Journal of Communicable Diseases
Volume 51, Issue 2 - 2019, Pg. No. 38-44
Peer Reviewed & Open Access Journal

Research Article

Kyasanur Forest Disease: Vector Surveillance and its Control

SN Sharma[1], Rina Kumawat[2], Sujeet Kumar Singh[3]

[1,2,3]National Centre for Disease Control, 22 - Sham Nath Marg, Delhi, India.
DOI: https://doi.org/10.24321/0019.5138.201915

I N F O

Corresponding Author:
SN Sharma, National Centre for Disease Control, 22 - Sham Nath Marg, Delhi, India.
E-mail Id:
drsns.nvbdcp@gmail.com
Orcid Id:
https://orcid.org/0000-0001-8569-1661
How to cite this article:
Sharma SN, Kumawat R, Singh SK. Kyasanur Forest Disease: Vector Surveillance and its Control. *J Commun Dis* 2019; 51(2): 38-44.

Date of Submission: 2019-05-28
Date of Acceptance: 2019-06-21

A B S T R A C T

Kyasanaur Forest Disease (KFD) is a tick-borne viral hemorrhagic fever caused by KFD Virus (KFDV), a member of the virus family Flaviviridae (Genus: Flavivirus). KFD was first recognized as a febrile illness in Shimoga district of Karnataka state, India in 1957. It is also called as monkey fever. KFDV gets transmitted by the bite infective ticks *Haemaphysalis* spp., especially at its nymphal stage.

There is wide range of hosts including human, tick species, rodents (shrews, forest rats) monkeys (black faced langurs and red faced bonnet monkeys), bats, squirrels, ground dwelling birds and porcupines and domestic ruminants. Rodents are the best maintenance hosts (short generation time). In KFD, Human act as dead end host. They do not develop adequate viremia to infect the ticks. Amplification of virus occurs in Monkeys. Domestic ruminants maintain the infected tick population for long time. Trans-stadial transmission in ticks is common, but trans-ovarial transmission is absent except in *Ixodes petaurisae.*

About sixteen species of ticks are known to be involved in transmission. Ten species carry natural infection. *Haemaphysalis spinigera* and *Haemaphysalis turturis* are the two major vector playing role in KFD transmission. Other species of *Haemaphysalis* involved in transmission of KFDV are *H. aculeata, H. bispinosa, H. cuspidata, H. kyasanurinsis* and *H. minuta, H. kinneari* and *H. wellingtoni.* An attempt has been made in this manuscript to discuss the vector surveillance in KFD transmission and vector control options available at present.

Keywords: Kyasanur Forest Disease (KFD), KFD Virus (KFDV), Trans-Stadial Transmission, Trans-Ovarial Transmission, Amplifier Host, Dead end Host

Introduction

Kyasanur Forest Disease (KFD)

Kyasanur Forest Disease (KFD) is caused by Kyasanur Forest Disease Virus (KFDV), a member of the virus Family-Flaviviridae. KFDV was identified in 1957 when it was isolated from a sick monkey from the Kyasanur Forest in Karnataka (formerly Mysore) State, India.[1] It is also known as "Monkey Disease/Monkey Fever" because of its association with monkey deaths. Since then, between 400-500 humans cases per year have been reported and has a fatality rate of 2-10%, Hard ticks (*Hemaphysalis spinigera*) are the reservoir of KFD virus and once infected, remain so for life. Rodents, shrews, and monkeys are common hosts

for KFDV after being bitten by an infected tick. KFDV can cause epizootics with high fatality in primates. *Boophilus microplus*, *H. bispunosa*, *Riphicephalus haemaphysaloides* and *R. sanguineus* have been reported from domestic animals.[2]

Epidemiological Situation

It is an emerging disease detected in 1957 from Shimoga district of Karnataka state. However, in recent years, it has moved its territory to seven districts of state as well as centripetally spread to neighbouring Kerala, Tamil Nadu, Goa and Maharashtra states which are sharing border with the states.

prostration. A papilo-vesicular lesion in the soft palate is observed as a constant finding in most cases. In severe cases neurological symptoms like neck stiffness, mental disturbance, coarse tremors, giddiness and abnormality of reflexes are noted. Un-treated cases rapidly progress to convulsions, coma and death. Case fatality is 2-10%. Fatality is higher in the elderly and in patients with co-morbid conditions like liver diseases (alcoholic) etc.

Incubation Period: 3-8 days

Transmission

KFDV is transmitted by an infected tick, especially nymphal

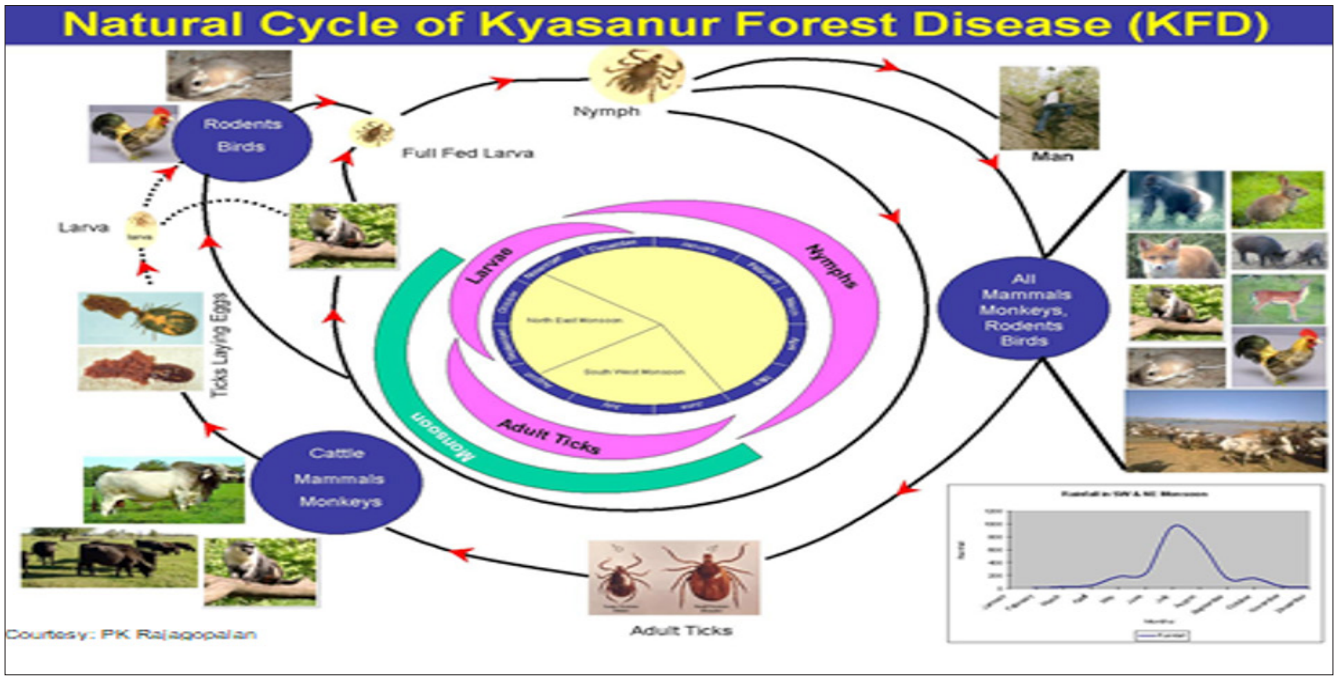

Figure 1.Natural Cycle of KFD Transmission

KFD has historically been limited to the Western and Central districts of Karnataka State, India. However, in November 2012, samples from humans and monkeys tested positive for KFDV in the Southern most district of the State which neighbour's Tamil Nadu State and Kerala State, indicating the possibility of wider distribution of KFDV. In India, KFD virus has been isolated from tick species namely Haemaphysalis spinigera, *H. turturis, H. bispinosa, H. cuspidata, H. wellingtoni* and other Ixodes species.[3-8]

Signs and Symptoms

Kyasanur Forest Disease (KFD) usually presents with sudden onset of high-grade fever with chills, intense frontal headache, severe Myalgia and body aches. Muscle tenderness, photophobia, nausea, vomiting and diarrhea are usually seen. Respiratory symptoms like persistent cough may be present in some cases. Temperature may be as high as 104^{0}F/40^{0}C and last for 5-12 days and there is intense

stage ticks. The wild monkeys *Semnopithecus entellus* and *Macaca radiata*, gets the disease through the bites of infected ticks. Infection causes severe febrile illness in most of the monkeys. When infected monkeys die, the ticks drop from their body, thereby generating "hot spots" of infectious ticks that further spread the disease. Humans can get the disease form an infected tick bite or by contact with an infected animal, such as sick or recently dead monkey. Available epidemiological data does not suggest any human-to-human transmission.

Risk of Exposure

People with recreational or occupational exposure to rural or outdoor settings (e.g. hunters, herders, forest workers, farmers) within Karnataka State are potentially at risk for infection by contact with infected ticks. Seasonality is another important risk factor as more cases are reported during the dry season from November through June.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201915

Ticks

Ticks are found throughout the world, in tropic and temperate zones. They are divided into two groups: the soft ticks of the Family - Argasidae (100 species) and the hard ticks of the Family - Ixodidae (700 species). Hard ticks are capable of transmitting diseases such as Tularaemia, Rocky Mountain spotted Fever, Lyme disease, Q fever, and Tick-borne Encephalitis. They can cause a direct injury resulting in a condition known as Tick Paralysis. The soft tick may transmit spirochetes that cause tick-borne relapsing fever. The tick gets spirochetes when ingesting the blood of an infected animal. The spirochetes then multiply within the body of the tick, invading the tissues and the body cavity of the tick. Spirochetes are transmitted to the tick's eggs by trans-ovarian transmission, even to the third generation.

Hard Ticks (Family Ixodidae)

Hard ticks belong to the family Ixodidae and represent one of the most medically important groups of arthropods. The mouthparts directed anteriorly (prognathous) can be seen from above and the hard tick has a shield on the back (Figure 2). The capitulum of hard ticks just as the mouthparts is visible from a dorsal view. Hard ticks can be easily differentiated by the shape of the basis capitulum.

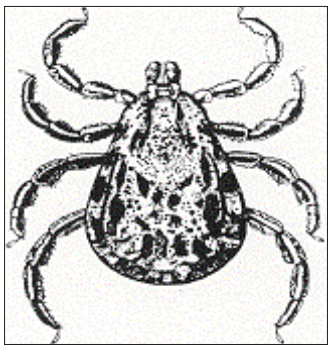

Figure 2.Adult hard tick

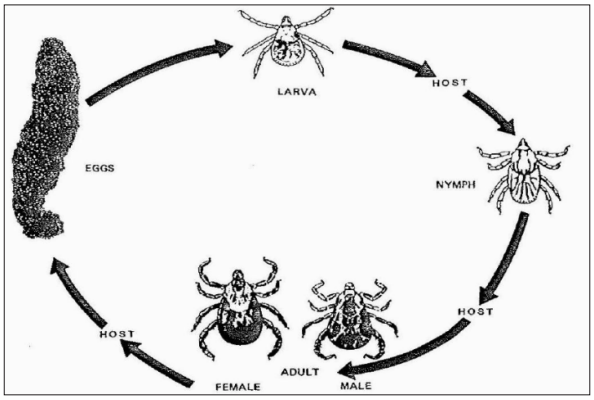

Figure 3.Life cycle of the hard tick

Life Cycle of Hard Ticks

The life cycle of the hard-tick is a type of gradual metamorphosis, consisting of four stages: egg, the six-legged larva (seed ticks), 8-legged nymph, and adult (male or female). The completion of this life cycle may take from 6 weeks to 2 years. Most of the tickes have a 3-host life cycle, whereas each of these stages feed on a different individual host animal taking a single blood meal.

Larvae feed to repletion on one animal, drop to ground and moult into nymph. The nymph must find and attach to another animal, engorge, drop to ground and moult into adult. The female becomes greatly distended while feeding, a period of usually 5 to 10 days. Copulation takes place on the host while the female is feeding. After copulation, the female takes more blood, drops to the ground, finds a sheltered place, and in a few days deposits a gelatinous mass of eggs that may number into the thousands. This oviposition may take several days, after which the female dies. Under favourable conditions, the eggs hatch in about a month; but during cold weather, they may not hatch for several months. Some days after hatching, the six-legged larvae (also called "seed ticks") climb weeds, stems, or twigs or walk over the ground to find a suitable host such as a small mammal. They engorge on the blood of the host, drop to the ground, and moult into the nymphal stage. The nymph then awaits an animal, feeds, drops to the ground, and moult into the adult which then repeats the cycle (Figure 3).

Soft Ticks (Family Argasidae)

The soft ticks are round or oval and lack a shield on the back; their skin is leathery, wrinkled and tough. In adults, the mouthparts are not visible from above (Figure 4). Their development is similar to hard ticks but they may have two to several larval and nymphal stages. Soft ticks are secretive in their habits, feeding at night and concealing themselves during the day in crevices or cracks near the nest or roost of the host. The female feeds and lays eggs alternately over a relatively long period. Thus, a single soft tick may feed, on several different hosts during one life time, which sharply increases its disease-carrying potential. Many soft ticks feed on birds and reptiles, although others prefer mammals as a host.

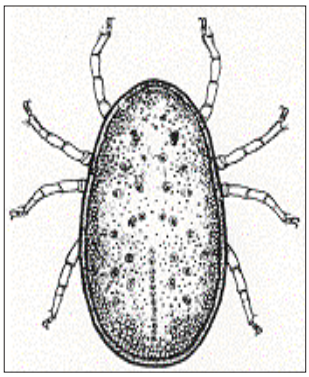

Figure 4.Adult of Soft tick

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201915

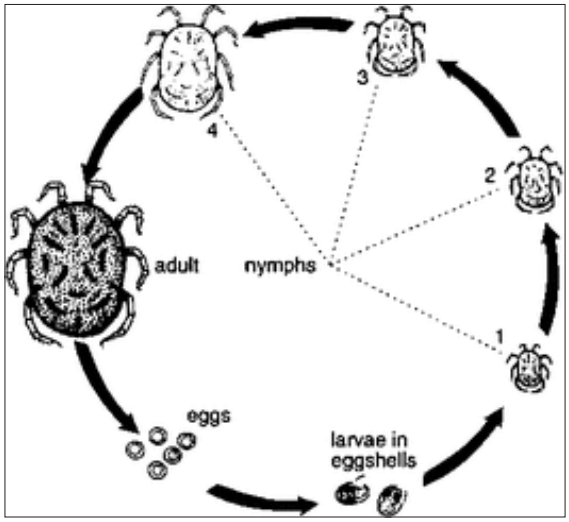

Figure 5.Life cycle of the soft tick

Life Cycle of Soft Ticks

The life cycle of Argasid (soft) ticks is multi host. Mating and egg-laying always occurs off the host in a sheltered area (usually an animal nest). Eggs hatch into six-legged larvae in the parent's sheltered area. They quest for a host in the vicinity of the sheltered area. Once a suitable host is found, they feed for anywhere from one hour to several days, depending on the species. After feeding, the larvae leave the host and moult into the first nymphal instar in the sheltered area. The nymphs' quest for and feed on, the second host rapidly (usually about an hour). The second host is usually the same species and often the same individual, as the first host. The first nymphal instar leave the host and moult into the next nymphal instar in the sheltered area. This cycle can continue to accommodate up to seven nymphal instars, depending on the species. After the last nymphal instar has fed, it leaves the host and moults into an adult in the sheltered area (Figure 5). Adults may continue to feed on the host, feeding rapidly and detaching after each blood meal. Females of some species lay egg batches after each meal. Humans are usually only incidental hosts for argasid ticks and may be fed upon by any of the stages.

Ticks have four stages to their lifecycle, namely egg, larva, nymph, and adult. Ixodid ticks have three hosts, taking at least a year to complete their lifecycle. Argasid ticks have up to seven nymphal stages (instars), each one requiring a blood meal. Because of their habit of ingesting blood, ticks are vectors of at least twelve diseases that affect humans and other animals.

The following Ixodid ticks have been reported to vectors of tick typhus:

- *Rhipicephalus sanguineus*
- *Ixodes ricinus*
- *Haemaphysalis indica*
- *H. kinneari*
- *H. turturis*
- *H. spinigera*

Rodents and dogs harbour the potential tick vectors and maintain the reservoir of the disease in nature. Among the potential vector species *R. sanguineus* is the most common tick distributed in India.

Tick Surveillance

Sampling Technique

Tick Population in an area is comprised of active and inactive phase. The population which are questing for the host or are attached for feeding on the host are considered as active phase. Quiescent population, usually away from the host are considered in inactive phase. The collection of ticks in active phase both questing and parasitic usually give a reliable estimate of tick prevalence in an area.

Tick vectors of KFD are almost exclusively forest inhabiting species. The dormant stage of these species is usually found under the forest litter, inside the burrows or in the resting or roosting places of the hosts, where they are difficult to reach. The questing stages are found on the vegetation, usually on the forest undergrowth, where they can be easily collected.

Tick surveys are conducted to determine the following: species of ticks present in an area, infested area boundaries, necessity for control and effectiveness of control operations. Ticks are more commonly found in brushy, wooded areas where wild or domestic animals are available for food. Such areas include training and maneuver areas. There is no easy or simple method to conduct a survey. Tick surveys require practice and experience in order to perfect techniques. One of the most successful techniques has been the use of the "tick drag." A "tick drag" is a one-yard square piece of white flannel cloth reinforced at both ends by a rod or stick. A string is attached to each end of one of the rods to allow you to drag the cloth behind you. There are three methods by which the drag of white cloths may be used (Figure 6).

- Pull the drag over a predetermined distance, usually 50 yards or 50 steps. Then stop and collect the ticks that have attached themselves to the cloth. Ticks may be collected with forceps or by rolling the drag with a disposable adhesive-type lint roller.
- Place the drag on the ground and sit on it for 5 to 10 minutes. Then collect the ticks that crawl onto the cloth. Clothing should be thoroughly examined for ticks and rolled with an lint roller to remove ticks. When clothing is removed, the body should be checked for ticks attached to skin, particularly the legs and the nape of the neck.

Any ticks found attached to the skin should be carefully removed with forceps by grasping the tick as close to your

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201915

skin as possible and using slow, steady traction to pull their mouthparts from the bite wound.

Figure 6.Tick drag method

- Place the drag on the ground and place a block of dry ice (2 to 3 inches on a side) on an inverted, disposable pie tin in the centre of the drag. Collect ticks as they crawl across the drag or next to the dry ice. The dry ice should be wrapped in paper to avoid damaging the tick specimens.

Hand Collection

For Hand Collection of Tick to evaluate the total tick counts, six clearly defined sites on each host animal can be selected for study because of their importance as feeding sites for the different stages of the commoner cattle ticks. All the ticks on these sites are removed, either by hand or with forceps, and taken to the laboratory for study. The sites are as follows:

- **Pinna:** Both surfaces of a single ear of each bovine are sampled. The actual ear passage can also be included but care must be taken with collections not to damage the ear canal but also not to damage the ticks.
- **Neck:** This site includes the lateral surfaces of the neck.
- **Leg:** This site includes the axilla, leg (from elbow to fetlock) and foot (below fetlock). Only one foreleg of each survey animal is sampled.
- **Tail:** This site includes the tail and tail brush.
- **Upper perineum:** This site, extending from the base of the tail to about 10 cm below the anus.
- **Lower perineum:** This site, extending from below the upper perineum to the base of the scrotum.

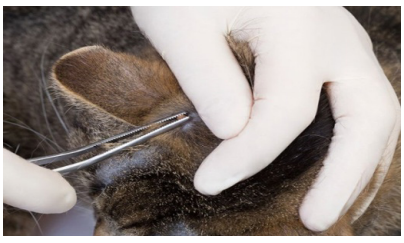

Figure 7.Tick collection by Hand collection

The density of tick infestation on a host species is evaluated in terms of tick index, which represents the average number of ticks per host individual examined and may be calculated by the following formula.

$$\text{Tick Index} = \frac{\text{Total number of ticks collected}}{\text{Total number of rats examined}}$$

Chigger Index: It is the number of chiggers infesting a single host.

Critical Value: 1 (for occurrence of a single case of scrub typhus).

Outbreak Investigation

Investigation the important features that deserve careful attention for investigations during an outbreak:

1. Occurrence of monkey in the areas should be established as outbreaks of KFD in humans are usually preceded by epizootic in the monkey population in the area.
2. Occurrence of any monkey death should be carefully investigated.
3. Collection of ticks on or close to dead monkey should be carefully carried out.
4. Establish presence of the known KFD Vectors especially in the area.
5. Identify the natural hosts of vectors ticks both among domestic and wild animals.
6. Identify the source of tick infestation to man.
7. If the area has no previous history of the disease and the known vector species are absent the first priority for investigation is virus isolation and transmission experiments to incriminate the vectors species.

Susceptibility to Insecticides: Limited studies have been carried out on the techniques to determine the susceptibility of ticks to insecticides. The existing methodology is comprised of the tropical application of a known volume of insecticide in aqueous or alcoholic solution in a series of two-fold solutions and to observe mortality after incubation period of 24 hours.

Strategy for the Prevention and Control of KFD Vectors

- **Identify the hot spots:** The area is identified based on the reported cases during the past 5 years to understand the timings, pattern and distribution of cases. The cases are to be classified into age and sex wise distribution based on occupation.
- **Mapping of the forested area infested with monkeys:** The forest/ wild life department need to map the areas with high monkey densities and the human activities around in the jungles. The reported deaths due to various ailments must be maintained by the wild life/ forest department.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201915

- **Regular vector surveillance:** Entomological studies are to be carried out on regular basis in the hot spots and neighbouring areas for tick / nymph index and tick infestations through virus isolations.
- **Selection of sentinel sites:** At least four fixed and four random stations should be surveyed for the vector surveillance. Vector surveillance may also be undertaken in the endemic and non-endemic areas.
- **Ticks Management:**

1. **Personal Protection**

- Personal Protection Proper clothing should be used to limit access of ticks to the skin, thereby helping to prevent bites.
- Pants should be tucked into the boots or socks, and the shirt should be tucked into the pants.
- Avoiding sitting or lying on scrubby areas.
- Avoiding hanging clothes on scrubs or trees.
- Disinfesting your pets regularly.
- Long sleeves will help, and a hat will be useful if crouching or crawling in bushes or undergrowth. Light-colored clothing should be used to make ticks much easier to detect.
- Repellents like DEET 33% (N, N-diethyl-m-toluamide or N, N-diethyl-3-methylbenzamide), Permethrin should be used to prevent tick bites.

2. **Landscape management:** Bringing change in the landscape under use with vegetation modification making environment less suitable for ticks' survival and hosts.
3. **Management of host abundance:** Keeping the animal hosts away from human population by fencing and host reduction by the management of the habitats. Source reduction through essentially involve clearing of vegetation allowing the area to dry for a few weeks and then being sprayed with malathion. Minimize contact with domestic animals, live stocks, pets etc. Discourage rodent activity in or around houses.
4. **Community awareness:** Need of community awareness to educate forest guards and people working in the forests.
5. **Inter-sectoral coordination:** Coordination and Involvement of Departments namely Forest, Wildlife, Veterinary Public Health, Tribal Welfare, Education
6. **Chemical control**

- Area wide application of acaricides (chemicals that will kill ticks and mites) to control tick habitats (e.g. Leaf litter and bushes).
- One or two treatments of forest floor with the insecticide, which is considered highly effective in killing ticks.
- Control measures consist of spraying of malathion dust within a radius of approximately 50 meters around the monkey death spot.
- Spraying should also be done along the forest tracks used by the villagers.
- If the human dwelling is adjacent to the infested forest, spraying should be done in the vicinity of the dwelling also.
- **Dust Formulation**: 5% malathion powder [1 part of 25% wettable powder (WP) Malathion and 4 parts of chalk powder or inert material].

Residual Insecticidal Spray

- **Malathion 25% WP:** Malathion suspension is applied 20 gm/sq.mt of active ingredient. To get 5% suspension, 2 kg of 25% of wp mixed in 10 litres of water.
- **Deltamethrin 2.5% WP:** The suspension is applied 35.0 mg/sqmt of active ingredient. To obtain 0.125% suspension, 500 gm of 2.5% deltamethrin is mixed in 10 litres of water. Two rounds of spray may be undertaken annually. It may be used only in case of an emergency.

Conclusion

KFD is rural based diseases particularly in the forested area wherein the natural cycle of the KFDV is always present. The vector of KFD is three hostic and need different situations droping at the land and mainly feed on the animal hosts and the humans are the incidental hosts. All precautions and control measures are to taken up by the persons engaged in jungles, fields and in close proximity with moneys i.e mail amplifier host.

Conflict of Interest: None

References

1. Work TH, Trapido H, Murthy DP et al. Kyasanur forest disease III. A Preliminary report on the nature of the infection and clinical manifestations in human beings. *Indian Journal of Medical Sciences* 1957; 11(8): 619-645.
2. Kumar K, Balakrishnan N, Katyal R et al. Prevalence of ixodid ticks in Nilgiri district of Tamilnadu state. *Journal of Communicable Diseases* 2002; 34(2): 124-127.
3. Mourya DT, Yadav PD, Patil DY. Highly infectious tick-borne viral diseases: Kyasanur forest disease and Crimean-Congo haemorrhagic fever in India. *WHO South East Asia Journal of Public Health* 2014; 3(1): 8-21.
4. Singh KR, Pavri KM, Anderson CR. Transmission of Kyasanur forest disease by *Haemaphysalis turusis*, *H. papuanakinneari* and *H. minuta*. *The Indian Journal of Medical Research* 1964; 52: 566-573.
5. Singh KR, Bhatt PN. Transmission of Kyasanur forest disease virus by Hyalomma marginatum isaaci. *Journal of Medical Research* 1968; 56(4): 610-613.
6. Singh KR, Goverdhan MK, Rao TR. Experimental

transmission of Kyasanur forest disease virus to small mammals by *Ixodes petauristae*, *I. ceylonensis* and *Haemaphysalis spinigera*. *The Indian Journal of Medical Research* 1968; 56(4): 594-609.
7. Singh KR, Goverdhan MK, Bhat UK. Transmission of Kyasanur forest disease virus by soft tick, argaspersicus (ixodoidea: argasidae). *The Indian Journal of Medical Research* 1971: 59(2): 213-218.
8. Kumar K, Balakrishnan, Sharma AK. Studies on the vertical distribution of ticks of domestic animals and their public health importance in Nilgiri hills and adjoining areas of Tamil Nadu state (India). *International Journal of Zoology* 2014, 1-6.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201915