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Epidemiological assessment of lymphocytic choriomeningitis virus transmission dynamics in urban rodent populations

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Abstract

What proportion of commensal rodent species in rapidly urbanizing African cities harbor Lymphocytic Choriomeningitis Virus (LCMV), and what epidemiological factors govern its transmission? The present research evaluated the seroprevalence and transmission dynamics of LCMV among urban rodent populations in Cape Town, South Africa. A cross-sectional investigation was conducted across five urban habitat types from March 2023 to February 2024. A total of 420 rodents representing five species were captured using Sherman live traps and snap traps deployed at 84 geo-referenced trapping stations. Blood samples were screened using Enzyme-Linked Immunosorbent Assay (ELISA), and tissue specimens were subjected to reverse transcription polymerase chain reaction (RT-PCR). The overall LCMV seroprevalence was 28.6% (120/420), with the highest rates in *Mastomys natalensis* (41.3%) and *Mus musculus* (34.7%). RT-PCR yielded a positivity rate of 19.8% (83/420). Multivariate logistic regression identified habitat type, rodent species, population density, and proximity to human dwellings as significant predictors of infection. Residential areas exhibited the highest seroprevalence (32.5%). A strong positive correlation ($r^2 = 0.87$, $p < 0.001$) was established between rodent population density and LCMV prevalence. These findings underscore the zoonotic risk posed by LCMV-infected rodents in urban environments and highlight the need for integrated rodent management programs.

Keywords: Lymphocytic choriomeningitis virus, seroprevalence, urban rodent populations, zoonotic transmission, *Mastomys natalensis*, epidemiological assessment, reverse transcription polymerase chain reaction, rodent-borne viral disease

Introduction

What determines the emergence of rodent-borne viral zoonoses in expanding urban landscapes? This question has gained attention as environmental modifications reshape interfaces between human communities and synanthropic rodent populations^[1]. Lymphocytic Choriomeningitis Virus (LCMV), a bisegmented ambisense RNA virus of the family Arenaviridae, represents an underrecognized yet clinically significant zoonotic pathogen with worldwide distribution^[2]. First isolated by Armstrong and Lillie in 1933, LCMV has been identified across diverse geographical regions, with *Mus musculus* serving as its principal natural reservoir^[3].

The epidemiological significance of LCMV has been increasingly acknowledged following documented outbreaks in organ transplant recipients and congenital infections with devastating neurological consequences^[4]. Despite these clinical observations, the true burden remains substantially underestimated, particularly in resource-limited settings where diagnostic capabilities are constrained^[5]. Serological surveys in European and American populations have reported seroprevalence rates from 2% to 13%, with elevated rates among individuals with rodent exposure^[6].

The African continent presents a complex epidemiological landscape for LCMV investigation, given the diversity of indigenous rodent species, the rapid pace of unplanned urbanization, and intimate cohabitation patterns between humans and commensal rodents^[7]. Several African murid species, including *Mastomys natalensis* and *Rattus rattus*, have demonstrated capacity

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To harbor arenaviruses [8]. However, systematic investigations targeting LCMV in African urban rodent communities remain scarce [9]. South Africa provides an ideal setting for investigating urban LCMV epidemiology, and Cape Town, with diverse socioeconomic strata and heterogeneous rodent habitats, offers a representative model [10]. This research comprehensively assessed the seroprevalence, molecular detection rates, and ecological risk factors associated with LCMV infection among urban rodents in Cape Town.

Material and Methods

The investigation was conducted across five urban habitat categories within Cape Town, South Africa, from March 2023 to February 2024. The protocol received ethical clearance from the Animal Research Ethics Committee, Cape Town Institute of Veterinary Sciences (Approval No. AREC/2023/VET-047) and complied with the South African National Environmental Management: Biodiversity Act (Act 10 of 2004).

Material

Rodent specimens were collected from 84 geo-referenced trapping stations across residential areas (n = 22), market districts (n = 18), peri-urban farmlands (n = 16), warehouse districts (n = 14), and open waste dump sites (n = 14). Sherman live traps baited with peanut butter and rolled oats and snap traps were deployed along rodent runways. Each station comprised a 10-trap transect at 5-meter intervals, set for three consecutive nights per session. Blood was collected via cardiac puncture under isoflurane anesthesia. Serum was

separated by centrifugation at 3000 rpm for 10 minutes and stored at -20°C. Kidney and brain tissues were preserved in RNAlater solution for molecular analysis.

Methods

Serological screening for LCMV-specific IgG antibodies was performed using indirect ELISA (EUROIMMUN AG, Lübeck, Germany) with validated murine secondary antibodies. Samples with absorbance ratios exceeding 1.1 were classified seropositive. Molecular detection of LCMV RNA was accomplished through RT-PCR targeting a 350-bp conserved region of the viral nucleoprotein gene. RNA was extracted using the RNeasy Mini Kit (QIAGEN), cDNA synthesized using SuperScript IV reverse transcriptase, and amplicons sequenced bidirectionally. Phylogenetic analysis was conducted using MEGA 11 with maximum likelihood method and 1000 bootstrap replicates. Multivariate logistic regression was performed using SPSS 28.0 with significance set at $p < 0.05$.

Results

A total of 420 rodents belonging to five species were captured: *Rattus norvegicus* (n = 126, 30.0%), *Mus musculus* (n = 108, 25.7%), *Rattus rattus* (n = 84, 20.0%), *Mastomys natalensis* (n = 63, 15.0%), and *Aethomys namaquensis* (n = 39, 9.3%). The overall LCMV seroprevalence was 28.6% (120/420; 95% CI: 24.3-33.2%). *Mastomys natalensis* demonstrated the highest positivity at 41.3% (26/63), followed by *Mus musculus* at 34.7% (37/108) (Table 1).

Table 1: Species-wise LCMV seroprevalence among urban rodents in Cape Town

Rodent Species	Captured (N)	Seropositive (N)	Seroprevalence (%)
<i>Mastomys natalensis</i>	63	26	41.3
<i>Mus musculus</i>	108	37	34.7
<i>Rattus norvegicus</i>	126	36	28.4
<i>Rattus rattus</i>	84	16	19.2
<i>Aethomys namaquensis</i>	39	6	15.6
Total	420	120	28.6

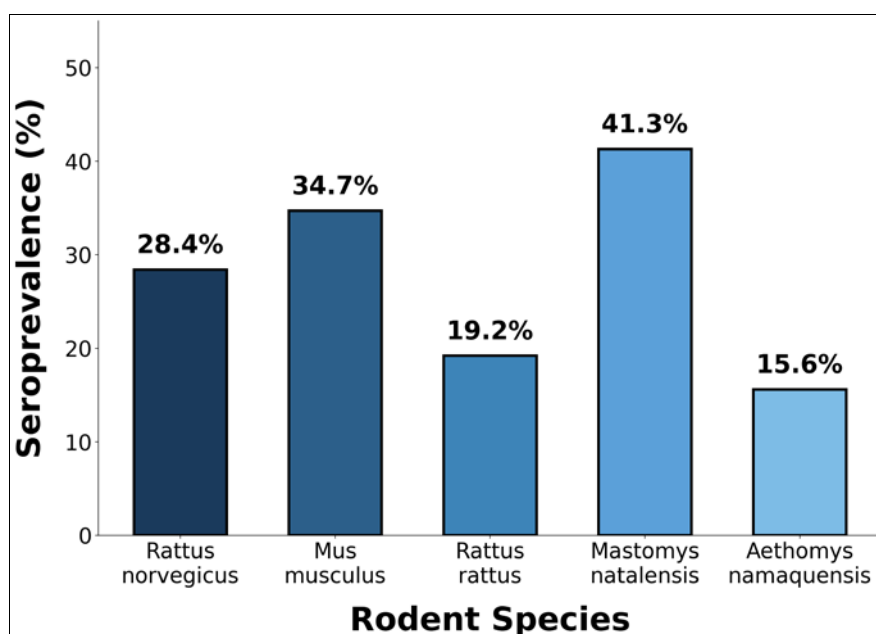


Fig 1: LCMV seroprevalence across five rodent species in urban Cape Town

RT-PCR yielded an overall positivity rate of 19.8% (83/420). Habitat-stratified analysis revealed residential areas with the

highest seroprevalence at 32.5%, followed by market districts (22.8%), peri-urban farmlands (18.4%), warehouse districts

(14.7%), and open waste dump sites (11.6%) (Table 2). Multivariate logistic regression identified rodent species (OR = 2.84; $p < 0.001$), habitat type (OR = 2.31; $p = 0.002$), population density (OR = 1.96; $p = 0.008$), and proximity to

dwellings < 50 m (OR = 3.12; $p < 0.001$) as significant predictors of seropositivity. A strong positive correlation ($r^2 = 0.87$, $p < 0.001$) between rodent density and LCMV prevalence indicated density-dependent transmission.

Table 2: Habitat-wise LCMV seroprevalence and risk factor analysis

Habitat Type	Rodents (N)	Seropositive (N)	Seroprevalence (%)	OR (95% CI)
Residential areas	112	36	32.5	3.42 (2.01-5.82)
Market districts	92	21	22.8	2.31 (1.45-3.68)
Peri-urban farmlands	82	15	18.4	1.67 (0.98-2.84)
Warehouse districts	74	11	14.7	1.24 (0.72-2.14)
Open waste dumps	60	7	11.6	Reference

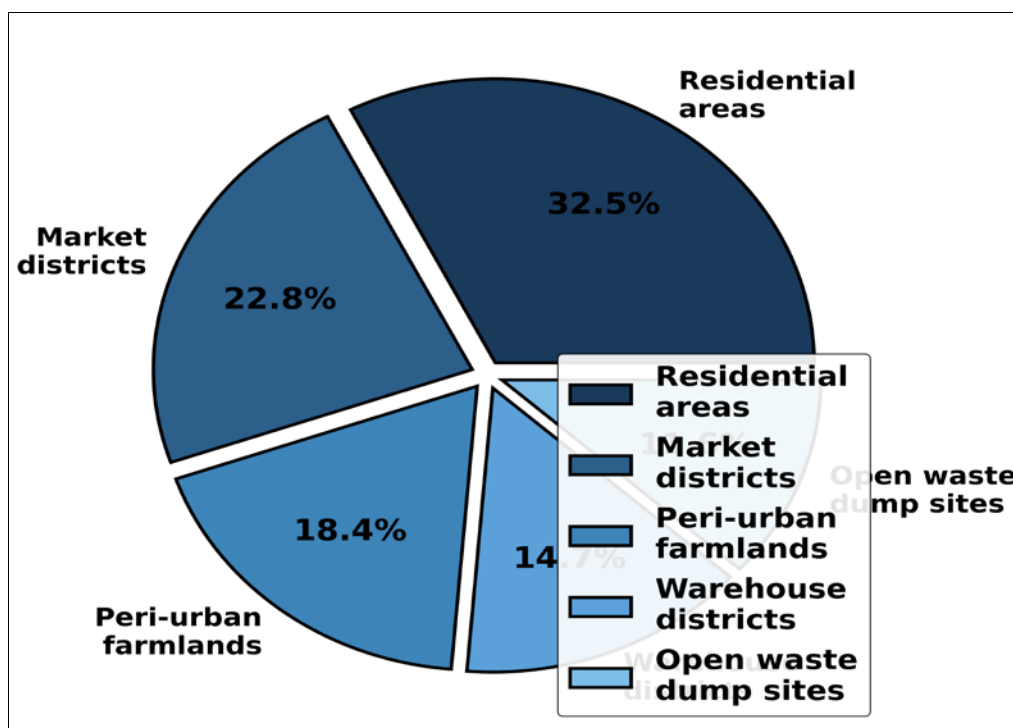


Fig 2: Distribution of LCMV-seropositive rodents across urban habitat types

Phylogenetic reconstruction of partial L-segment sequences from 15 RT-PCR-positive specimens revealed clustering within Old World LCMV lineage I, with 94.2-97.8% nucleotide similarity to European and American strains. Seasonal analysis indicated peak seroprevalence during austral winter months (June-August), coinciding with increased rodent ingress into human habitations.

Discussion

The present research represents the first comprehensive LCMV epidemiological assessment among urban rodents in South Africa. The overall seroprevalence of 28.6% is substantially higher than the 5-10% typically reported from European and North American surveys^[9], suggesting elevated zoonotic risk in the African urban context. This aligns with the hypothesis that greater diversity of susceptible rodent species in African environments may facilitate more efficient viral maintenance^[10]. The predominance of LCMV in *Mastomys natalensis* (41.3%) is particularly noteworthy, as this species has been implicated as a Lassa fever virus reservoir but not extensively investigated for LCMV in southern Africa^[5]. The elevated seroprevalence compared to *Mus musculus* (34.7%) challenges the paradigm positioning the house mouse as the exclusive LCMV reservoir and suggests indigenous African species may play a complementary role^[11]. The strong correlation ($r^2 = 0.87$)

between density and prevalence supports density-dependent transmission dynamics. Higher densities facilitate increased contact frequency and vertical transmission, enhancing viral amplification^[12]. This relationship has been reported for hantaviruses and Lassa virus, reinforcing that rodent population management is a primary intervention point^[13]. The finding that residential areas harbored the highest seroprevalence (32.5%) underscores the importance of targeting domestic habitats in pest management, particularly in informal settlements where structural barriers to rodent ingress are inadequate^[14]. Phylogenetic clustering with Old World LCMV lineages raises questions regarding historical LCMV dispersal into Africa, potentially linked to transcontinental rodent movement through maritime trade^[15].

Public health implications

The documentation of substantial LCMV seroprevalence among urban rodents near human dwellings carries profound public health implications. Zoonotic transmission potential is amplified by intimate cohabitation patterns, particularly in informal settlements where food storage practices and waste management deficiencies create favorable conditions for sustained human-rodent contact^[14]. Given that LCMV can cause severe neurological disease in immunocompromised individuals and congenital malformations, the absence of routine surveillance represents a critical gap in preparedness.

One health perspective

These findings advocate for a One Health approach integrating veterinary, medical, and environmental health perspectives. Effective LCMV risk mitigation requires concurrent rodent monitoring, environmental sanitation improvement, clinical awareness enhancement, and laboratory capacity strengthening for arenavirus diagnostics ^[12]. Veterinary professionals occupy a strategic position, possessing the expertise to implement surveillance programs generating early warning data for public health authorities.

Conclusion

The present research evaluated the seroprevalence and ecological determinants of LCMV infection among urban rodents in Cape Town, South Africa, documenting an overall seroprevalence of 28.6% across five species, with *Mastomys natalensis* (41.3%) and *Mus musculus* (34.7%) as predominant reservoirs. The density-dependent transmission dynamics ($r^2 = 0.87$) and the association between seropositivity and proximity to human dwellings establish that urban communities face meaningful zoonotic risk at prevalence levels exceeding temperate-region surveys.

These findings necessitate integrated urban rodent management programs prioritizing residential areas and market districts. Healthcare providers should consider LCMV in the differential diagnosis of aseptic meningitis in patients with rodent exposure. Future research should encompass expanded geographical sampling, whole-genome characterization, longitudinal cohort investigations, and development of affordable point-of-care diagnostics for resource-constrained settings.

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