. <sup>7</sup>Leukocyte Antigen Biology Laboratory, UC Davis, VM PMI, Davis, CA, USA.

Received: 15 December 2021 Accepted: 28 June 2022

Published online: 11 July 2022

#### References

- Gross TL, Ihrke PJ, Walder E, Affolter VK. Lymphocytic tumors. In: Gross TL, Ihrke PJ, Walder E, Affolter VK, editors. *Skin diseases of the dog and cat: clinical and histopathologic diagnosis*. 2nd ed. Ames, Iowa: Blackwell Science; 2005. p. 866–93.
- Scott DW, Miller WH. CHAPTER 16 - Neoplasms, Cysts, Hamartomas, and Keratoses. In: Scott DW, Miller DH, editors. *Equine Dermatology*. 2nd ed. Saint Louis: W.B. Saunders; 2011. p. 468–516.
- Specht L, Skov L. Cutaneous Lymphomas. *Clin Oncol (R Coll Radiol)*. 2019;31(11):797–807.
- Fontaine J, Bovens C, Bettenay S, Mueller RS. Canine cutaneous epitheliotropic T-cell lymphoma: a review. *Vet Comp Oncol*. 2009;7(1):1–14.
- Fontaine J, Heimann M, Day MJ. Cutaneous epitheliotropic T-cell lymphoma in the cat: a review of the literature and five new cases. *Vet Dermatol*. 2011;22(5):454–61.
- Peleteiro M, Pinto C, Correia J, Silva J, Branco S. Two cases of cutaneous T cell lymphoma in Friesian cows in the Azores. *Vet Dermatol*. 2000;11:299–304.
- Mineshige T, Kawarai S, Yauchi T, Segawa K, Neo S, Sugahara G, Kamiie J, Hisasue M, Shirota K. Cutaneous epitheliotropic T-cell lymphoma with systemic dissemination in a dog. *J Vet Diagn Invest*. 2016;28(3):327–31.
- Moore PF, Affolter VK, Graham PS, Hirt B. Canine epitheliotropic cutaneous T-cell lymphoma: an investigation of T-cell receptor immunophenotype, lesion topography and molecular clonality. *Vet Dermatol*. 2009;20(5–6):569–76.
- Durham AC, Pillitteri CA, San Myint M, Valli VE. Two hundred three cases of equine lymphoma classified according to the World Health Organization (WHO) classification criteria. *Vet Pathol*. 2013;50(1):86–93.
- Miller CA, Durham AC, Schaffer PA, Ehrhart EJ, Powers BE, Duncan CG. Classification and clinical features in 88 cases of equine cutaneous lymphoma. *J Vet Diagn Invest*. 2015;27(1):86–91.
- Knottenbelt DC. Skin Disorders of the Donkey and Mule. *Vet Clin North Am Equine Pract*. 2019;35(3):493–514.
- Lima TS, Silva RAF, Pereira RMF, Soares KL, Santos NTA, Sousa MS, Mendonça FS, Lucena RB. Skin Diseases in Donkeys and Mules-An Update. *Animals (Basel)*. 2020;11(1):65.
- Davis CR, Valentine BA, Gordon E, McDonough SP, Schaffer PA, Allen AL, Pesavento P. Neoplasia in 125 donkeys (*Equus asinus*): literature review and a survey of five veterinary schools in the United States and Canada. *J Vet Diagn Invest*. 2016;28(6):662–70.
- Tesfaye A, Tekle Y, Taddele H, Gezahagn K, Yihdego H. Survey of common skin problem of working equines in and around Mekelle, North Ethiopia. *Acad J Animal Dis*. 2015;4:30–8.
- White SD, Bourdeau PJ, Brement T, Vandenabeele SI, Haspelslagh M, Bruet V, Sloet van Oldruitenborgh-Oosterbaan MM. Skin disease in donkeys (*Equus asinus*): a retrospective study from four veterinary schools. *Vet Dermatol*. 2019;30(3):247–e276.
- Burden F, Hazell-Smith E, Mulugeta G, Patrick V, Trawford R, Brooks Brownlie H. Reference intervals for biochemical and haematological parameters in mature domestic donkeys (*Equus asinus*) in the UK. *Equine vet Educ*. 2016;28(3):134–9.
- van Doorn R, Van Haselen CW, van Voorst Vader PC, Geerts ML, Heule F, de Rie M, Steijlen PM, Dekker SK, van Vloten WA, Willemze R. Mycosis fungoides: disease evolution and prognosis of 309 Dutch patients. *Arch Dermatol*. 2000;136(4):504–10.
- Moore PF, Olivry T, Naydan D. Canine cutaneous epitheliotropic lymphoma (mycosis fungoides) is a proliferative disorder of CD8+ T cells. *Am J Pathol*. 1994;144(2):421–9.
- Wong HK, Mishra A, Hake T, Porcu P. Evolving insights in the pathogenesis and therapy of cutaneous T-cell lymphoma (mycosis fungoides and Sezary syndrome). *Br J Haematol*. 2011;155(2):150–66.
- Meyer J, Delay J, Bienzle D. Clinical, laboratory, and histopathologic features of equine lymphoma. *Vet Pathol*. 2006;43(6):914–24.

21. Hollis A. PCR for antigen receptor rearrangement (PARR) in equine veterinary medicine. *Equine vet Educ.* 2019;31:419–20.
22. Keller SM, Vernau W, Moore PF. Clonality Testing in Veterinary Medicine: A Review With Diagnostic Guidelines. *Vet Pathol.* 2016;53(4):711–25.
23. Collar E, Parker J, Gorman E, Russell D, Valentine B. PCR for antigen receptor rearrangement (PARR) clonality testing in a horse with a solitary retropharyngeal lymphoma. *Equine vet Educ.* 2019;31:413–8.
24. de Bruijn CM, Veenman JN, Rutten VP, Teske E, van Nieuwstadt RA, van den Ingh TS. Clinical, histopathological and immunophenotypical findings in five horses with cutaneous malignant lymphoma. *Res Vet Sci.* 2007;83(1):63–72.
25. Luethy D, Frimberger AE, Bedenice D, Byrne BS, Groover ES, Gardner RB, Lewis T, MacDonald VS, Proctor-Brown L, Tomlinson JE, et al. Retrospective evaluation of clinical outcome after chemotherapy for lymphoma in 15 equids (1991–2017). *J Vet Intern Med.* 2019;33(2):953–60.
26. Risbon RE, de Lorimier LP, Skorupski K, Burgess KE, Bergman PJ, Carreras J, Hahn K, Leblanc A, Turek M, Impellizzeri J, et al. Response of canine cutaneous epitheliotropic lymphoma to lomustine (CCNU): a retrospective study of 46 cases (1999–2004). *J Vet Intern Med.* 2006;20(6):1389–97.
27. Beck W, Folster-Holst R. Tropical rat mites (*Ornithonyssus bacoti*) - serious ectoparasites. *J Dtsch Dermatol Ges.* 2009;7(8):667–70.
28. Jawed SI, Myskowski PL, Horwitz S, Moskowitz A, Querfeld C. Primary cutaneous T-cell lymphoma (mycosis fungoides and Sezary syndrome): part II. Prognosis, management, and future directions. *J Am Acad Dermatol.* 2014;70(2):223 (e221–217; quiz 240–222).
29. Photiou L, van der Weyden C, McCormack C, Miles Prince H. Systemic Treatment Options for Advanced-Stage Mycosis Fungoides and Sezary Syndrome. *Curr Oncol Rep.* 2018;20(4):32.
30. Littlewood JD, Whitwell KE, Day MJ. Equine Cutaneous Lymphoma: A Case Report. *Vet Dermatol.* 1995;6(2):105–11.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Ready to submit your research? Choose BMC and benefit from:**

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

**At BMC, research is always in progress.**

Learn more [biomedcentral.com/submissions](https://biomedcentral.com/submissions)

