



Tacheng Tick Virus 1 and Songling Virus Infection in Great Gerbils (*Rhombomys opimus*) in Northwestern China

Authors: Ji, Na, Wang, Nan, Liu, Gang, Zhao, Shanshan, Liu, Zhiqiang, et al.

Source: Journal of Wildlife Diseases, 59(1) : 138-142

Published By: Wildlife Disease Association

URL: <https://doi.org/10.7589/JWD-D-21-00137>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Tacheng Tick Virus 1 and Songling Virus Infection in Great Gerbils (*Rhombomys opimus*) in Northwestern China

Na Ji,^{1,2,3,6} Nan Wang,^{1,2,6} Gang Liu,^{1,2,6} Shanshan Zhao,^{1,2} Zhiqiang Liu,⁴ Wenbo Tan,^{1,2} Shiyi Wang,^{1,2} Jinjiang Sheng,^{5,7} Fengshi Li,^{1,2} and Yuanzhi Wang^{1,2,7} ¹Department of Basic Medicine, School of Medicine, Shihezi University, Shihezi City, Xinjiang Uygur Autonomous Region 832002, People's Republic of China; ²NHC Key Laboratory of Prevention and Treatment of Central Asia High Incidence Diseases, First Affiliated Hospital, School of Medicine, Shihezi University, Shihezi City, Xinjiang Uygur Autonomous Region 832002, People's Republic of China; ³Xiangyang Central Hospital, Affiliated Hospital of Hubei University of Arts and Science, Xiangyang, Hubei, 441021, People's Republic of China; ⁴Institute of Veterinary Medicine, Xinjiang Academy of Animal Science, Urumqi, 830000, People's Republic of China; ⁵Department of Veterinary Medicine, College of Animal Science and Technology, Shihezi University, Xinjiang Uygur Autonomous Region 832002, People's Republic of China; ⁶These authors contributed equally to this work. ⁷Corresponding authors (email: 1572621211@qq.com [J.S.]; wangyuanzhi621@126.com [Y.W.])

ABSTRACT: Tacheng tick virus 1 (TcTV-1) and Songling virus (SGLV) were originally found in human patients in China who had had tick bites. Tamdy virus (TAMV) was detected for the first time in a tick-infested person from Kyrgyzstan in 1973. In this study, 276 great gerbils (*Rhombomys opimus*) were collected in Xinjiang Uygur Autonomous Region in northwestern China. The total RNA of individual spleen samples was extracted, and the viral L segments of TcTV-1, SGLV, and TAMV were detected by nested reverse transcription PCR. Overall, 2.9% (8/276) and 2.2% (6/276) of spleen samples tested positive to the viral L segments for TcTV-1 and SGLV, respectively; TAMV was not detected in any samples. The SGLV from the great gerbils shared 93.7% (236/252 nucleotide [nt]) and 94.0% (78/83 amino acid [aa]) identities to SGLV detected in patients infected with SGLV in northeastern China. The TcTV-1 in great gerbils was closest to TcTV-1 from a patient in China, with 98.5% (797/809 nt) and 98.9% (265/268 aa) sequence identities. This is the first molecular evidence for the presence of TcTV-1 and SGLV in great gerbils. High genetic diversity in SGLV was observed among geographical locations. Multiregion surveillance of Tamdy orthonairoviruses in more wildlife species is necessary.

Key words: China, great gerbil, *Rhombomys opimus*, Songling virus, Tacheng tick virus 1.

Tickborne orthonairoviruses (Nairoviridae: Bunyavirales) have been characterized as a global health threat to humans, domestic animals, and wildlife (Garrison et al. 2020). Tamdy virus (TAMV) was first detected in a febrile patient from Kyrgyzstan in 1973 (L'vov et al. 2014) and subsequently isolated from *Hyalomma asiaticum* ticks from Bactrian camels (*Camelus bactrianus*) in Xinjiang

Uygur Autonomous Region (XUAR) in 2018 (Zhou et al. 2019). Tacheng tick virus 1 (TcTV-1) was first isolated from a patient who had tick bites plus fever and rash and was then detected in cattle and sheep from XUAR in 2019 (Liu et al. 2020). Recently, Songling virus (SGLV) has been identified in 42 of 658 hospitalized patients who had tick bites in Heilongjiang Province and Inner Mongolia Autonomous Region (IMAR) in northern China (Ma et al. 2021). However, information is lacking regarding tickborne orthonairoviruses, such as SGLV, TcTV-1, and TAMV, in wildlife, especially in northwestern China.

The great gerbil (*Rhombomys opimus*) belongs to the order Rodentia, family Cricetidae, subfamily Gerbillinae (Liu et al. 2012). Its distribution encompasses arid and semiarid regions throughout central and south Asia (Kamranrashani et al. 2013). It is a dominant mammalian species in the Gurbantünggüt Desert, XUAR, in northwestern China (covering 48,800 km²) and is a valuable sentinel animal for multiple vectorborne diseases (Wilschut et al. 2013). It is considered a natural reservoir for *Yersinia pestis*, *Leishmania donovani*, Crimean-Congo hemorrhagic fever virus (CCHFV), Phlebotomus fever Sicilian virus, lymphocytic choriomeningitis virus, and Chim virus (Darwish et al. 1983; Hardestam et al. 2007; Kamranrashani et al. 2013; Ishii et al. 2014; Zhang et al. 2018). It remains unclear whether great gerbils could be potential reservoirs for SGLV, TcTV-1, and TAMV.



FIGURE 1. Map showing sites (in red) at which great gerbils (*Rhombomys opimus*) were caught and sampled for viruses during 2019–2021, providing new confirmed locations for Tacheng tick virus 1 (TcTV-1) and Songling virus (SGLV). Areas in which SGLV and TcTV-1 have previously been detected in China are also shown on the map, in pale blue and dark blue, respectively.

During 2019–21, 276 great gerbils were collected at 16 sampling sites in Alataw City (45°19'N, 82°56'E) and Manas County (43°28'N, 85°34'E), Gurbantünggüt Desert, XUAR (Fig. 1). The gerbils were captured using 390 Sherman live traps (30 cm × 15 cm × 15-cm wire mesh; Alataw City) baited with walnut, cucumber, or tomato. Traps were checked twice daily and rebaited whenever necessary; trap success rate was from 0.5% to approximately 3% (Kamranrashani et al. 2013; Zhao et al. 2020; Ji et al. 2021). To prevent the spread of highly pathogenic infections, the rodents were trapped and handled following biosafety guidelines (Mills et al. 1995). All wild rodents were morphologically identified by an experienced zoologist. The rodents in

Manas County were kept in a cool, shaded place with sufficient food and then transported to our laboratory, whereas the wild animals captured in Alataw City were transported to the Vectorborne Laboratory at Alataw Customs. Tiletamine-zolazepam (Zoletil 50, Virbac, Paris, France) was given by intramuscular injection to anesthetize the gerbils (Yan et al. 2020). The rodents were killed by cervical dislocation while anesthetized (Feldman and Hillman 1969), and necropsy was performed. The spleen was aseptically removed from each individual, placed in an individual sterile polypropylene tube, and stored frozen at –80 C (Laakkonen et al. 2001). This study was reviewed and approved by the ethical stan-

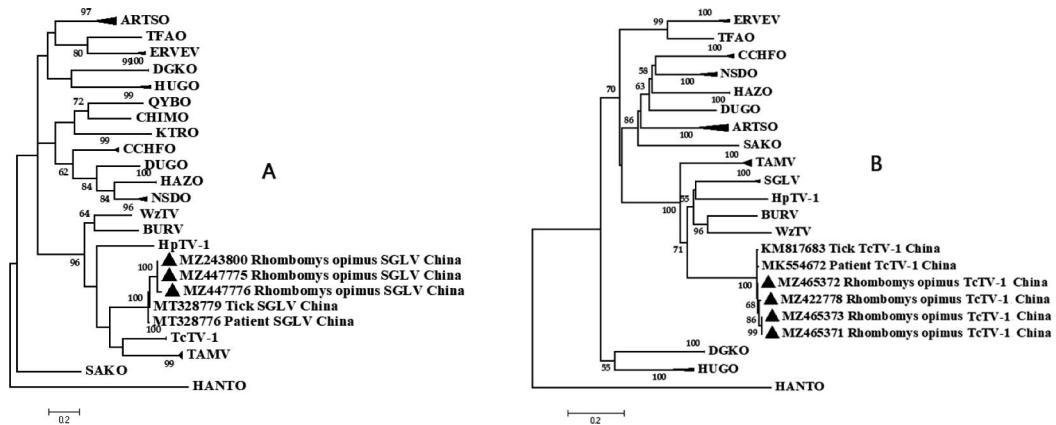


FIGURE 2. Phylogenetic tree based on partial sequences of the L segment gene (820 base pairs) of spleens from great gerbils (*Rhombomys opimus*) in border regions of northwestern China. The evolutionary history was inferred using the maximum likelihood method (bootstrap replicates: 1,000) with MEGA7 (Kumar et al. 2016). Sequences obtained in this study are indicated by black triangles. (A) Songling virus. (B) Tacheng tick virus 1.

dards of Animal Ethics Committee of Shihezi University (approval A2018-143-01).

A minced spleen sample (~0.2 g) was used to extract genomic RNA by using the RNeasy Pure Tissue Kit (Qiagen, Beijing, China). The cDNAs were obtained by using a RevertAid First Strand cDNA Synthesis Kit (Thermo Fisher Scientific, Shanghai, China), following the manufacturer's instructions. The quantity and purity of RNA were assessed with a NanoDrop 2000 spectrophotometer (Thermo Fisher Scientific) using a representative number of randomly selected samples. We used a concentration of RNA >50 ng/ μ L (50–100 μ L); we have found this concentration to be sufficient to detect pathogens, although Gilbert et al. (2004) suggested 100 ng/ μ L. We carried out specific nested reverse transcription (nRT)-PCR for partial L segments of TcTV-1 (809 base pairs [bp]), SGLV (229 bp), and TAMV (228 bp) on the 276 spleen samples. Based on genome sequences available in GenBank (TcTV-1: KM817683, MK554672; SGLV: MT328776, MT328779; and TAMV: MK757580, MN792651), primer design was carried out using DNAMAN software (Lynnon Biosoft, San Ramon, California, USA). For the primers and nRT-PCR cycling conditions, see the Supplementary Material. Positive and negative controls were included in each amplification (Liu et al. 2020;

Ma et al. 2021). The amplified products were cloned into the pGEM-T Easy vector (TransGen Biotech, Beijing, China) and then sequenced (Song et al. 2018). In addition, we used a BLASTn (NCBI 2021) search to identify closely related sequences. Molecular phylogenetic analyses were conducted using MEGA7 software (Kumar et al. 2016).

The viral L segments of TcTV-1 and SGLV were detected in 2.9% (8/276) and 2.2% (6/276) of spleen samples, respectively; TAMV was not detected in any samples. The BLASTn alignments indicated that 1) SGLV in great gerbil shared 93.7% (236/252 nucleotide [nt]) and 94.0% (78/83 amino acid [aa]) sequence identities to SGLV (GenBank no. MT328776) detected in human patients who had had tick bites in northeastern China; and 2) the viral segment in great gerbil was the closest to that of TcTV-1 from a human patient in China (GenBank no. MK554672), having 98.5% (797/809 nt) and 98.9% (265/268 aa) sequence identities. Phylogenetic analysis showed that the segments of SGLV in great gerbil from XUAR were different from viral sequences from patients (GenBank no. MT328776; Fig. 2). The viral segment of TcTV-1 in our study was most closely related to that from a human patient sampled in 2018 in XUAR (GenBank no. MK554672), although four sequences from the spleen samples of

great gerbils showed remarkable genetic diversity (98.8–99.0%; Fig. 2).

Tamdy orthonairoviruses (Nairoviridae: *Orthonairovirus*) include at least six valid viruses (Zhou et al. 2019; Liu et al. 2020; Ma et al. 2021). To date, TcTV-1, SGLV, and TAMV have been considered human pathogens with public health significance. However, potential reservoirs for TcTV-1, SGLV, and TAMV are unknown. Our detections of TcTV-1 and SGLV in spleen samples of great gerbils suggest that these rodents may be reservoirs in the epidemiologic cycles of TcTV-1 and SGLV, although the presence of other members of Tamdy orthonairoviruses should be investigated in more wild mammal species in follow-up studies.

Previous phylogenetic analyses indicated that CCHFV isolates collected in a worldwide context belonged to seven distinct clades according to geographical location (Deyde et al. 2006). Our finding that the viral L segment of SGLV in great gerbil shared 93.7% (236/252 nt) and 94.0% (78/83 aa) identities with those of SGLV (accession no. MT328776) in a human patient from northeastern China who had had tick bites indicates that SGLVs show high genetic diversity between geographic regions, similar to the polymorphism of CCHFV among different countries, and even within a country (Drosten et al. 2002; Deyde et al. 2006). In addition, TcTV-1 presented genetic diversity (98.8–99.0%) even among great gerbils captured in the same region. Future studies examining whether links exist between viral genetic diversity, geographic locations, and hosts of TcTV-1 may provide additional insights.

Previously, TcTV-1 had been found in seven counties or cities of northwestern China (Liu et al. 2020) and SGLV had been detected from Heilongjiang Province and IMAR (Ma et al. 2021). Our study expands knowledge of the geographical distribution of TcTV-1 and SGLV.

To gain further understanding of Tamdy orthonairovirus infections in great gerbils, future studies should examine whether pathologic changes occur after natural infection with SGLV or TcTV-1 and evaluate whether other species of Tamdy orthonairoviruses infect great gerbils.

The authors thank the staff at the School of Medicine and College of Animal Science and Technology, Shihezi University, for contributions. This work was supported in part by the International Cooperation Projects of XUAR (2020E01035), Natural Science Foundation of China (81960379), Non-profit Central Research Institute Fund of Chinese Academy of Medical Sciences (2020-PT330-003), High-level Talent Initiative Foundation of Shihezi University (RCZK202033), and Open Subject of Central Asia High Incidence Disease Control Key Laboratory of National Health Commission (KF202102).

SUPPLEMENTARY MATERIAL

Supplementary material for this article is online at <http://dx.doi.org/10.7589/JWD-D-21-00137>.

LITERATURE CITED

- Darwish MA, Hoogstraal H, Roberts TJ, Ghazi R, Amer T. 1983. A sero-epidemiological survey for Bunyaviridae and certain other arboviruses in Pakistan. *Trans R Soc Trop Med Hyg* 77:446–450.
- Deyde VM, Khristova ML, Rollin PE, Ksiazek TG, Nichol ST. 2006. Crimean-Congo hemorrhagic fever virus genomics and global diversity. *J Virol* 80:8834–8842.
- Drosten C, Minnak D, Emmerich P, Schmitz H, Reinicke T. 2002. Crimean-Congo hemorrhagic fever in Kosovo. *J Clin Microbiol* 40:1122–1123.
- Feldman H, Hillman H. 1969. Cardiac arrest following neck dislocation in rats. *J Physiol* 200(Suppl):54P–55P.
- Garrison AR, Alkhovsky SV, Avšič-Županc T, Bente DA, Bergeron É, Burt F, Di Paola N, Ergünay K, Hewson R, et al. 2020. ICTV virus taxonomy profile: Nairoviridae. *J Gen Virol* 101:798–799.
- Gilbert ER, Li H, Emmerson DA, Webb KE Jr, Wong EA. 2004. Dietary protein composition influences abundance of peptide and amino acid transporter messenger ribonucleic acid in the small intestine of 2 lines of broiler chicks. *Poult Sci* 89:1663–1676.
- Hardestam J, Simon M, Hedlund KO, Vaheri A, Klingström J, Lundkvist Å. 2007. Ex vivo stability of the rodent-borne Hantaan virus in comparison to that of arthropod-borne members of the *Bunyaviridae* family. *Appl Environ Microbiol* 73:2547–2551.
- Ishii A, Ueno K, Orba Y, Sasaki M, Moonga L, Hang'ombe BM, Mweene AS, Umemura T, Ito K, et al. 2014. A nairovirus isolated from African bats causes haemorrhagic gastroenteritis and severe hepatic disease in mice. *Nat Commun* 5:5651.

- Ji N, Chen X, Liu G, Zhao S, Tan W, Liu G, Zhang J, Wang Y. 2021. *Theileria*, *Hepatozoon* and *Taenia* infection in great gerbils (*Rhombomys opimus*) in northwestern China. *Int J Parasitol Parasites Wildl* 15:79–86.
- Kamranrashani B, Kia EB, Mobedi I, Mohebbali M, Zarei Z, Mowlavi GH, Hajjaran H, Abai MR, Sharifdini M, et al. 2013. Helminth parasites of *Rhombomys opimus* from Golestan Province, northeast Iran. *Iran J Parasitol* 8:78–84.
- Kumar S, Stecher G, Tamura K. 2016. MEGA7: Molecular evolutionary genetics analysis version 7.0 for bigger datasets. *Mol Biol Evol* 33:1870–1874.
- Laakkonen J, Sukura A, Oksanen A, Henttonen H, Soveri T. 2001. Haemogregarines of the genus *Hepatozoon* (Apicomplexa: Adeleina) in rodents from northern Europe. *Folia Parasitol (Praha)* 48:263–267.
- Liu W, Xu W, Yang W, Guo C, Blank D, Xia C, Lin J, Xu F, Qiao H. 2012. Food habits of the great gerbil (*Rhombomys opimus*) in the southern Gurbantunggut Desert, Xinjiang, China. *Pak J Zool* 44:931–936.
- Liu X, Zhang X, Wang Z, Dong Z, Xie S, Jiang M, Song R, Ma J, Chen S, et al. 2020. A tentative Tamdy orthonairovirus related to febrile illness in northwestern China. *Clin Infect Dis* 70:2155–2160.
- L'vov DK, Al'khovski SV, Shchelkanov MIu, Shchetinin AM, Deriabin PG, Gitel'man AK, Aristova VA, Botikov AG. 2014. [Taxonomic status of the Burana virus (BURV) (Bunyaviridae, *Nairovirus*, Tamdy group) isolated from the ticks *Haemaphysalis punctata* Canestrini et Fanzago, 1877 and *Haem. concinna* Koch, 1844 (Ixodidae, Haemaphysalinae) in Kyrgyzstan.] *Vopr Virusol* 59(4):10–15. Russian.
- Ma J, Lv XL, Zhang X, Han SZ, Wang ZD, Li L, Sun HT, Ma LX, Cheng ZL, et al. 2021. Identification of a new orthonairovirus associated with human febrile illness in China. *Nat Med* 27:434–439.
- Mills JN, Childs JE, Ksiazek TG, Peters MD, Velleca WM. 1995. *Methods for trapping and sampling small mammals for virologic testing*. US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Atlanta, Georgia, 61 pp.
- NCBI (National Center for Biotechnology Information). 2021. *Basic local alignment search tool*. <http://blast.ncbi.nlm.nih.gov/Blast.cgi>. Accessed August 2021.
- Song R, Wang Q, Guo F, Liu X, Song S, Chen C, Tu C, Wureli H, Wang Y. 2018. Detection of *Babesia* spp., *Theileria* spp. and *Anaplasma ovis* in border regions, northwestern China. *Transbound Emerg Dis* 65:1537–1544.
- Wilschut LI, Addink EA, Heesterbeek JAP, Dubynskiy VM, Davis SA, Laudisoit A, Begon M, Burdellov LA, Atshabar BB, de Jong SM. 2013. Mapping the distribution of the main host for plague in a complex landscape in Kazakhstan: An object-based approach using SPOT-5 XS, Landsat 7 ETM+, SRTM and multiple random forests. *Int J Appl Earth Obs Geoinf* 23:81–94.
- Yan B, Zhu Q, Xu J, Zhao S, Piao D, Chen C, Liu Q, Hornok S, Wang Y, et al. 2020. *Brucella* in Himalayan marmots (*Marmota himalayana*). *J Wildl Dis* 56:730–732.
- Zhang L, Li S, Huang SJ, Wang ZD, Wei F, Feng XM, Jiang DX, Liu Q. 2018. Isolation and genomic characterization of lymphocytic choriomeningitis virus in ticks from northeastern China. *Transbound Emerg Dis* 65:1733–1739.
- Zhao S, Yang M, Liu G, Hornok S, Zhao S, Sang C, Tan W, Wang Y. 2020. Rickettsiae in the common pipistrelle *Pipistrellus pipistrellus* (Chiroptera: Vespertilionidae) and the bat soft tick *Argas vespertilionis* (Ixodida: Argasidae). *Parasit Vectors* 13:10.

Submitted for publication 17 August 2021.

Accepted 25 January 2022.