पशुपालन एवं डेयरी विभाग, भारत सरकार
Department of Animal Husbandry and Dairying
Government of India

Azadi Ka Amrit Mahotsav

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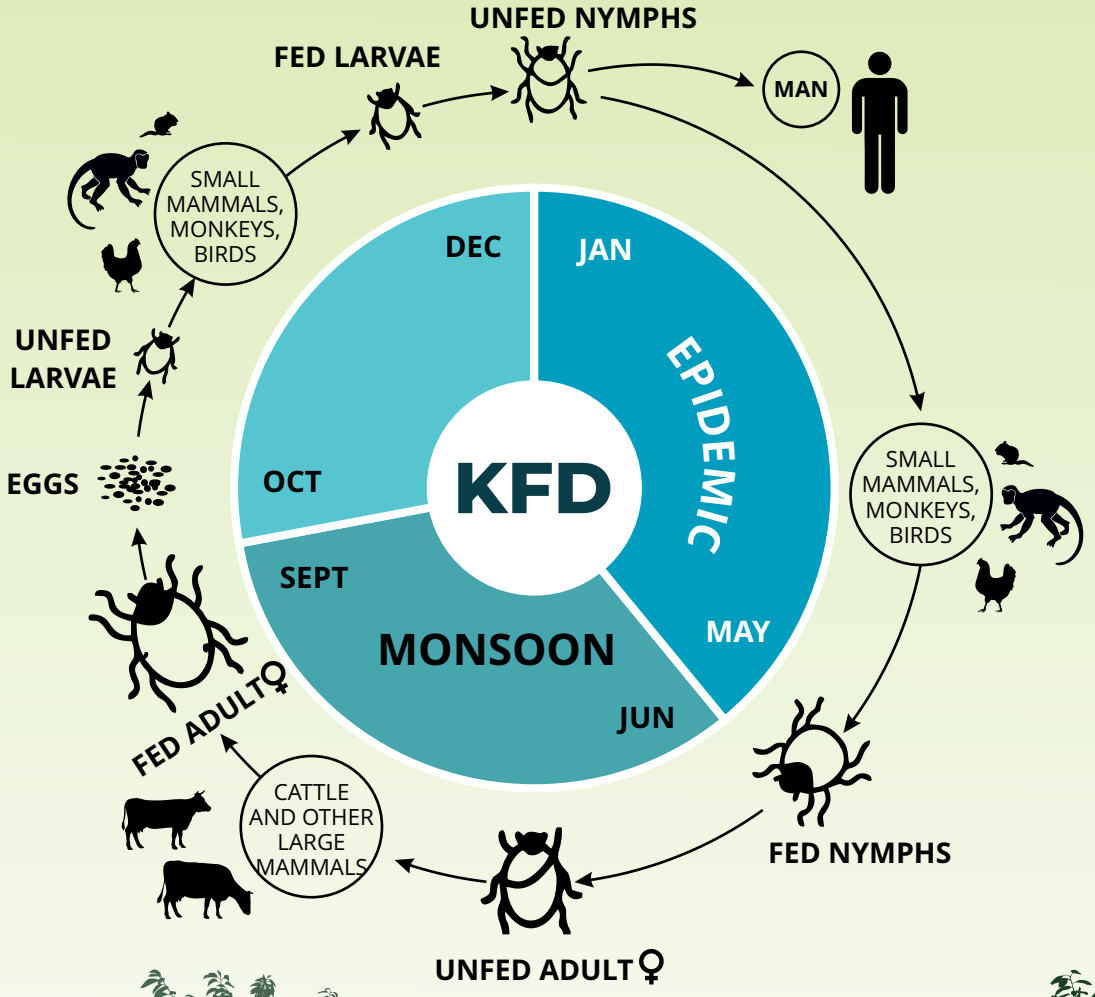
KYASANUR FOREST DISEASE

DISEASE STATUS REPORT

April 2023



ONE HEALTH
HEALTHY ANIMALS, HEALTHY PEOPLE, HEALTHY NATIONS

One Health Support Unit (OHSU)
Department of Animal Husbandry and Dairying, MoFAHD
Government of India

OHSU Publication #09

परशोत्तम रूपाला
PARSHOTTAM RUPALA

सत्यमेव जयते

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मत्स्यपालन, पशुपालन एवं डेयरी
भारत सरकार
Minister
Fisheries, Animal Husbandry and Dairying
Government of India

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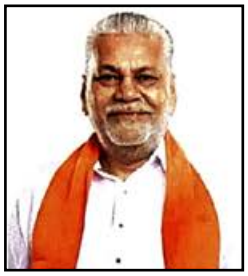

MESSAGE

The Kyasanur Forest Disease (KFD) - also known as Monkey Fever - is a tick-borne viral disease that affects humans and non-human primates. Symptoms of KFD include fever, headache, muscle pain, vomiting, and bleeding. If you experience any of these symptoms, it is important to seek medical attention immediately. Early detection and treatment are crucial in the management of the disease. The disease has been expanding in its geography and it has become urgent to halt the further spread of KFD. Accordingly, efforts have been made in this direction and disease surveillance and control program for KFD has been in place in Karnataka and other affected states.

Under the One Health Pilot project operational in Karnataka, the One Health Support Unit (OHSU) team has developed **Disease Status Report for Kyasanur Forest Disease (KFD).** The report provides valuable information about the current status of KFD and the measures being taken by the government to control its spread. We understand that the disease has significant public health and economic implications, especially in the endemic regions. The government is working tirelessly to control the spread of KFD through active surveillance programs, awareness campaigns, and rapid response teams and the Government of India remains committed to providing all necessary resources and support to combat this disease.

The report provides plenty of useful information on the disease and prevention methods. It is a valuable resource for all citizens in understanding the current status of KFD and the measures being taken to combat its spread. This report will serve as a resource guide for the public to guide them while taking necessary precautions to protect themselves and their families from the disease.

I urge all the citizens to join in the fight against the disease and to work together towards a healthier and safer India.

(Parshottam Rupala)

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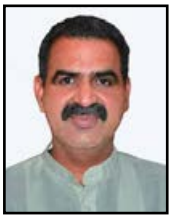

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

राज्य मंत्री
मत्स्यपालन, पशुपालन एवं डेयरी मंत्रालय
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KRISHI BHAWAN, NEW DELHI-110001

Message

Kyasanur Forest Disease, commonly known as Monkey Fever, is a tick-borne viral hemorrhagic fever that affects humans and non-human primates in the Western Ghats region of India. The disease has significant public health implications, especially in the endemic regions. The expanding geographical area of KFD remains a challenging concern.

In view of the public health significance of KFD, the One Health Support Unit team of the Department of Animal Husbandry and Dairying, Government of India has synthesized the **Disease Status Report for Kyasanur Forest Disease (KFD).** The report provides a detailed analysis of the disease, including its history, pathogen, epidemiology, and control measures. The report also highlights the gaps in the current control measures and suggests interventions that can be taken to further control and prevent the spread of KFD. The report is a valuable resource for policymakers, health professionals, and the general public in understanding the current status of KFD and the measures being taken to combat its spread.

I urge all stakeholders to work together to prevent the spread of KFD and to continue to monitor its prevalence. We need to collaborate with other concerned departments to make the report reach the general public, especially in endemic areas, so that we can have collaborative efforts towards monitoring, prevention, and control of the disease. Our ultimate goal is to develop effective control strategies for the disease with the vision to ultimately eradicate it from the country.

I would like to express my appreciation for the hard work and dedication of the One Health Support Unit team in preparing this report.

(Sanjeev Kumar Balyan)

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SECRETARY

भारत सरकार
मत्स्यपालन, पशुपालन एवं डेयरी मंत्रालय
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Government of India
Ministry of Fisheries, Animal Husbandry & Dairying
Department of Animal Husbandry & Dairying
Krishi Bhawan, New Delhi-110001

MESSAGE

KFD is a disease of significant public health importance that can cause severe illness and can even lead to death in humans. The rapid pace of climate change, increasing human-animal interactions, afforestation/deforestation and biodiversity loss, pollution, and increased incidences of disease spillovers have led to an increase in the geographical spread of this disease which is a serious puzzle to solve. The Government of India also recognizes the importance of developing effective control strategies for KFD, with a vision to ultimately eradicate the disease from the country.

The timely synthesis of the **Disease Status Report for Kyasanur Forest Disease** (KFD) by the One Health Support Unit team is a welcome initiative. This report provides a comprehensive overview of the current status of KFD, including details on tick control measures, the vector for disease transmission, and initiatives taken by the state government to control disease transmission and restrict its spread to other states. The report highlights the extensive efforts being made by the state government to monitor and control the spread of KFD including active surveillance programs to detect and report suspected cases, as well as the deployment of rapid response teams to investigate outbreaks and implement control measures. The report also discusses the challenges faced by the government in controlling and preventing the spread of KFD.

As KFD is an emerging disease that may pose a threat of widespread transmission, this report is an invaluable resource for researchers, vaccine industries, policymakers, health professionals, forest officials, and the general public in understanding the current status of KFD and the measures being taken to combat its spread.

The need of the time is to invent the ways and means to make the report easily accessible to the general public, particularly in endemic areas, to spread awareness about the disease so that the general public can effectively collaborate with other stakeholders towards implementing the program for prevention, monitoring, and control of the disease.

I extend my sincere appreciation to the One Health Support Unit team at the Animal Husbandry Department for their hard work in preparing this report. The situation entails taking proactive measures in collaboration with all the stakeholders towards the goal of eradicating this disease and protecting the health of our communities.

(Rajesh Kumar Singh)

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Government of India
Ministry of Fisheries Animal Husbandry, & Dairying
Department of Animal Husbandry and Dairying
Krishi Bhawan, New Delhi-110001

Dated: 11th April, 2023

DO No.K-11053/17/2023-Cattle Div (E-24171)

Foreword

Kyasanur forest disease (KFD) - also referred to as monkey fever by local people - is a tick-borne viral haemorrhagic fever endemic (constant presence of disease) in Karnataka State, India. The virus causing the disease, KFD virus (KFDV), is a member of the genus Flavivirus and family Flaviviridae. The disease was noticed first in 1955 with heavy mortality of two species of monkey, viz., langur and red-faced bonnet monkeys. Since then, the disease has seen recurring in Karnataka with its spread to other states. The largest KFD outbreak is of 1983-1984 where 2167 cases and 69 deaths were reported. The control programmes were also run by the State governments as the KFD vaccine (prepared by the Institute of Veterinary Biologicals, Bengaluru) and diagnostics were available. However, KFD eradication still remains a distant dream as it entails multi-sectoral participation and transdisciplinary collaborations which is aptly termed as One Health.

There are many One Health initiatives of the Government of India and one of them is the One Health Pilot Project of DAHD, MoFAH&D which is being implemented in Uttarakhand and Karnataka. The One Health Support Unit (OHSU) Team of this pilot project has drafted the **Disease Status Report for Kyasanur Forest Disease** (KFD). This report provides a comprehensive analysis of the current status of KFD and outlines the measures taken by the government to control and prevent its spread. The report highlights the government's efforts to implement robust surveillance and control measures to monitor the spread of KFD. The animal husbandry department has also conducted extensive awareness campaigns in collaboration with other concerned departments to educate the public about the disease and its symptoms, emphasizing that early detection is critical for the successful management of the disease, wherein the public plays an important role in realizing the goal of containing its spread.

This report is an important resource for researchers, policymakers, health professionals, forest officials, and the public in understanding the current status of KFD and strategizing the mitigation measures to control its spread. The need of the time is that all the stakeholders work collaboratively to prevent the spread of KFD and to continuously monitor its prevalence. The government is committed to providing all necessary resources and support towards the mitigation of KFD in the region and preventing ingress in newer areas. However, the efficacy of the KFD vaccine in India has been under debate in the last two years. Focussed R&D efforts to develop an efficacious KFD vaccine along with a policy push for its manufacture and distribution would go a long way in tackling this important disease.

I encourage all the stakeholders to peruse this report and be informed about KFD status so as to strategize and initiate proactive measures including R&D efforts in developing much-needed rapid and precise diagnostics and safe and efficacious vaccines, developing suitable surveillance mechanisms, creating behavioural change communication tools for spreading mass awareness among all the stakeholders including public at large, and devise disease mitigation measures towards controlling and ultimately eradicating this disease.

I congratulate the OHSU Team at the department for their hard work in bringing out this report.

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Content

Introduction

The Kyasanur Forest Disease (KFD) is a tick-borne viral hemorrhagic fever infecting non-human primates and man transmitted by the bite of 'Ticks' infected with KFD Virus (KFDV). The disease was first reported in 1957 in 'Kyasanur Forest' of Shivamogga district, Karnataka, India. Hence, the disease was named as "Kyasanur Forest Diseases". Initially KFD was reported from Sagar and Soraba taluks of Shivamogga district of Karnataka[1]. Presently the spread of the disease is from Sindhudurg district in Maharashtra to the north to Palakkad district in Kerala to the south (Fig.1)[2,3,4]. The presence of viral antibodies in human beings have been reported from parts of Gujarat, West Bengal and Andaman and Nicobar Islands[5]. The possibility of the occurrence of KFD in other parts of the country has also been expressed by some authors[6].

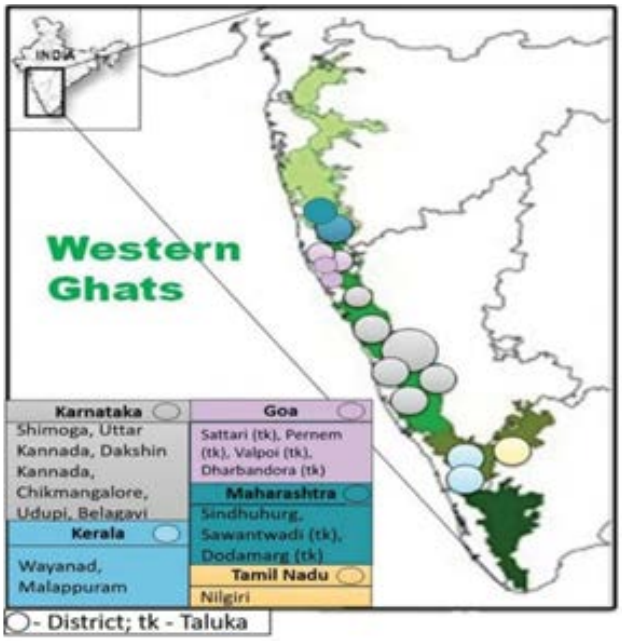

Fig. 1. Distribution of Kyasanur forest disease affected districts along the course of Western Ghats of India. Different colours represent different KFD affected states in India. Circles represent KFD affected districts in that state. Each circle denotes one affected district[2].

The disease was not reported among humans or monkeys in the Kyasanur forest region prior to december 1955[7]. Scientific opinion points to extensive deforestation and climate change to be factors that have favored the spread of disease to regions other than Kyasanur[8,5]. Clearly several contributing causes can be identified for the initial outbreak of KFD among monkeys and the subsequent spread to humans[9].

The recent estimation of KFD occurrence among monkeys is 9594 cases in 16 districts from 1957 to 2017 (Fig. 2 & 3). The occurrence of the disease not show any regularity and of the 61 years of its occurrence 37 had less than 100 cases, 16 had between 100 and 399 cases while 8 years had 400 or more cases[1].

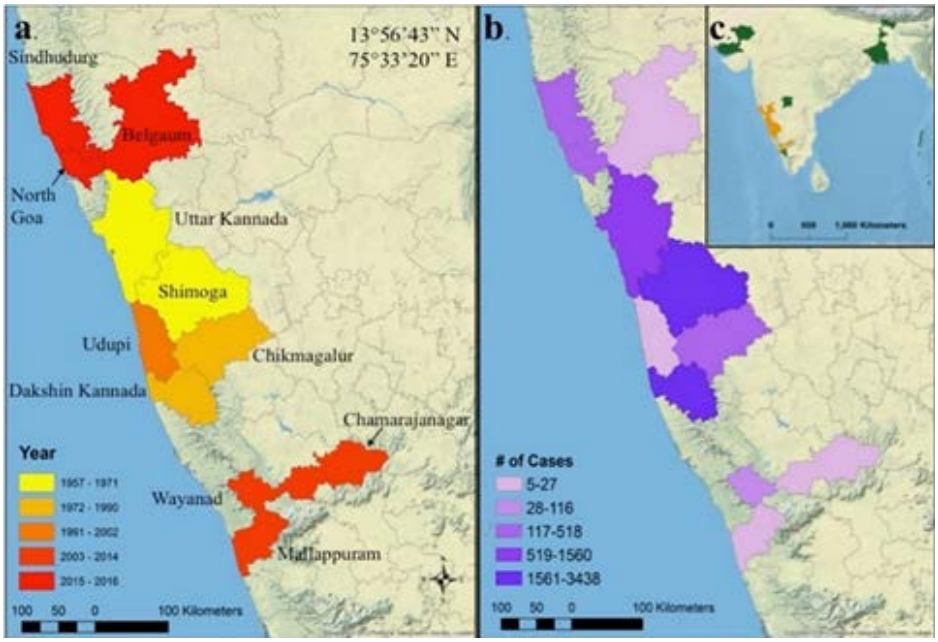

Fig. 2. Cases of Kyasanur Forest disease in India depicted by (a) year of the first case in each district (n = 16), (b) number of human cases (n = 9594), and (c) and all seroprevalence antibodies discovered outside of this study's region of interest (n = 6).[1]

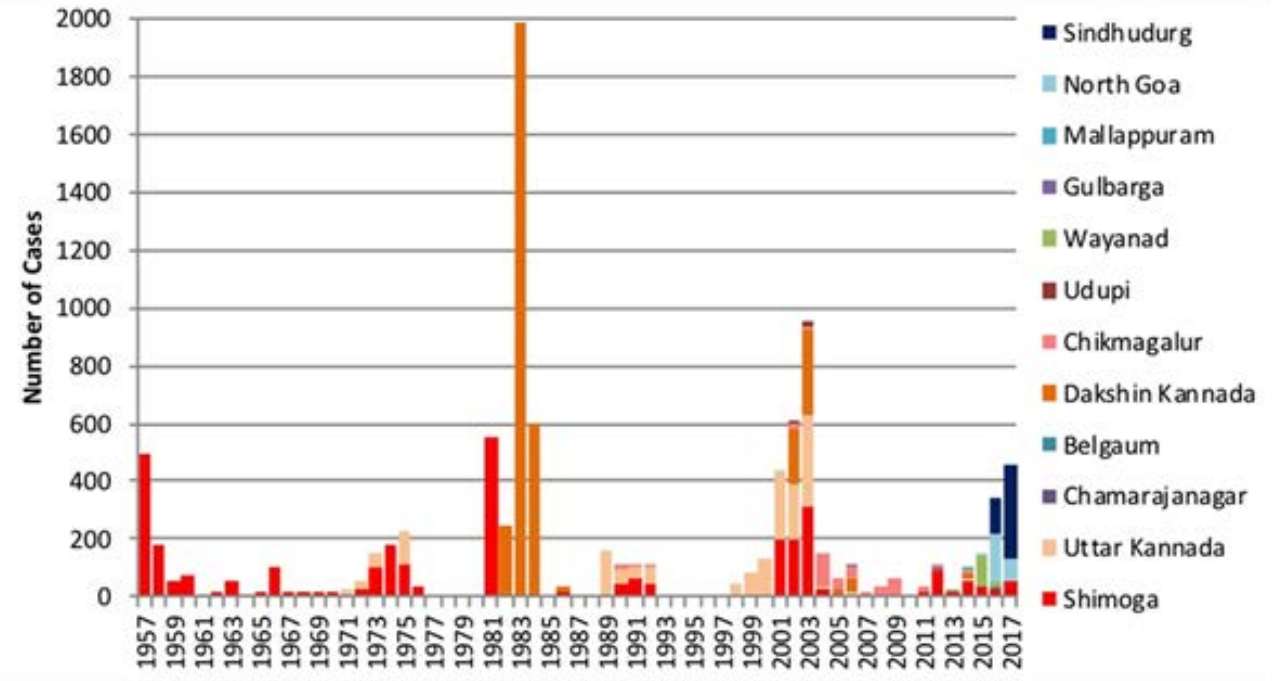

Fig. 3. Distribution of Kyasanur Forest disease cases by districts in India (1957–2017)[1]

Among humans the disease is reported to have caused 93 fatalities out of 3836 cases of infection reported, which would indicate a case fatality rate (CFR) of 2.42%[1]. Silent foci are reported from Andaman and Nicobar Islands, Kutch in Gujarat, parts of West Bengal and Rajasthan. In these areas evidence of hemagglutination inhibition antibodies against KFDV were noted, despite no reports of outbreaks of the disease in these places[10,11,12]. Unpublished data on the status of KFD in Karnataka during 12 years from 2008 to 2020 shows 13% of monkey deaths to have been caused by KFD and 2.2% CFR among human beings (Table 1.)

Table 1. KFD status in Karnataka

Year	Number of Serum Samples tested	Number of Humans Positive for KFD	Number of Human Deaths	Number of autopsies of dead monkeys	Number of Monkey Deaths
2008	112	36	0	7	0
2009	179	64	1	16	1
2010	5	0	0	9	0
2011	41	19	1	8	5
2012	359	97	1	22	5
2013	82	17	1	17	4
2014	400	166	1	8	3
2015	126	41	1	8	4
2016	115	25	0	3	2
2017	250	45	3	12	1
2018	536	37	0	18	3
2019	6723	434	15	305	41

Year		Number of Serum	Outbreak	Affected	Death	Vaccination
2020	4967	165	2	107		3
Total (2008-2020)	13895	1146	26	540		72

Data source: Viral Diagnostic Laboratory (VDL), Shivamogga

History

1957 to 1958 : First KFD outbreak observed. 681 cases in Karnataka.

1958 : Rockefeller Foundation donated US$100,000 to build vaccines for KFDV in the United States.

1961–1971 : First KFD vaccine developed by the Walter Reed Army Institute Research Laboratory, Washington D.C., USA. Major outbreaks not observed, small number of cases reported throughout this period

1972–1976 : Major outbreaks not observed, moderate number of cases reported throughout this period.

1977–1980 : No cases reported

1981–1984 : Largest outbreak of KFD ever reported

1985–1997 : Major outbreaks not observed, medium number of cases reported throughout this period.

1998–2006 : Major outbreaks not observed, large number of cases reported throughout this period in four districts of Karnataka.

2007–2014 : Major outbreaks not observed, medium number of cases reported throughout this period. KFD spread to Kerala.

2015–2017 : Large number of cases reported throughout this period. KFD expanded to three states.

The Disease

The pathogen: KFD is caused by Kyasanur Forest Disease Virus (KFDV) which is an arthropod-borne virus classified under the genus flavivirus of the Group B Togaviridae family. The virus has a positive sense, single-stranded RNA genome measuring 25nm in diameter which encodes a single polyprotein which can be cleaved into three structural (C, M and E) and seven non-structural (NS1, NS2a, NS2b, NS3, NS4a, NS4b and NS5) proteins. Serologic studies and phylogenetic sequencing indicate that it is part of a group of tick-borne viruses of mammals associated with hemorrhagic fever and is closely related to Alkhurma virus in Saudi Arabia and Egypt[13,14,5]. Other viruses of note that are part of this complex circulate in different regions of the world and include Omsk hemorrhagic fever virus in Siberia and Powassan virus in the United States and Russia[15,16].

Origin of the virus: The virus might have been in circulation in Malnad forests very early on, but due to the difficult terrain there was hardly any human movement in these deep forest areas. However, due to manipulation of the forest and ecological changes, the virus might have become active and the gradual increase in movement of humans along with migration of susceptible mammalian hosts due to de-forestation may have led to infections which later on developed to epidemic proportions.

Epidemiology: KFD is being reported from Western Ghats of Southern India which consists of evergreen, deciduous and semi-deciduous forest on the slopes mixed with bamboo and shrub jungle at the edges. The villages or discrete hamlets range in size from a cluster of few houses to over a hundred. Villagers frequently visit the forest for collection of firewood / dry leaves and get infected by tick bites. Also, the forest sustains a large population of wild monkeys which harbor these ticks. High humidity generated from the cultivated field is suitable for maintenance of ticks throughout the year.

Host: KFD is frequently fatal among nonhuman primates and is known to affect two South Indian species; *Macaca radiata* (bonnet macaque) and langurs (e.g., gray langur) in the genus Semnopithecus[5].

Amplifying hosts: The amplifying host for KFDV include primates, black-faced Hanuman langoor (*Presbytis entellus*) (Fig. 4) and red-faced bonnet monkeys (*Macaca radiata*) (Fig. 5). Monkeys are important reservoir hosts of KFDV, but they are often unable to withstand the onslaught of the virus and die shortly after infection[17,18,19].

Fig 4. Hanuman langur *(Presbytis entellus)*
(Photograph courtesy: Meena P Kumar)

Fig. 5. Bonnet monkey *(Macaca radiata)*
(Photograph courtesy: Santhanu Kuveskar)

These amplifying hosts are also susceptible hosts since they amplify the virus load. These infected monkeys develop tremendous viremia and suffer from the disease like humans. In the recent years, the bonnet monkeys were found dead due to KFD. The bonnet monkey deaths act as a “sentinel event” to forecast a possible KFD epidemic in an area.

Reservoir hosts: Cattles are also hosts for the primary vectors of KFDV, but they do not amplify the virus. Though cattle may act as maintenance hosts, the role of cattle in KFD transmission needs to be studied[20,21]. In addition to larger mammals, field studies have revealed that many small forest mammals can maintain the KFDV and have the potential to infect ticks. These include blanford’s rat, jungle striped squirrel, field mice, Indian gerbil, frugivorous and insectivorous bats, and the common house shrew[22,23,5]. Mammals of different sizes are usually involved at different stages of the tick life cycle[5]. It is argued that virus transmission when ticks co-feed on a single host is even more likely to transmit the virus than when ticks bite a host with low-level viremia as found in cattle, produced by the bites of infected ticks on large mammals, primates and humans[24].

Maintenance host: Cattle, goat, and sheep may become infected but play a limited role in transmission of KFD to human. These animals neither suffer nor amplify KFDV but have shown the presence of KFDV antibodies. However, these animals play a major role in maintaining and distributing the tick population.

The vector: The vector responsible for transmission of KFDV is *Haemaphysalis spinigera*, a hard-bodied multi host tick species[25] (Fig. 6). KFDV also circulates in several other tick species, including *Haemaphysalis turturis, Haemaphysalis kinneari, Haemaphysalis kyasanurensis, Haemaphysalis wellingtoni, Haemaphysalis minuta, Haemaphysalis cuspidata, Ixodes petauristae, Ixodes sceylonensis, Dermacentor auratus*, and *Rhipicephalus haemaphysaloides*, as well as is capable of being transmitted by soft ticks of the Ornithodoros genus[23,26]. In India, these tick species have been reported in eleven states out of 29 states and 7 Union territories[27] (Fig.7). Nymphal stage is the most active stage for transmission of KFD Virus to human. Transmission of virus is through trans-stadial transmission; however, trans-ovarian transmission has been reported under laboratory conditions in *H. spinigera* species. In KFD prone area, approximately 95% of the isolations are from Haemaphysalis species. *H. spinigera* is the most predominant species which has yielded the maximum number of isolates.

Fig. 6. *Haemaphysalis spinigera*, tick dorsal and ventral view[29]

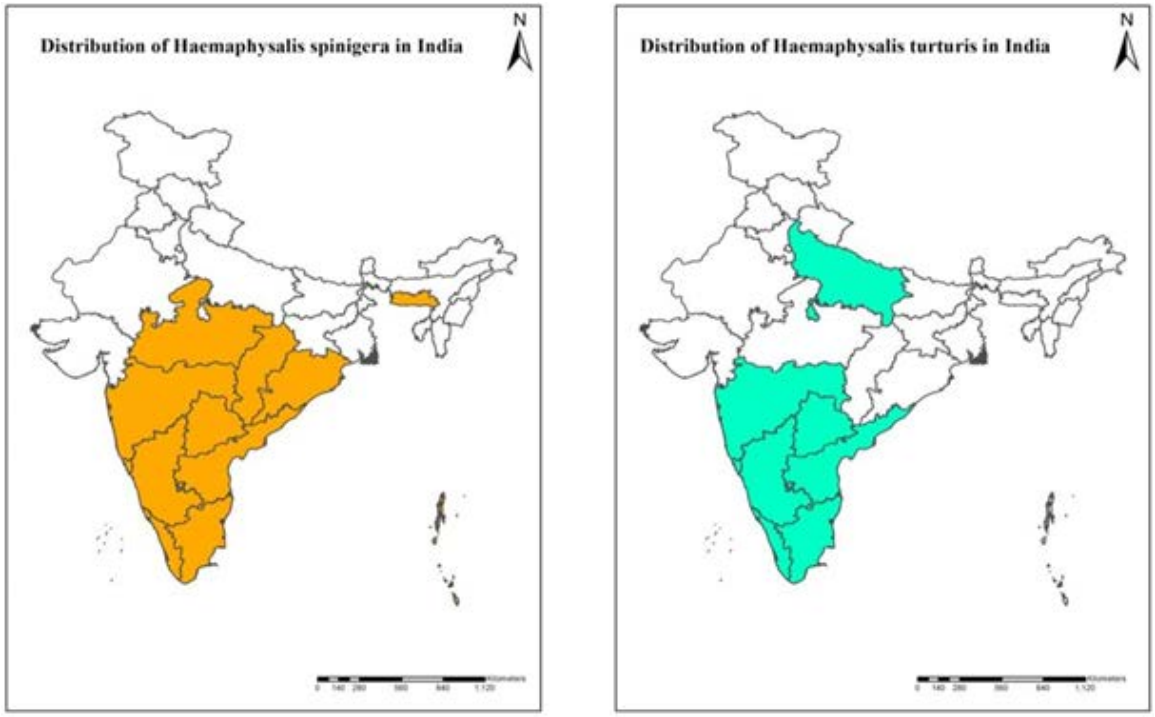

Fig. 7. Distribution of *Haemaphysalis spinigera & turturis* in India[32]

Life-cycle of the vector:

Eggs and larvae (October–December): During post-Monsoon, the adult tick lay their eggs in sheltered spots, under the stones, soil near the wooden surface, cracks and crevices of the walls. Eggs are small, spherical, light to dark brown in color and are laid in masses. These eggs will hatch into six- legged larvae and these larvae feed on small mammals and rest underneath the leaves and vegetation. The eggs laid down by the unmated females are not viable and fertile. Larval prevalence is from November–December. Infection of tick with KFDV takes place during larval stage. After moulting to nymphs, it becomes capable of transmitting the virus to other animals upon which it feeds (Fig.8).

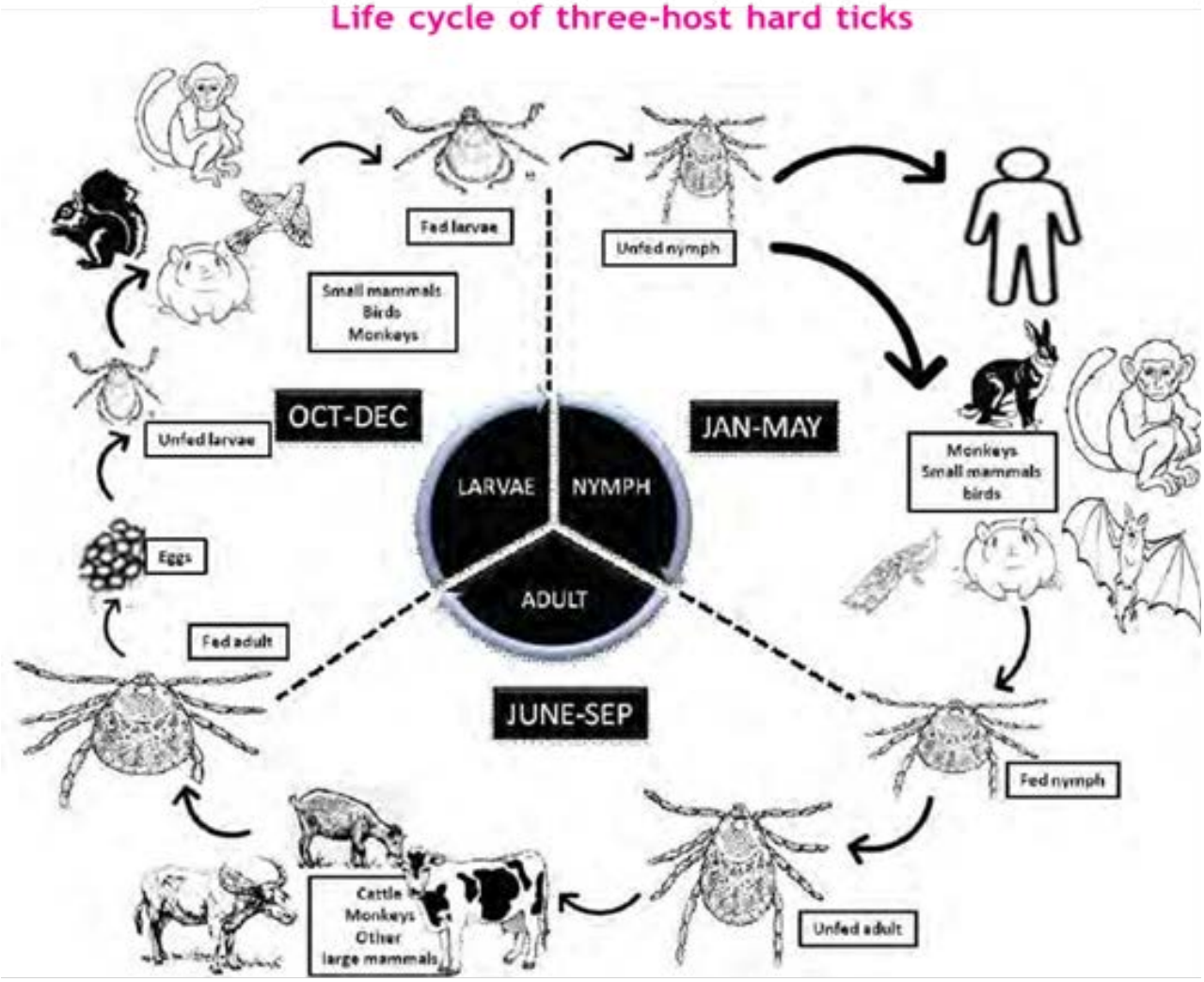

Fig. 8. Life cycle of Haemaphysalis spinigera

Nymphs (January–May): After 10–20 days, larvae are transformed to nymphs with four pairs of legs and rests underneath the leaves and vegetation and wait for blood meal (questing stage). These nymphs are attached to hosts and sucks blood for 1–6 days. The nymphs get infected with KFDV during the larval stage. When they bite monkeys/human beings, the virus gets transmitted. Engorged nymphs fall on the ground.

Adult male and female ticks (June–September): The nymphs will rest for 15–20 days and moult to become adult. Adults rest underneath the vegetation till the rainy season and wait for large animals for blood meal (cattle). During Monsoon, the adult male and female ticks mate on cattle and other large mammals. The fed females drop off and rest in the vegetation and after 8–10 days they lay eggs (4000–5000 eggs) and die. (Fig.9)

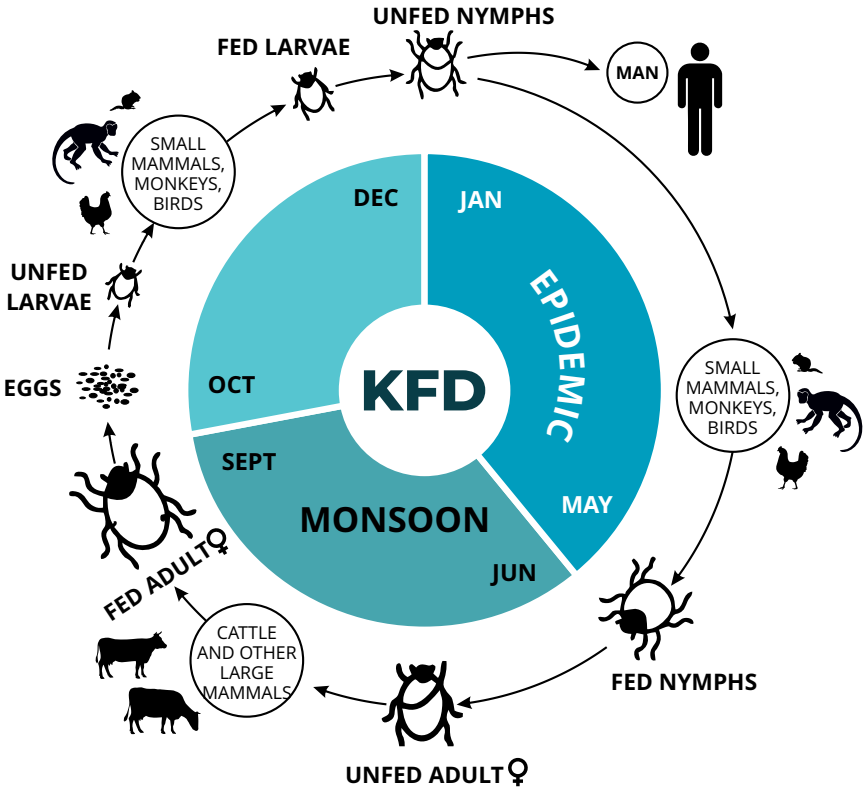

Fig. 9. Transmission cycle of *Haemaphysalis spinigera*

Transmission dynamics: Usually the disease transmission begins from late November and continues till the end of June every year and disease peaks between December to March (Fig. 10) months of the year. The transmission is interrupted by the onset of monsoon. The lean period is from July to October. However, the sighting of monkey deaths is an early sign of transmission of the disease. The transmission cycle involves mainly monkeys and ticks (Fig. 11). The disease is transmitted by the bite of infective tick, especially Nymph stage. The tick, once infected, remain infective throughout its life. Usually, adult ticks feed on cattle and other large mammals. Inside the forest, they feed on monkeys and other mammalian hosts in the forest. However, they rarely feed on human and can be easily identified by the humans when they are attached on the skin of the human. The adult ticks can be removed or plucked out. But the nymphs which feed on any animal/ rodent/ humans due to their small size and as they are not sensed by the skin when they attach on to the host, cause the infective bite and transmit the disease to monkeys and human. The wild monkeys *Macaca radiata* and *Semnopithecus entellus*, contracting the disease develop fever, get dehydrated and move towards the water sources either in the forest or near the human settlements where they succumb to the disease. After the death, the body temperature comes down; the ticks which are present on the skin of such monkeys move on to the nearest forest floor generating 'Hotspot'. Thus, the infected ticks which were deep inside the forest move towards the outskirts of the forest near human settlements along with the infected monkey. Then they settle down on the forest floor and bite humans when they move into the forest, by attaching onto their skin, as they brush the forest floor when they move. Human is only a tangential host and a 'dead end'. Usually, a tick takes a few hours to get accustomed to the surrounding temperature (of the skin) and then bites the host for blood meal. This advantage is used in advising the humans moving into the forest to come back within 2 hours and dip all the clothes in hot water and pluck out the nymphs sticking on to their skin, before they could bite. It is always advisable to apply tick repellent before visiting the forest. Available epidemiological data does not suggest any human-to-human transmission.

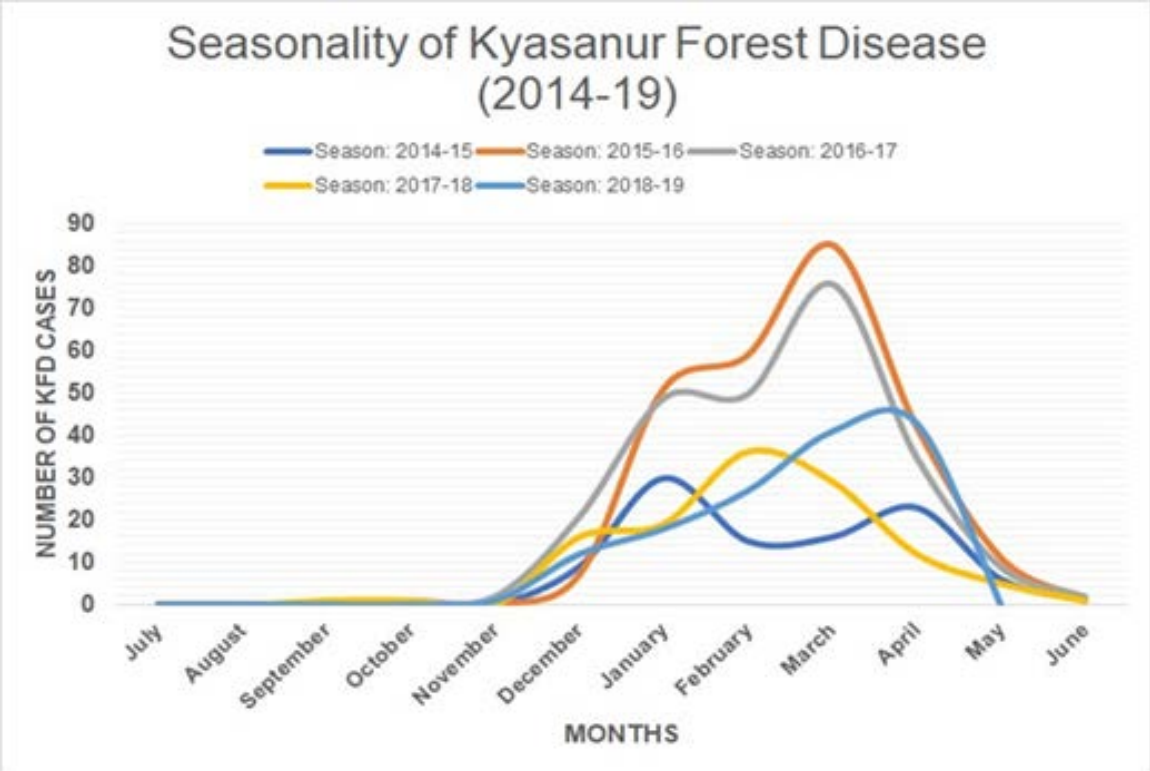

Fig. 10. Seasonality of KFD [32]

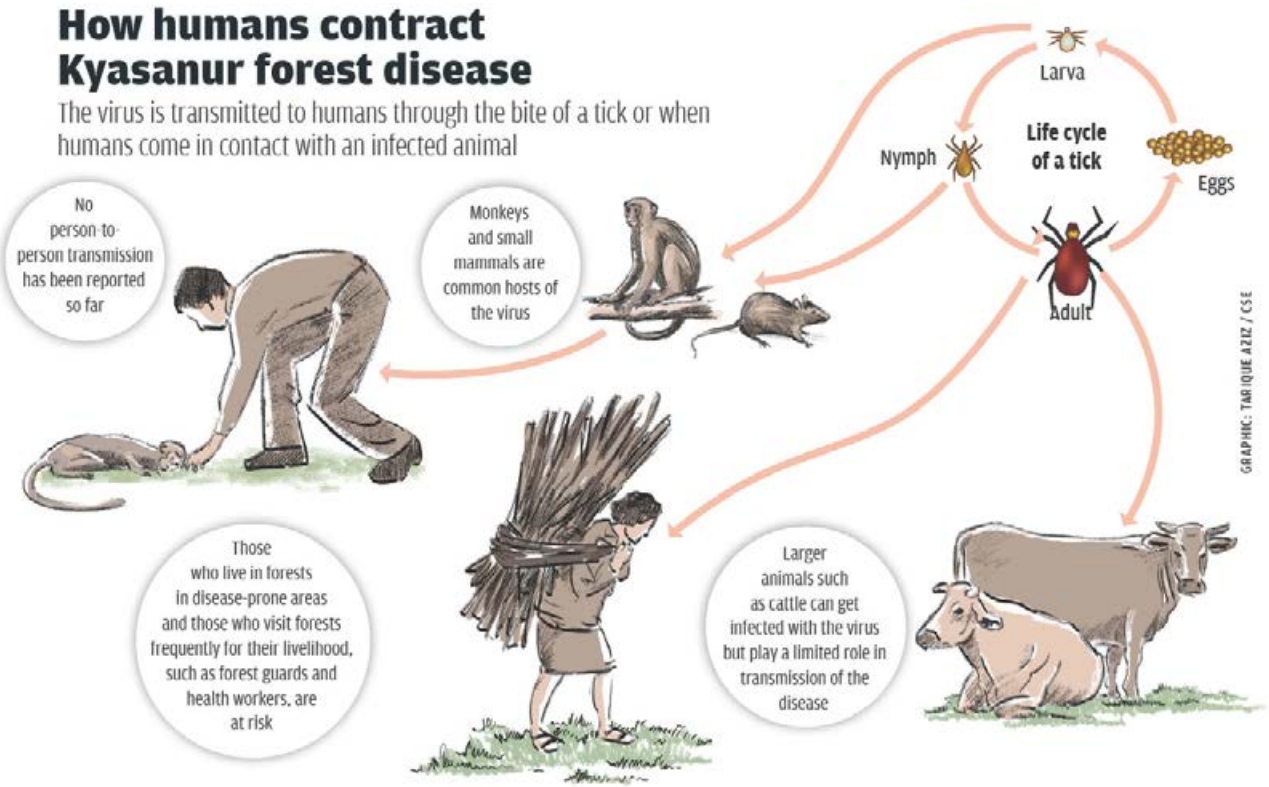

Fig. 11. Transmission of KFD (Source: CDC)

Seasonality is another risk factor, as an increased number of cases is reported during the dry season, i.e., from November to June with peak between December and March. The KFD risk is higher in areas with forest plantation activities with high coverage of moist evergreen forest and high-cattle density. Various risk factors for increased incidence of KFD include practice of firewood and dry leaf collection and storage around the residence and use of dry leaves as bedding material for cattle. The persons handling dead monkey are also most prone for KFDV transmission. Households storing piles of dry leaves within their compounds are having four-times risk of getting infection compared to people who do not store dry leaves The mortality rate ranges from 3–10%.

High-risk groups/ factors:

- Monkey and people living in the forests of endemic area.
- KFD risk is higher in areas with forest-plantation activities with high coverage of moist evergreen forest and high-cattle density.
- People with recreational or occupational exposure wherein they directly come in contact with tick (e.g., people visiting the forest for their livelihood, coffee/tea and other plantation workers, cashew nut/arecanut farm workers.
- Farmers who work in the agricultural fields located at the outskirts of village and in the vicinity of the forest.
- Forest department officials, tourists visiting forest area, and wild-life photographers, etc.,
- People who handle cattle and people who visit forest in endemic areas are at around five times higher risk of getting KFD infection compared to people who do not handle cattle and who do not visit the forest.

Clinical manifestations: Symptoms of KFD appear 3–8 days after the bite of an infective tick which is the usual incubation period. Typically, the disease appears with a sudden onset of fever which peaks by 3rd or 4th day. Redness of the eyes, pulsating severe headache and myalgia are very common. Malaise and anorexia with prostration (fatigue with inability to get up) are often seen in patients. Gastrointestinal symptoms like vomiting and diarrhea may occur 3-4 days after the onset of initial symptoms and patients may have low blood pressure. KFD may occur as biphasic disease in 5–10% of patients. After 1-2 weeks of symptoms, some patients recover without complication. However, the illness is biphasic for a subset of patients who experience a second wave of symptoms at the beginning of third week. In severe cases, bleeding from nose and gums may occur and in most severe cases gastrointestinal, pulmonary, and vaginal bleeding may also occur. Cervical and axillary lymph nodes enlarge and may be palpable. Patients will have low platelet, red blood cell and white blood cell counts. Jaundice and liver function abnormality and acute renal failure may develop in the acute phase. Some patients may have altered sensorium and meningitis. Hemorrhagic manifestations and neurological manifestations can occur in both the phases, and severe bleeding from various sites can lead to shock and death.

Diagnosis: All specimens collected for laboratory investigations should be regarded as potentially infectious. Earlier laboratory tests for diagnosis of KFD included conventional tests such as virus isolation by in vivo inoculation of serum from patients into suckling mice, serological tests such as haemagglutination inhibition, complement fixation and neutralization test. All these tests were labour-intensive and time-consuming. diagnostic approaches for identification of KFDV, including nested polymerase chain reaction (PCR) and real-time PCR. IgM and IgG ELISA were also developed and validated. These tests have contributed immensely to the early identification of KFD[2]. Handling of serum samples, RT-PCR/ real-time RT-PCR, IgM ELISA, *etc*., can be performed in a BSL-2 laboratory, but virus isolation should be carried out in a BSL-4 laboratory.

Treatment: There is no specific medication for KFD. As in case of most of the viral diseases, the treatment is purely symptomatic and supportive. Supportive therapy includes the maintenance of hydration and the usual precautions for patients with bleeding disorders.

Prevention: Since 1990, in all KFD endemic areas of Karnataka, the State government has initiated vaccination campaign using formalin-inactivated tissue-culture vaccine. Vaccination is usually carried out within a range of 5 km of the affected area. The schedule for vaccine is two doses at baseline and one month to all persons aged 7-65 yr and with a booster dose at 6-9 months. Vaccine efficacy was low with 62.4 per cent for first two doses and 82.9 per cent with booster dose after receiving the first two doses[28]. Human vaccination (723881 doses) has been carried out in the hot spot areas of Karnataka against KFD virus till 2020 (Table 2).

Table 2. KFD Vaccination progress from 2012-13 to 2019-20

Year	Target population	1st dose	2nd dose	Booster dose	Total doses	Coverage (%)
2012–13	20531	8668	5758	6758	21184	61
2013–14	42844	11247	7731	14510	33588	52
2014–15	80435	24136	14807	26136	65079	47
2015–16	82483	9899	7252	31282	48433	47
2016–17	76262	16355	14161	37989	68505	68
2017–18	96209	27433	19983	37687	85053	60
2018–19	152129	62057	45901	57309	165267	68
2019–20	172988	71951	55306	86514	213771	82
Total	**723881**	**231746**	**170899**	**298185**	**700880**	

Data source: VDL, Shivamogga

Surveillance:

- **Active Fever Surveillance** in the community is done by Health Assistant (Male/Female) supported by ASHA (Accredited Social Health Activist) workers. The surveillance details should be entered into IDSP (Integrated Disease Surveillance Programme) and IHIP (Integrated Health Information Platform) reporting form (S-form). Further, the suspected cases should be referred to Primary Health Centre (PHC) for case management, blood sample collection and transportation (ensure that the suspected case visits the health facility). The suspected case details to be documented in the Case Investigation Form-cum-Lab Referral Form (CIF-LRF) at health facility (responsibility of the Medical Officer). Line list of suspected cases should be entered into KFD Human Surveillance Register (responsibility of the Laboratory Technologist).

- **Passive Fever Surveillance** in the health facility: The sample collection, treatment, and case management is done at health facility and documentation of the patient details in the CIF-LRF (responsibility of the Medical Officer). Line list of suspected cases should be entered into KFD Human Surveillance Register (responsibility of the Laboratory Technologist). Further, the surveillance details should be entered into IDSP and IHIP reporting form (P-form).

- **Monkey death surveillance**: Reporting of unusual monkey death(s) is to be done with the respective Panchayat Development Officer of the Gram Panchayath (Nodal person). The responsibility for the transport of monkey samples for autopsy to the laboratory lies with the Health Assistant of the Hotspot Management team. The responsibility of documenting the monkey death surveillance and autopsy report in register lies with Laboratory Technologist. Responsibility of sharing results of the monkey autopsies are to be shared with the concerned Primary Health Centre (PHC), Taluk Health Officer (THO), District Surveillance Officer (DSO), and District Vector Borne Disease Control Office (DVBDCO) lies with Virus Diagnostic Laboratory (VDL) of Shivamogga.

- **Tick surveillance**: The tick pools collected should be sent to the laboratory for virus detection along with the Laboratory Request Form – Tick pool and documented in Tick Surveillance Register. The responsibility for this lies with Health Assistant at PHC, and, at district level, Entomologist, office of the DVBDCO who shall also maintain the details of tick surveillance. A Hotspot: Laboratory Request Form - Tick pool is to be filled by the Health Assistant of Hotspot Management Team and the same must be documented in the Tick Surveillance Register maintained at PHC.

Tick Control:

Insect repellants: The insect repellent compounds currently in use for include:

- DEPA (N,N-diethyl phenylacetamide)
- DEET (N, N-diethyl-m-toluamide, also known as N,N-diethyl-3-methylbenzamide).
- IR3535 (Ethyl Butylacetylaminopropionate or 3-[N-Butyl-N-acetyl]-amino propionic acid, ethyl ester).
- Picaridin (1-piperidinecarboxylic acid, 2-(2-hydroxy) ethyl)-, 1-methylpropylester).
- MGK-326 (di-n-propyl isocinchomeronate), used in conjunction with DEET in composite formulation.
- MGK-264 (N-octyl-bicycloheptene dicarboximide), used in conjunction with DEET in composite formulation.
- Oil of Lemon Eucalyptus (PMD; p-Mentane-3,8-diol).
- Citronella, Soybean, Peppermint, and other plant essential oils

Tick management:

Personal Protection: Tick-bite prevention, tick checks and tick removal.

Landscape Management: Vegetative modifications to render the environment less suitable for tick survival and for tick hosts.

Management of Host: Abundance Exclusion of hosts by fencing, host reduction, and host reduction by management of the host habitat.

Area Application of Acaricides: Spraying chemical insecticides to control ticks

Biological & Natural Control: Use of fungal pathogen Metarhizium anisopliae – the fungal exposure on ticks revealed that the egg laying capacity of ticks is reduced by 50%, weight of larvae and nymphs was reduced significantly, suggesting that the fungus reduced the tick fitness and growth and caused mortality. Also, there was a 5-10-fold reduction in the number of tick population and plant extracts as biopesticides to control ticks.

Actions to consider in an integrated management approach include:

- Keep grass mowed.
- Remove leaf litter, brush, and weeds at the edge of the lawn.
- Remove brush and leaves around stonewalls and wood piles.
- Discourage rodent activity. Cleanup and seal stonewall and small openings around the home.
- Move firewood piles and bird feeders away from the house.
- Injection of ivermectin to the cattle post-monsoon in September/October may reduce the tick burden on cattle stocks.
- Manage pet activity, keep dogs and cats out of the woods to reduce ticks brought back into the home.
- Use plantings that do not attract monkeys.
- Trim tree branches and shrubs around the lawn edge to let in more sunlight.
- Adopt hardscape and xeriscape (dryer or less water demanding) landscaping techniques with gravel pathways and mulches. Create a 3-foot or wider wood chip, mulch, or gravel border between lawn and woods or stonewalls.
- Consider areas with decking, tile, gravel and border or container plantings in areas by the house or frequently traveled.
- Widen woodland trails.

Control Strategy:

The National Centre for Disease Control (NCDC) has formulated strategy for effective control of KFD thereby ensuring better health of animal and human population in the affected areas. The departments and their expected input are summarized in Table 3.

Table 3. Responsibilities assigned for control of KFD

Sl. No	Department	Responsibilities
1	Public Health	• Surveillance • Field investigation, hotspot identification • Vector study and vector control measures • Laboratory Services • Clinical Management of cases/Referral arrangements • Protocols for primary/secondary and tertiary care • KFD Vaccination • Tick control activities • Health Education to masses • Vaccination of the vulnerable groups

Sl. No	Department	Responsibilities
		• Reporting to State Surveillance unit (SSU)/State Health Directorate • Media management • Engagement with all stakeholders
2	Animal Husbandry Department, Veterinary Colleges, Institutes	• Tick control in domestic animals in villages near the periphery of KFD-endemic areas • Postmortem of dead monkeys wherever necessary • Collection of tissue samples from dead monkeys for KFD detection • IEC and Advocacy efforts in the district • Support in vector identification and surveillance • Participation in multidisciplinary Rapid Response Teams (RRTs) investigations • Technical support for tick control among domestic animals
3	Forestry	• Detecting and reporting of monkey deaths to the concerned • Disposal of dead monkeys in collaboration with other stakeholders • Declaration of Hotspot & tick control at hotspot areas • Ensure personal protection of all Labourers in forest • Facilitate vector control in tick-infested spots/monkey death spots • Strict vigil on all entering/leaving reserve forest areas • Widespread IEC displayed in hotspots • Guided all investigating teams into the deep forest areas
3	Wildlife	• Arrangement for autopsy of dead monkeys • Arrangements for capturing sick monkeys • Isolation and care of sick monkeys • Coordination with district authorities in unexpected Law & Order situations • Support to other departments
5	Tribal welfare	• Tribal health promoters to support surveillance activities • Ambulance support for referral of cases to Hospitals • Arrangement for organizing Medical Camps in all difficult-to-reach colonies
6	Revenue Department	• Financial support for the KFD activities
7	Education department	• Vaccination and IEC activities coordination in Schools • Information to the surveillance system
8	Women and child welfare	• Taking services of Anganwadi workers where there is no availability of ASHA workers

Sl. No	Department	Responsibilities
9	Information and broad casting department	• Dissemination of IEC materials
10	NGOs	• Support surveillance and IEC activities

Source: CD Alert Technical Bulletin of National Centre for Disease Control (NCDC)

Gaps identified.

1. Linkages have been established among various departmental agencies, but effective coordination of activities are yet to be achieved.

2. Reporting of occurrence of KFD is yet to be streamlined.

3. Turn-around time of lab testing and reporting is not always timely and prompt, since only National Institute of Virology (NIV) Pune has the facility for testing for KFD.

4. Awareness programs are being conducted by health department and the involvement of other departments is not always ensured.

5. Helpline numbers for individual departments are displayed but there is no provision for displaying the helpline number for a coordinated inter-departmental response.

6. New methods for tick control using biosafe acaricides to be explored to replace the current obsolete practices of using harmful chemicals, viz., use of Malathion.

7. Development of safe and efficacious vaccine(s) against KFD is still a dream.

8. Biosafe carcass disposal of affected monkeys not ensured.

Suggested Interventions for prevention and control of KFD:

Intervention #1: Institutionalization

- Administrative impetus to be given to ensure effective coordination and involvement of the related sectors in the hotspot areas.

- One Health Support Unit of Karnataka (OHSU-K) team – jointly with nodal officers of the three sectors – to conduct awareness camps covering all aspects of KFD control.

Intervention #2: Strengthening of diagnostic capacities

- Labs to be established under One Health with technical staff from health, forest and animal husbandry working solely for the control and diagnosis of zoonotic disease having BSL-II and BSL- III/IV facilities to be opened in Shivamogga at the earliest under the National Disaster Relief Force (NDRF).

Intervention #3: Digital Disease Reporting & Response System

- Data collection Apps for different end-users with provision for controlled data sharing and retrieval by policy makers from all the three departments.
- Digital warning facility in the hotspot areas to the public through mobile alert could be a joint activity of National Centre for Disease control (NCDC) and ICAR-NIVEDI.

Intervention #4: Customized trainings on Epidemiology

- Trainings required for veterinarians, medical officers, epidemiologists, and forest officers on diagnosis of KFD, one health approach to reduce KFD incidence, sample collection, storage and transportation of samples for KFD diagnosis.

Intervention #5: Communication Strategies

- Posters and digital display at required points to drive the message of necessary precautions against KFD.
- Extension activities for KFD awareness in schools.
- Mobile Veterinary Units (MVUs) to be used for public announcements in hotspot areas.
- Spraying of anti-tick medicine on livestock at animal camps regularly in hot-spot areas.

Intervention #6: Community Outreach and Strengthening Biosafety & Biosecurity

- Enhanced biosecurity measures through cordoning of hot-spot areas (during incidence of monkey death, since monkeys are the sentinel indicators of KFD) to prevent spread.
- Mobile incinerators to ensure biosafe disposal of carcasses of affected monkeys.

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