



Complete Genome Sequences of Three *Leptospira mayottensis* Strains from Tenrecs That Are Endemic in the Malagasy Region

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ABSTRACT Leptospirosis is a zoonosis caused by *Leptospira*, a diversified genus containing more than 10 pathogenic species. Tenrecs are small terrestrial mammals endemic in the Malagasy region and are known to be reservoirs of the recently described species *Leptospira mayottensis*. We report the complete genome sequences of three *L. mayottensis* strains isolated from two tenrec species.

Leptospirosis is an environmental infectious disease caused by spirochetal bacteria belonging to the genus *Leptospira*. Humans usually get infected during recreational or work-related outdoor activities through contact with urine excreted by animal reservoirs. This zoonosis is estimated to cause more than one million human cases and 58,900 deaths each year (1). Disease incidence is highest on tropical islands, notably in the southwestern Indian Ocean, where investigations carried out under a One Health framework have revealed distinct transmission chains in the different islands (2–5), including the occurrence of *Leptospira mayottensis*, a pathogenic *Leptospira* species recently recognized as new to science (6). Representatives of *L. mayottensis* (formerly known as *Leptospira borgpetersenii* group B) were originally isolated from human acute cases (7) and later identified in tenrecs (2, 5, 8), a diversified family of mammals endemic to Madagascar (9, 10).

Three *L. mayottensis* strains were isolated in the field from two tenrec species, namely, *Tenrec ecaudatus* on Mayotte (MDI222 and MDI272) (2) and *Microgale dobsoni* on Madagascar (VS2413) (5). Frozen isolates were thawed in liquid Ellinghausen-McCullough-Johnson-Harris (EMJH) medium containing albumin fatty acid supplements (AFAS) (3), and they were further subcultured in EMJH supplemented with AFAS, 1% fetal calf serum, and 8% rabbit serum. DNA was extracted with the EZ1 virus minikit v.2.0 (Qiagen, Germany), and sequencing was performed on PacBio platforms. The sequence for VS2413 was assembled *de novo* with SMRT Analysis HGAP.2, those for MDI222 and MDI272 were assembled *de novo* using Canu 1.6, and contigs were circularized using AMOS v.3.1 (11).

Overall, genome sizes and structures (see Table 1) are close to those of previously published ones, with comparably low ($\leq 40\%$) GC contents, two chromosomes, and, in the case of *T. ecaudatus*-borne strains, an additional plasmid (12).

Automatic annotation was performed with the NCBI Prokaryotic Genome Annotation Pipeline (13), which revealed that the VS2413, MDI272, and MDI222 genomes are composed of 3,893, 3,917, and 4,136 coding sequences, respectively.

Human leptospirosis on Mayotte is peculiar because it is associated with four distinct bacterial species, including *L. mayottensis* (14), and characterized by a relatively low fatality rate (0.9%) (15). The epidemiology is clearly distinct in the neighboring Seychelles and on Reunion Island, where *L. interrogans* is overwhelmingly dominant and fatality rates are higher (11.8% in the Seychelles and 3 to 5% on Reunion Island) (3, 4, 16). An attenuated virulence of *Leptospira* species prevailing on Mayotte, including *L. mayottensis*, may be at

Received 29 August 2018 Accepted 14 September 2018 Published 18 October 2018

Citation Cordonin C, Toty C, Mavingui P, Tortosa P. 2018. Complete genome sequences of three *Leptospira mayottensis* strains from tenrecs that are endemic in the Malagasy region. *Microbiol Resour Announc* 7:e01188-18. <https://doi.org/10.1128/MRA.01188-18>.

Editor Jason Stajich, University of California, Riverside

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TABLE 1 Genome architecture of *L. mayottensis* isolates^a

Isolate	Source host	Sampling location	Chromosome length (bp)		Plasmid length (bp)	No. of reads	N ₅₀ length (bp)
			I	II			
MDI222	<i>Tenrec ecaudatus</i>	Mayotte	3,934,331 (not circularized)	330,241	111,328	44,976	20,779
MDI272	<i>Tenrec ecaudatus</i>	Mayotte	3,861,885	332,647	52,509	52,101	17,832
VS2413	<i>Microgale dobsoni</i>	Madagascar	3,787,562	300,219		55,595	21,656

^aAll but one replicon were successfully circularized.

least in part responsible for this contrasted regional epidemiology. The genomes presented herein will accelerate comparative genomic approaches aimed at delineating the main genomic features involved in *Leptospira* virulence.

Data availability. Genome sequences were deposited in DDBJ/EMBL/GenBank under the accession numbers CP030142 and CP030143, CP030144 to CP030146, and CP030147 to CP030149 for strains VS2413, MDI222, and MDI272, respectively, as well as BioProject number PRJNA477299. Raw sequence data are available from the NCBI Sequence Read Archive (accession number SRP154442).

ACKNOWLEDGMENTS

We are thankful to Pierre Lefeuvre, Frédéric Pagès, and Claire Valiente-Moro for fruitful discussions.

This work was financed by European Regional Development Funds ERDF PO INTERREG V ECOSPIR number RE6875 and was carried out in the framework of Colette Cordonin's Ph.D. degree, financed by the French Ministry of Higher Education, Research and Innovation. We thank members of the IRD i-trop Plantes Santé bioinformatics platform for providing HPC resources and support.

REFERENCES

- Costa F, Hagan JE, Calcagno J, Kane M, Torgerson P, Martinez-Silveira MS, Stein C, Abela-Ridder B, Ko AI. 2015. Global morbidity and mortality of leptospirosis: a systematic review. *PLoS Negl Trop Dis* 9:e0003898. <https://doi.org/10.1371/journal.pntd.0003898>.
- Lagadec E, Gomard Y, Le Minter G, Cordonin C, Cardinale E, Ramasindrazana B, Dietrich M, Goodman SM, Tortosa P, Dellagi K. 2016. Identification of *Tenrec ecaudatus*, a wild mammal introduced to Mayotte Island, as a reservoir of the newly identified human pathogenic *Leptospira mayottensis*. *PLoS Negl Trop Dis* 10:e0004933. <https://doi.org/10.1371/journal.pntd.0004933>.
- Biscornet L, Dellagi K, Pagès F, Bibi J, de Comarmond J, Mélande J, Govinden G, Tirant M, Gomard Y, Guernier V, Lagadec E, Mélanie J, Rocamora G, Le Minter G, Jaubert J, Mavingui P, Tortosa P. 2017. Human leptospirosis in Seychelles: a prospective study confirms the heavy burden of the disease but suggests that rats are not the main reservoir. *PLoS Negl Trop Dis* 11:e0005831. <https://doi.org/10.1371/journal.pntd.0005831>.
- Guernier V, Lagadec E, Cordonin C, Le Minter G, Gomard Y, Pagès F, Jaffar-Bandjee M-C, Michault A, Tortosa P, Dellagi K. 2016. Human leptospirosis on Reunion Island, Indian Ocean: are rodents the (only) ones to blame? *PLoS Negl Trop Dis* 10:e0004733. <https://doi.org/10.1371/journal.pntd.0004733>.
- Dietrich M, Gomard Y, Lagadec E, Ramasindrazana B, Le Minter G, Guernier V, Benlali A, Rocamora G, Markotter W, Goodman SM, Dellagi K, Tortosa P. 2018. Biogeography of *Leptospira* in wild animal communities inhabiting the insular ecosystem of the western Indian Ocean islands and neighboring Africa. *Emerg Microbes Infect* 7:57. <https://doi.org/10.1038/s41426-018-0059-4>.
- Bourhy P, Collet L, Brisse S, Picardeau M. 2014. *Leptospira mayottensis* sp. nov., a pathogenic species of the genus *Leptospira* isolated from humans. *Int J Syst Evol Microbiol* 64:4061–4067. <https://doi.org/10.1099/ijs.0.066597-0>.
- Bourhy P, Collet L, Clément S, Huerre M, Ave P, Giry C, Pettinelli F, Picardeau M. 2010. Isolation and characterization of new *Leptospira* genotypes from patients in Mayotte (Indian Ocean). *PLoS Negl Trop Dis* 4:e724. <https://doi.org/10.1371/journal.pntd.0000724>.
- Dietrich M, Wilkinson DA, Soarimalala V, Goodman SM, Dellagi K, Tortosa P. 2014. Diversification of an emerging pathogen in a biodiversity hotspot: *Leptospira* in endemic small mammals of Madagascar. *Mol Ecol* 23:2783–2796. <https://doi.org/10.1111/mec.12777>.
- Everson KM, Soarimalala V, Goodman SM, Olson LE. 2016. Multiple loci and complete taxonomic sampling resolve the phylogeny and biogeographic history of tenrecs (Mammalia: Tenrecidae) and reveal higher speciation rates in Madagascar's humid forests. *Syst Biol* 65:890–909. <https://doi.org/10.1093/sysbio/syw034>.
- Olson LE. 2013. Tenrecs. *Curr Biol* 23:R5–R8. <https://doi.org/10.1016/j.cub.2012.11.015>.
- Treangen TJ, Sommer DD, Angly FE, Koren S, Pop M. 2011. Next generation sequence assembly with AMOS. *Curr Protoc Bioinformatics*. Chapter 11:Unit 11.8. <https://doi.org/10.1002/0471250953.bi1108s33>.
- Wang Y, Zhuang X, Zhong Y, Zhang C, Zhang Y, Zeng L, Zhu Y, He P, Dong K, Pal U, Guo X, Qin J. 2015. Distribution of plasmids in distinct *Leptospira* pathogenic species. *PLoS Negl Trop Dis* 9:e0004220. <https://doi.org/10.1371/journal.pntd.0004220>.
- Tatusova T, DiCuccio M, Badretdin A, Chetvernin V, Nawrocki EP, Zaslavsky L, Lomsadze A, Pruitt KD, Borodovsky M, Ostell J. 2016. NCBI Prokaryotic Genome Annotation Pipeline. *Nucleic Acids Res* 44:6614–6624. <https://doi.org/10.1093/nar/gkw569>.
- Bourhy P, Collet L, Lernout T, Zinini F, Hartskeerl RA, van der Linden H, Thiberge JM, Diancourt L, Brisse S, Giry C, Pettinelli F, Picardeau M. 2012. Human *Leptospira* isolates circulating in Mayotte (Indian Ocean) have unique serological and molecular features. *J Clin Microbiol* 50:307–311. <https://doi.org/10.1128/JCM.05931-11>.
- Pagès F, Collet L, Henry S, Margueron T, Achirafi A, Bourhy P, Picardeau M, Lernout T, Filleul L. 2017. Leptospirosis in Mayotte: contribution of epidemiological surveillance, 2008–2015. *Bull Epidemiol Hebd* 8/9:147–156.
- Pagès F, Polycarpe D, Dehecq J-S, Picardeau M, Caillère N, Jaffar-Bandjee M-C, Michault A, Filleul L. 2014. Human leptospirosis on Reunion Island: past and current burden. *Int J Environ Res Public Health* 11:968–982. <https://doi.org/10.3390/ijerph110100968>.