



Research Article

Vectors of Crimean-Congo Hemorrhagic Fever (CCHF): Prevention and its Control

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A B S T R A C T

CCHF is caused by a tickborne virus (Nairovirus) in the family Bunyaviridae. It was first characterized in the Crimea in 1944 and given the name Crimean hemorrhagic fever. Later, it was recognized in 1969 as the cause of illness in the Congo, thus resulting in the current name of the disease. CCHF is a zoonotic viral disease that is asymptomatic in infected animals, but a serious threat to humans. The virus is mainly transmitted by tick species of the genus *Hyalomma*. During January 2011, Nosocomial (infections caught in hospitals) outbreak was detected in Gujarat, Ahmedabad. Thereafter, several outbreaks and cases of CCHF were reported in the states of Gujarat and Rajasthan during 2012-15. Cases were documented from six districts of Gujarat (Ahmedabad, Amreli, Patan, Surendranagar, Kutch and Aravalli), 3 districts of Rajasthan (Sirohi, Jodhpur and Jaisalmer) and in state of Uttar Pradesh were also affected. During 2019, 3 cases were reported in Rajasthan & 17 cases reported from Gujarat from the districts of Bhavnagar, Botad, Amreli, Kheda, Jamnagar, Rajkot, Surendranagar, Morbi, Jodhpur. An attempt has been made to describe the vectors of CCHF in India and its prevention and control so as to benefit the program managers working at the grass root level.

Keywords: Crimean-Congo Hemorrhagic Fever (CCHF), Zoonotic, *Hyalomma*, Nosocomial, Ixodid, Bionomics

Introduction

CCHF is a zoonotic disease transmitted by ticks and characterized by fever and hemorrhage.^{1,2} It was first described in Soviet soldiers in the Crimea in 1944 and was named Crimean fever. In 1956, the virus was isolated from a child with similar symptoms and was named Congo virus.³ The causative agent of both illnesses was shown to be the same virus, which was subsequently termed CCHF virus.⁴ CCHF infects a range of animals; humans are the only known host that develops disease. CCHF is an emerging infectious disease given the expanding distribution of its main vector, ticks of the genus *Hyalomma*. Each year, more than 1000

human cases are reported from Europe and western Asia.⁵⁻⁷ The primary means of transmission to humans is via tick bites. The reservoir and vector of CCHFV are the ticks of the *Hyalomma* genus. Therefore, the circulation of this virus depends upon the distribution of the ticks. The virus can be transmitted from tick to animal, animal to human and human to human.

Vector, amplifying host and climatic conditions exist for centuries. Serological evidence of CCHF in camel, sheep and goats was reported by NIV Pune 2010 and Nosocomial infection reported in January 2011. CCHF outbreaks constitute a threat to public health, because



of its epidemic potential, high case fatality, potential for nosocomial outbreaks and difficulties in treatment and prevention.

Vectors of CCHF

CCHFV is primarily transmitted via hard-bodied *Hyalomma* ticks of the family Ixodes, particularly *Hyalomma marginatum*.⁸ The geography of CCHF infection reflects the distribution of *Hyalomma* ticks, which have a northern geographic limit of 48° north latitude.⁹ CCHFV has also been isolated from *Rhipicephalus*, *Boophilus* and *Dermacentor* spp., which may also transmit the virus.¹⁰

Infected animals may also act as reservoir during the period of viremia. Most important source for acquisition of the virus by ticks is believed to be infected small vertebrates on which immature *Hyalomma* ticks feed. The larvae and nymphs mainly feed on the lower vertebrates such as rodents, rabbits and hares. Adults feed on higher vertebrates such as cattle, goat and sheep etc as well as man. Domestic ruminant animals, such as cattle, sheep and goats, are viraemic for around one week after becoming infected

Twenty-five tick species and sub-species have been reported to be CCHF virus reservoirs/vectors (the single record from an argasid, the bird parasitizing *Argas persicus*, remains to be confirmed).¹¹ One-host ticks, *Boophilus annulatus*, *B. microplus*, *B. decoloratus* (and probably *B. geigyi*), appear to maintain intense virus inter-action for many weeks or months between several tick species infesting cattle. The 2-host vectors are *Hyalomma m. marginatum*, *H. marginatum turanicum* and *H. marginatum rufipes* (and probably *H. marginatum isaaci*); they feed as immatures on birds, hares, or hedgehogs and, as adults, chiefly on cattle. Other 2-host vectors, *H. anatolicum*, *H. detritum*, and *Rhipicephalus bursa*, feed both as immatures and adults on cattle. The *H. marginatum* complex, and *H. a. anatolicum*, are especially important in causing epidemics and outbreaks of human CCHF owing to their great numbers during certain periods and to their aggressiveness in seeking human hosts. Others, including 13 species of 3-host ticks [*Haemaphysalis punctata*, *Amblyomma variegatum*, *Dermacentor* (2 spp.), *Hyalomma* (5 spp.), and *Rhipicephalus* (4 spp.)], which generally seek human hosts less aggressively than the cited hyalommas, serve chiefly to maintain enzootic foci of CCHF virus circulation between ticks and wild and domestic mammals.

Ground-feeding birds are often hosts of CCHF virus-infected ticks, but birds apparently do not become viraemic. Unusually severe winter-spring weather, resulting in decimation of *Hyalomma* populations and also of hosts of immature stages, appears to have been largely responsible for virus circulation to revert from epizootic (epidemic) to enzootic intensity. Humans become infected, when bitten

by infected ticks, or when crushing these ticks in their bare hands or shearing tick infested sheep. Household and nosocomial cases resulting from contamination by bloody discharges from CCHF patients have been especially numerous and severe, often with great mortality in villages and hospitals, where the disease was unrecognized.

Ixodid (Hard Ticks)

Ixodid (Hard) ticks are characterized by the presence of scutum (dorsal shield) and the capitulum (head) is terminal. Ticks are the obligate blood feeding arthropods from animals and man and all stages of life cycle viz., larvae, nymph and both sexes of adults are blood feeders. Ticks transmit a greater variety of infective agents, than any other group of haematophagous arthropods many of them are zoonotic diseases which are inter transmissible between animals and man. Toxins and most infectious agents are transmitted to vertebrate to salivary fluids inoculated while the parasite feeds.

Genus; Hyalomma

World: Mainly distributed from Africa, Asia and Europe, 30 known species. India: 9 species.



Figure 1. Hyalomma Tick

Hyalomma Tick: Morphological Characters

- Scant ornamentation sometimes bands present on legs (Figure 1).
- Eyes present, irregular festoons, partially consealed.
- Palpi long segment two approximately twice as long as segment 3.
- Basis capituli sub triangular dorsally.
- Coxa I deeply cleft. Males with adanal and accessory shields.

Bionomics of Hyalomma Ticks

Ticks of the genus *Hyalomma* remain on the same host during the larval and nymphal stages, the engorged nymph dropping to the soil where it moults to the adult form which then seeks a new host; ticks possessing this type of life cycle which involve two hosts are required are known as two-host ticks. The larvae and nymphs mainly feed on the lower vertebrates such as rodents, rabbits and hares while the adults feed on higher vertebrates such as cattle, goat and sheep etc as well as man. Trans-stadial and trans-

ovarian route of transmission have been exhibited by the ticks and these phenomena are useful in the maintenance of tickborne arbo viruses in nature.

The members of the genus *Hyalomma* are extremely hard ticks, often existing under varied conditions of cold heat and aridity. *H. anatolicum* and *H. marginatum* are the vectors of CCHF. The engorged larvae and unfed adults of the *H. anatolicum* exhibit overwintering phenomenon by hibernating in cracks and wooden crevices in animal shelters of Russia and in rodent burrows in African deserts. The survival of larvae is up to 241 days, nymphs up to 246 days and adults over one year. *H. marginatum* often occurs in high numbers and is an aggressive human parasite and the unfed adults survive over 2 years. It may oviposit 4 to 15 thousand eggs in their lifetime.

Reservoirs and Vectors of CCHF

Hard ticks are the reservoir and vector of CCHF virus and in addition the infected animals may also act like a reservoir during the period of viremia. The CCHF virus may infect a wide range wild animal like hare, rodents and domestic animals such as sheep, goats, cattle and camel. Many birds are resistant to this infection except ostriches in endemic areas. Animals become infected with CCHF virus by the bite of infected ticks. The various environmental factors also influence the transmission of the virus.^{12,13}

CCHF is transmitted mainly by tick vector *Hyalomma anatolicum*, and apart from this by *H. marginatum*, *H. marginatum rufipes*, *H. marginatum turanicum* and *H. marginatum isaaci*. Sporadic cases or import cases of CCHF virus (CCHFV) have been reported from Gujarat and Rajasthan recently during 2019. Antibody survey in domestic animals has shown a wide prevalence of CCHF throughout the country.

Life Cycle

CCHF vectors are two-host ticks and require two hosts to complete their life cycles. The adults lay eggs and emerging larvae attach to the vertebrate host. *Hyalomma anatolicum* parasitizes mainly cattle. The detachment and dropping rhythms of the species are so adjusted that these occur only at a time when the cattle is resting in the sheds normally at night time.

The engorged ticks that drop in the sheds find suitable niche in the cracks and the crevices, where the female ticks oviposit and the larvae and the nymph moult to the next stage. The questing larvae, the unfed nymphs and adults that have moulted from the previous stage can easily find their hosts in the cattle sheds. The humans acquire infection when they come in close contact of this environment.

A number of tick genera are capable of becoming infected with the CCHF virus, but the most efficient and common vectors for CCHF appear to be members of the *Hyalomma*

genus. Trans-ovarial (transmission of the virus from infected female ticks to offspring via eggs) and venereal transmission have been demonstrated amongst some vector species, indicating one mechanism which may contribute to maintaining the circulation of the virus in nature.

Vector Surveillance

Sampling may be undertaken to identify tick habitats, where the cases have been reported and vector control may be needed. Collection of free-living ticks- unfed larvae, nymphs and adults by flagging/ drag net method (per man hour density to be recorded). Collection of ticks from domestic and wild animals to determine the tick index and isolation of virus is done from them. The frequency of sampling at monthly intervals and the frequency may be increased during epidemics. It is very difficult to select any site for vector surveillance to detect viral activity through ticks and the infestation rate of ticks among cattle (Sheep, Goat, Cows, Buffalos, Camel) due to their presence across the country with large population density. The ideal method may be to select collection sites based on the reporting of positive human CCHF cases and ecological parameters in within the affected area. Based on the total existing livestock in the affected area, an appropriate formula may derive to determine the sample size. The livestock may be investigated for tick collection during spring and summer seasons.^{14,15,16}

Surveillance Tools

Active tick surveillance involves effective monitoring of prevalence, distribution, and infection rate among the vector ticks in a targeted geographical area. Efficiency of each method might vary based on the tick species, developmental stage, and host-seeking behavior. The following surveillance methods can be applied for the surveillance of CCHF vectors.

- Dragging, flagging, and dry ice-baited traps are the few collection methods, which targets hosts seeking tick population.
- Collection of tick parasitizing live host including rodent surveys.
- Leaf litter sampling method.

Entomological Indicators

The followings are the common entomological indicators being used for vector surveillance.

Prevalence Rate of *Hyalomma* spp

$$\frac{\text{Hyalomma tick species collected}}{\text{Total number of ticks collected}} \times 100$$

Infestation Rate

$$\frac{\text{Total positive livestock for ticks}}{\text{Total livestock surveyed or investigated}} \times 100$$

Tick Index

$$\frac{\text{No. of ticks collected}}{\text{Total Numbers of Hosts examined}} \times 100$$

RNA Extraction and CCHFV Genome Detection

Ticks collected from each host are kept alive in separate labelled tubes, and then processed for identification by morphological characteristics using a stereomicroscope on the basis of valid identification keys. Identified ticks were kept in micro tubes for testing with both an antigen-detecting Enzyme-Linked Immunosorbent Assay (ELISA) and RT real-time PCR (RT PCR) method. Ticks species identified and processed from each host is considered as a single pool.

Virus Detection Rate

No. of Ticks found positive for CCHF Virus / No. of ticks processed for CCHF virus detection

Prevention & Control

In the areas, endemic for tickborne diseases like CCHF the integrated tick control strategy need to be undertaken which has the following components.

Surveillance

Sampling to identify tick habitats where control is needed. Collection of free-living ticks- unfed larvae, nymphs and adults by flagging/ drag net method (Per man hour density to be recorded). Collection of ticks has to be carried out from domestic and wild animals to determine the tick index and isolation of virus from them. The frequency of sampling at monthly intervals and the frequency may be increased during epidemics.

Vegetation Management

Physical or chemical measures to reduce and isolate tick habitats. In areas with tick infestation like camp sites and parks, ticks can be controlled by removal of vegetation serving as their habitat by cutting, mowing or by applying herbicides.

Host Management

This is practice by the removal or exclusion of host animals: Tick populations can be controlled by removing of animals on which they usually feed. Fences may also be made to exclude wild animals from entering into human habitation.

Targeted Chemical Control

Pesticide applications need to be under taken against ticks, at the tick host or habitat. In areas with tick infestation they can be controlled by insecticidal application mainly by applying bio degradable insecticidal dusts. The animal houses, houses, furniture's and wall crevices and cavities should be treated with residual insecticides. The heavy tick infested animals also treated with insecticidal dusts and

formulation on their body. Spraying should be undertaken in the forest tracts frequented by the villagers. Surveillance and monitoring of ticks' infestation on animals and occurrence of human cases in a locality on long term basis.

Various insecticidal formulations can apply to domestic pets, such as dogs, to get rid of their ticks. Recommended treatment includes solution of 0.5% Dichlorvos (DDVP), 1% Carbaryl (Sevin) or 3-5% Malathion can be applied to the coats of animal habitats. The dipping of sheep and cattle, and sometime other livestock, in acaricidal bathes, or spraying them with insecticides. It is crucial if ticks and tickborne diseases of man as well as livestock rate to be effectively controlled.

Cultural Practices

Lifestyle changes to limit the exposure of ticks. Avoiding of sitting and lying down on tick infested ground. IEC need to be imparted to the public on the ticks and ticks borne diseases. Vector control measures in the forest peripheral and high-risk villages to be carried out. Entomological, epidemiological and serological surveillance should be undertaken in new areas bordering the affected districts.

Personal Protection

Protective clothing repellents checking for and removing of ticks. Personal protection form tick bites are mainly by use of protective clothing (full length clothing). The persons return from tick infested areas should examine the body for tick infestation and their removal through scrubbing. Washing of clothes and body with hot water and soap need to be undertaken after visiting the forest to get rid of tick infestation. Vaccinating the people at risk and persons looking after animals.

Conclusion

Studies can be undertaken to undertake vector surveillance for CCHF to understand the prevalence in different ecological zones and associated hosts. Virus isolation can also be undertaken among some pools of vector species to understand the dynamics of CCHF transmission. Thereafter, a comprehensive plan of action can be made for the prevention and control of the diseases.

Conflicts of Interest: None**References**

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