Identification of non-tuberculous mycobacteria isolated from opossum (Didelphis virginiana) lymph nodes and characterisation of lesions

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ABSTRACT. The aim of this study was to investigate the presence of NTM in the lymph nodes of opossums (D. virginiana) and to characterise the microscopic changes in affected tissue. Retropharyngeal and tracheobronchial lymph nodes were collected postmortem from 18 opossums in the state of Colima, Mexico in 2013. The lymph nodes were also cultured for mycobacterial organisms and processed for histopathological examination. Bacteriological cultures yielded 5/18X100 (28%) isolates of NTM, which were subsequently identified as M. terrae, M. szulgai, M. gastri and M. asiaticum. Microscopic examination of the affected nodes revealed a necrotic granulomatous lymphadenitis (3/60%) composed of histiocytes, epithelioid cells and giant cells with intralesional alcohol-resistant acid bacteria. An association between the sex of the opossum and the presence of NTM was observed. To our knowledge, this is the first report of NTM isolation in opossums with granulomatous lymphadenitis in Mexico.

Key words: mycobacteria, tuberculosis, opossums, lesions.

INTRODUCTION

There are more than 130 species of non-tuberculous mycobacteria (NTM), also known as atypical or environmental mycobacteria. These opportunistic bacteria are regular inhabitants of soil, water, earth and inanimate objects. They are well distributed in our environment and have great pathogenic potential, with a clinical profile or lesions similar to those caused by tuberculosis (Casal and Casal 2000). The lymph nodes of the head are the tissues of choice for tuberculosis inspection in wild boar, since the diagnosis of tuberculosis can be done just by observing these nodes (Bercovier and Vincent 2001). The NTM bacteria important to humans are M. kanssii, M. genavense, M. marinum, M. simiae, M. scrofulaceum, M. szulgai, M. avium, M. haemophilum, M. intracellulare, M. malmoense, M. ulcerans, M. abscessus, M. chelonae, M. fortuitum and M. smegmatis (Holland 2001, Iseman and Marras 2008, Piersimoni and Scarparo 2008). The species M. chelonae-abscessus and M. flavescens cause cutaneous lesions in cats and dogs (Jang and Hirsh 2002). In bovines, the NTM species that have been isolated are M. gastri, M. flavescens, M. phlei, M. triviale, M. terrae, M. nonchromogenicum, M. intracellulare, M. gordonae M. thermoresistibile, M. xenopi, M. fortuitum, M. chelonae, M. szulgai, M. ulcerans and M. kanssii (Proano et al 2006, Hernández 2014). The species M. marinum and M. kanssii have been isolated from wild animals such as manatees (Trichechus manatus latirostris) (Sato et al 2003). In addition, M. kanssii has been isolated from black-tailed deer (Odocoileus hemionus columbianus) (Hall et al 2005). The lymph nodes of the head are the tissues of choice for tuberculosis inspection in wild boar, since the diagnosis of the mycobacteria can be done just by observing these nodes in more than 90% of the infected population (Martín et al 2007). The aim of this study was to investigate the presence of NTM in the lymph nodes of opossums (D. virginiana) and to characterise the microscopic changes in affected tissue.

MATERIAL AND METHODS

HOST COLLECTION AND NECROPSY

During 2013, eighteen road-killed D. virginiana were collected in the state of Colima, Mexico. The site was located...
at 19°41’-19°16’ N, 102°46’-103°47’ W, with an altitude of 500 meters (INEGI 2010). A necropsy identified lesions suggestive of tuberculosis. Homologous tissue sections collected from the tracheobronchial and retropharyngeal lymph nodes were preserved in a 6% borate solution (Pronabive-SAGARPA) and 10% buffered formalin.

BACTERIOLOGY

After the sodium borate and the excess fat were removed, the lymphoid tissue was cut into small pieces in a sterile mortar; sterile sand was added, and the tissue was manually macerated. The liquid was decanted into a 1:1 proportion into a 4% sodium hydroxide solution with phenol red, and then it was incubated at 37 °C for 20 minutes, after which it was centrifuged at 3000 x g for 20 minutes. The sediment was deposited in a sodium hypochlorite solution, which was then neutralized with a 1 N hydrochloric acid solution until a shift in the color (from pink to yellow) was observed.

Three cultures were seeded in two tubes of Stonebrink (Pronabive) culture medium and one tube of Lowenstein-Jensen medium (Pronabive), which were then incubated at 37 °C for 24 hours. After 24 hours, they were incubated at 37 °C under a 5% CO2 atmosphere for 9 weeks. The growth obtained was verified using the Ziehl-Neelsen stain.

The isolates were identified based on their characteristics and growth morphology as well as metabolic activity, specifically, niacin production, nitrate reduction, catalase activity at 22 °C and 68 °C, urea activity, TWEEN 80 hydrolysis, growth on MacConkey agar without crystal violet and 5% NaCl tolerance. All isolates were seeded in four replicates. The four replicates were incubated for 30 days under different conditions: one culture was incubated at 22 °C, another at 45 °C and two at 37 °C under a 5% CO2 atmosphere, one in the absence of light and another in the presence of light.

HISTOLOGY

The lymph nodes were assessed for the presence of NTM. They were embedded in paraffin; 4.0-micron-thick sections were cut and stained with hematoxylin-eosin (H and E), and Ziehl-Neelsen (ZN) (Prophet et al 1995).

STATISTICAL ANALYSIS

A chi-squared test was performed to evaluate the association between the sex of the opossum and the presence of NTM, and the prevalence rates were expressed as percentages.

RESULTS AND DISCUSSION

Eighteen D. virginiana were collected, of which 7/18 (39%) were female and 11/18 (61%) were male. Five out of the 18 animals (28%) were positive for the isolation of NTM, and three of them presented granulomatous lesions in their lymph nodes. The NTM isolated corresponded to the species Mycobacterium szulgai, M. terrae, M. asiaticum and M. gastri (table 1 and figure 1). An association was found between the sex of the animal and its NTM status: infection was more frequent in males of D. virginiana (table 2). The distribution of NTM in the environment and their importance as opportunistic pathogenic organisms or even strict pathogens in humans, domestic animals and wild animals have been reported as sources of the disease called mycobacteriosis (García and García 2012). The role of NTM does not appear anywhere in the research literature about D. virginiana; however, life habits imply a strong interaction between them and their environment due to their varied diet and their behaviour and distribution patterns. These habitat interactions facilitate the presence of NTM in D. virginiana, which could eventually become a wild reservoir of the bacteria, hindering the microbiological isolation of the complex of mycobacteria when mixed infections exist. It has also been proved that some NTM interfere with today’s official diagnostic tests for bovine tuberculosis due to cross-reactivity (Jaroso et al 2010).

The problem with this interference in the epidemiological study of bovine tuberculosis in Mexico is that despite 21 years of efforts to eradicate the disease, only 82% of the national territory has less than 0.5% prevalence of bovine tuberculosis (NOM-031-ZOO-19954). The association between sex and the presence of NTM is due to D. virginiana having a sex ratio of 1:1, which is considered an ideal condition for population growth. However, in polygamous species such as D. virginiana, there tends to be a larger number of males, especially in zones where resources are more available, and competition is far less stringent. In these zones, it is believed that the sex ratio observed could be associated with the size of the population and the distribution patterns of the species, which are determined primarily by competence, predation, availability of food resources, shelter, immigration, dispersion and extinction (Cruz et al 2014). The wild boar is considered the most

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1 INEGI, Instituto Nacional de Estadística y Geografía. 2010; http://www.inegi.org.mx/inegi/default.aspx?z=geo&c=06.
2 NOM-033-ZOO-1995. Sacrificio humanitario de los animales domésticos y silvestres. http://www.senasica.gob.mx/?doc=529.
3 NOM-051-ZOO-1995. Trato humanitario en la movilización de animales. http://www.senasica.gob.mx/?doc=531.
4 NOM-031-ZOO-1995. Campaña Nacional contra la Tuberculosis Bovina (Mycobacterium bovis). http://www.senasica.gob.mx/?doc=725.
Table 1. *D. virginiana* positive for nontuberculous mycobacteria (NTM), and histological lesions of retropharyngeal lymph nodes and positive to Ziehl Neelsen originated in the State of Colima, Mexico, in 2013.

| Sex    | Locality-Location | Classification of NTM | Ziehl Neelsen | Granuloma Lesion |
|--------|-------------------|-----------------------|---------------|------------------|
| Male   | Tecomán 18°55’N104°31’O | *M. szulgai*         | Yes           | Yes              |
| Female | Tecomán 18°55’N104°31’O | *M. terrae*          | No            | No               |
| Male   | Colima 19°15’N103°43’O | *M. asiaticum*       | No            | Yes              |
| Male   | Manzanillo 19°31’N104°19’O | *M. gastri*         | No            | No               |
| Male   | Tecomán 18°55’N104°31’O | *M. terrae*          | Yes           | Yes              |

Figure 1. Retropharyngeal lymph node of *D. virginiana* in which a nodule can be observed in the cortical region. It measures 8X8 mm, well-defined, solid and brown (see the pointing arrow).

Table 2. Association between the sex of *D. virginiana* and the presence of Non-tuberculous Mycobacteria (NTM) in the state of Colima, Mexico.

| Sex    | Positive | Negative | Chi-square | P   |
|--------|----------|----------|------------|-----|
|        | N       | %        | n          | %   |     |
| Male   | 4       | 36.36    | 7          | 63.64 | 12.95 | 0.00 |
| Female | 1       | 14.29    | 6          | 85.71 |      |     |

Important reservoir of tuberculosis, and it is primarily accountable for transmitting the disease to red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) (García et al 2013). In Spain, diversity and co-infections of NTM and *M. bovis* in wild boar, fallow deer, red deer and cattle (in the south) have been described (Gortázar et al 2011). The NTM *M. chelonae* and *M. avium* have been isolated from wild boar (García et al 2015). Wild animals infected with *Mycobacterium* spp. may, under certain conditions, become reservoirs of such agents. In the wild, the badger, deer, opossum, ferret and buffalo are recognised as reservoirs of bovine tuberculosis (Machackova et al 2003).

In this study, we present the finding of four NTM species that nevertheless produce similar granulomatous lesions. Therefore, the opossum *D. virginiana* could become a reservoir of *Mycobacterium* spp. for wild and domestic animals.
The risk represented by *D. virginiana* is determined by its interaction with the environment due to its habitat, eating habits and behavioral patterns that expose it to mycobacteria present in environments such as water, soil, plants and animals; their coexistence with domestic animals and even with humans can spread these mycobacterial infections. This could facilitate a high presence of NTM in the lymph nodes of these animals, so it is useful to verify the presence, prevalence and variety of NTM in opossums in areas where bovine tuberculosis is endemic. These cases indicate that NTM can cause tuberculosis-like disease in *D. virginiana* and illustrates the importance of identifying causal agents of tuberculosis-like diseases in wildlife.

The lesions in the lymph nodes consisted of granulomas characterised by histiocytes, epithelial cells and giant cells; in two of the animals, acid-fast bacteria (ZN+) were observed (table 1 and figure 2). Granulomatous lesions associated with NTM have been described in black-tailed deer (Hall *et al* 2005), and granulomas in the lymph nodes of *D. virginiana* caused by *M. bovis* have been described in Mexico (Acosta *et al* 2012). Two types of lesions, pyogranulomatous and granulomatous, have been classified in the lymph nodes of bovines in Mexico where NTM were isolated (Hernández 2014). Depending on the susceptibility of the host, granulomas caused by mycobacteria in the wild can vary in size and may or may not be well delimited by connective tissue. The literature contains a great variety of descriptions of the types of lesions (macroscopic) and granulomas (microscopic) observed in wild fauna (Zanella *et al* 2008, García *et al* 2012). Granulomatous lesions in the lymph nodes and lungs of *D. virginiana* caused by mycobacteria could be confused with lipid pneumonia, as it manifests with whitish multifocal lesions on the lung parenchyma, which are common in opossums with the lung parasite *Didelphostrongylus hayesi* (García *et al* 2012).

Another parasite similar to *Paragonimus mexicanus* causes granulomatous pneumonia in opossums (García *et al* 2010).

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REFERENCES

Acosta R, Ocampo J, Arellano Z, Ramírez L, Martínez V, *et al*. 2012. Histopathological and PCR *Mycobacterium bovis* Identification in Mexican Opossums (*Didelphis virginiana*) from Hidalgo, Mexico. *J Anim Vet Adv* 11, 207-210.

Bercovier H, Vincent V. 2001. Mycobacterial infections in domestic and wild animals due to *Mycobacterium marinum*, *M. fortuitum*, *M. chelonae*, *M. porcinum*, *M. farrcinogenes*, *M. smegmatis*, *M. scrofulaceum*, *M. xenopi*, *M. kansaii*, *M. simiae* and *M. genavense*. *Rev Sci Tech* 20, 265-290.

Casal M, Casal M. 2000. Las micobacterias atípicas como patógenos emergentes. *Enf En* 2, 220-230.

Cruz B, Ruiz L, Navarrete D, Espinoza E, Vázquez E, *et al*. 2014. Genetic diversity and relative abundance of *Didelphis marsupialis* and *Didelphis virginiana* in Chiapas, Mexico. *Rev Mex Bio* 85, 251-261.

Gadkowski B, Stout E. 2008. Cavitary pulmonary disease. *Clin Microbiol Rev* 21, 305-33.

García L, Vázquez J, Sarabia D, León V, García L, *et al*. 2010. Lesiones pulmonares en tlacuaches (*Didelphis virginiana*) infectados naturalmente por *Paragonimus mexicanus* en Colima, México. *Vet Méx* 41, 65-72.

García ML, López RA, López A, Prado OF. 2012. Neumonía lipídica endógena en tlacuaches (*Didelphis virginiana*) capturados en el estado de Colima, México. *Vet Mex* 43, 241-246.

García MP, García L. 2012. Infections due to rapidly growing mycobacteria. *Enf Inf Microbiol Clin* 30, 192-200.

García WL, Fernández P, Gómez L, Benítez J, García A, *et al*. 2012. Histological and immunohistochemical characterisation of *Mycobacterium bovis* induced granulomas in naturally infected Fallow deer (*Dama dama*). *Vet Immunol Immunop* 149, 66-75.
García WL, Fernández P, Benítez J, Cerratos R, Cuesta J, et al. 2013. Reducing Eurasian wild boar (Sus scrofa) population density as a measure for bovine tuberculosis control: Effects in wild boar and sympatric fallow deer (Dama dama) population in Central Spain. Prev Vet Med 110, 435-446.

García WL, Benítez J, Martínez R, Carranza J, Cerratos R, et al. 2015. Non-tuberculous mycobacteria in wild boar (Sus scrofa) from Southern Spain: epidemiological, clinical and diagnostic concerns. Transb Emerg Dis 62, 72-80.

Gortázar C, Torres M, Acevedo P, Aznar J, Negro J, et al. 2011. Fine-tuning the space, time, and host distribution of mycobacteria in wildlife. BMC Microbiol 11, 1-16.

Hall B, Bender C, Garner M. 2005. Mycobacteriosis in a black-tailed deer (Odocoileus hemionus columbianus) caused by Mycobacterium kansasii. J Zoo Wildlife Med 36, 115-116.

Hernández JA. 2014. Identificación de micobacterias no tuberculosas aisladas de nódulos linfáticos de bovinos y caracterización de lesiones asociadas. Tesis Maestría en Ciencias Veterinarias y Zootécnicas, Facultad de Medicina Veterinaria y Zootecnia, Universidad Autónoma de Tamaulipas, México.

Holland M. 2001. Nontuberculous mycobacteria. Am J Med Sci 321, 49-55.

Iseman D, Marras K. 2008. The importance of non-tuberculous mycobacterial lung disease. Am J Resp Crit Care Med 178, 999-1000.

Jang S, Hirsh C. 2002. Rapidly growing members of the genus Mycobacterium affecting dogs and cats. J Am Anim Hosp Assoc 38, 217-220.

Jaroso R, Vicente J, Martín MP, Aranaz A, Lyshchenko K, et al. 2010. Ante-mortem testing wild fallow deer for bovine tuberculosis. Vet Microbiol 146, 285-289.

Koneman W, Win C, Allen D, Landa M, Procop W, et al. 2008. Diagnóstico Microbiológico. Médica Panamericana. Buenos Aires, Argentina.

Machackova M, Matlova L, Lamka J, Smolik J, Melicharek I, et al. 2003. Wild boar (Sus scrofa) as a possible vector of mycobacterial infections: review of literature and critical analysis of data from Central Europe between 1983 to 2001. Vet Med Czech 48, 51-65.

Martín HMP, Höfle U, Vicente J, Ruiz F, Vidal D, et al. 2007. Lesions associated with Mycobacterium tuberculosis complex infection in the European wild boar. Tubercle 87, 360-367.

Piersimoni C, Scarparo C. 2008. Pulmonary infections associated with non-tuberculous mycobacteria in immunocompetent patients. Lancet Infect Dis 8, 323-334.

Proano F, Rigouts L, Brandt J, Dormy P, Ron J, et al. 2006. Preliminary observations on Mycobacterium spp. in dairy cattle in Ecuador. Am J Trop Med Hyg 75, 318-323.

Prophet E, Mills B, Arrington J, Sobin H. 1995. Métodos Histotecnológicos. Washington DC: Instituto de Patología de las Fuerzas Armadas de los Estados Unidos de América (AFIP) y Registro de Patología de los Estados Unidos de América (ARP).

Sato T, Shibuya H, Ohba S, Nojiri T, Shirai W. 2003. Mycobacteriosis in two captive Florida manatees (Trichechus manatus latirostris). J Zoo Wildlife Med 34, 184-188.

Zanella G, Duvauuchelle A, Hars J, Moutou F, Boschiroli ML, et al. 2008. Patterns of lesions of bovine tuberculosis in wild red deer and wild boar. Vet Rec 163, 43-47.
