Vector-Borne Diseases: (Tabanidae: Diptera) – A mechanical vector of *Trypanosoma evansi*

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Abstract

Climatic and ecological changes, national rules on the management of stray dogs and cats, as well as an increase in pet travel and transfer of pet animals, can all have an impact on Europe's current vector-borne illness epidemiology. Rare illnesses may become more common in specific locations, either as a result of an increasing importation of sick animals or when the causative agents and vectors expand to and establish in previously non-endemic areas. The females of the Tabanidae (Diptera) family are bloodsucking insects that significantly affect farming activities. Female tabanids are considered a significant livestock pest and mechanical carriers of several illnesses. The species of the flies in a particular location must be identified in order to implement control-limiting techniques, such as environmental and zoo technological management. The Tabanidae family includes the genus Tabanus of horseflies that bite. The mouthparts of females resemble scissors and may pierce farm animals' skin. The animal's blood may then be drawn out and consumed by the horsefly. This genus of horseflies is reported to carry trypanosomes, worms, and anthrax. Because of their size, painful bites, and frequent interruptions of blood feeds, tabanids are mostly day-biters and are effective mechanical carriers of disease organisms. The Tabanidae family is distributed from Lao to Thailand and Vietnam, and from Pakistan and India to China.

Keywords: Tabanids, Biting behavior, Distribution, Disease vector, Control

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Introduction

Vector-borne illnesses are those that are spread by vectors. Numerous vector-borne illnesses are zoonotic, or illnesses that humans and animals can contract either directly or indirectly. A living thing that spreads an infectious agent from an affected animal to a person or another animal is called a vector. Zoonosis is a major part of the World Health Organization's global health mission. Humans can either directly or indirectly catch 250 zoonotic diseases from a variety of animal species. Treating and controlling zoonotic illnesses is a top priority for primary health systems. Humans are an abnormal host of zoonosis, which is typically thought of as an animal illness (Bezerra-Santos *et al.*, 2021). The disease zoonosis has two sides. The cattle industry suffers significant financial losses as a result of two factors: first, the transmission of harmful illnesses to people; and second, the damage to animal health and productivity. Vector-borne diseases (VBDs) are diseases spread by ticks and are categorized as zoonosis. These diseases can be caused by viruses, bacteria, or parasites and occur all over the world. Stated differently, the majority of these diseases are transmitted from animals to humans. The implications of vector-borne zoonosis for the environment and public health make it noteworthy (Zahoor *et al.,* 2023).

Vector-borne zoonosis is intimately correlated with environmental conditions. The dynamics of zoonotic diseases can be altered by variations in climate, land use, and ecological disturbances, which can also affect the distribution and behavior of vectors. The economic consequences of vector-borne zoonosis are severe. In the affected areas, these infections may lead to decreased agricultural output, increased medical costs, and lost productivity. The cost may be quite expensive in areas where these illnesses are endemic. The connection of human, animal, and environmental health is highlighted by vector-borne zoonosis. Using One Health approach, public health experts, veterinarians, ecologists, and other stakeholders must work together to treat and prevent these illnesses. Because of factors including globalization, urbanization, and climate change, vector-borne zoonosis remains a problem. It may be challenging to monitor, diagnose, and manage emerging diseases when they are introduced into new regions via vectors (Hassall *et al.,* 2023).

The Vector

A living thing called a vector spreads an infectious agent from an affected animal to a person or another animal. Among the vectors include arthropods including lice, fleas, flies, ticks, and mosquitoes (Swei *et al.,* 2020). Via vectors, infectious illnesses can spread either actively or passively. Biological vectors such as ticks and mosquitoes can carry some illnesses, multiplying within them before biting new victims. Infectious illnesses can be acquired and spread by mechanical vectors, such as flies, by direct physical contact. Vectors can be long-range. This might have an impact on the range of zoonotic diseases spread by vectors (Combs *et al.,* 2022).

Tabanus -Tabanidae

The term "Tabanus" Originally used by Pliny the Younger and persisted as a generic name. There are several common names for Tabanidae. The subfamily Chrysopsinae is known as "deer flies," maybe because they are abundant on moors where deer wander, and that buffalo, moose, and elephant flies are widespread around the world. Generally speaking, the phrase "horsefly" refers to Tabaninae, which are stouter and bigger than deer flies and do not have banded wings. Green flies, tabanids, gadflies, and green-headed flies are some more common names (Marren & Mabey, 2010).

The Tabanidae belong to the Dipteran order of insects and are really flies. Table 1 shows the classification of Tabanus. Tabanidae belongs to the superfamily Tabanoidea, which also includes the families Athericidae, Pelecorhynchidae, and Oreoleptidae. This superfamily is part of the infraorder Tabanomorpha, which also includes the Rhagionoidea. It appears that the existence of a venom channel in the larvae's jaw unites tabanoid groups. Over 1,300 of the approximately 4,455 species of Tabanidae that have been identified worldwide are found in the genus Tabanus (Morita *et al.,* 2015).

Table 1: Scientific Classification of Tabanus

Domain:	Eukaryota	References
Kingdom:	Animalia	
Phylum:	Arthropoda	
Class:	Insecta	
Order:	Diptera	
Family:	Tabanidae	(Thompson, 2013)
Subfamily:	Tabaninae	
Genus:	*Tabanus*	

The females of the majority of species are blood feeders that can spread a variety of infections to hosts when feeding on humans and animals, biting flies belonging to the Tabanidae family are important for both medical and veterinary purposes. Bacteria, protozoa, helminths, and viruses are among the pathogens spread by the Tabanidae (Mugasa *et al*., 2018).

They are a major annoyance to animals because of their size and incredibly susceptible telmophagous-type mouthparts, which can cause painful bites and a lot of blood spoliation, pressure, defensive actions, and opportunities to transfer from one host to another. They are also extremely prolific, with a female generating 500–4,000 eggs in a gonotrophic cycle (100–800 eggs each batch) and maybe 5–8 cycles in a lifetime. They repeatedly feed on blood from one or more hosts until they are fully engorged, which causes their annoying behavior (Desquesnes *et al*., 2013; Baldacchino *et al.,* 2014; Wongthangsiri *et al*., 2019).

Life cycle of Tabanus

Tabanidae go through four life stages as part of their total metamorphosis. These are the stages of the egg, larva, pupa, and adult *(*Carlos, 2023).

The number of eggs in the female's egg mass might range from a few to several hundred. Usually, the bulk is placed on the foliage that dangles over the water. The eggs have a spindle-like form and are black and glossy. The larvae fall into the water or damp soil after hatching, which takes five to twelve days. After hatching and dropping into the water, the larvae spend the winter underground, burrowing in the river substrate or the ground along the riverbank. The six to thirteen stages of development (referred to as "instars") that are characteristic of the Tabanidae life cycle might occasionally take the larvae one to three years to complete. The larvae move into drier soils in late spring and enter the pupal stage, the next stage of life. The pupal stage can last anywhere from six to twelve days, depending on the species and climate. Adult Tabanidae start mating and blood eating as soon as they leave the pupal stage. Adults are excellent flyers and use their eyes to find potential mates. The majority of horse and deer fly species only produce one generation year *(*Mullens, 2019; Carlos, 2023).

Distribution and Habitat

Throughout Asia, at least twenty-nine species of Tabanus have been successfully spread through experiments, including *Tabanus partitus, Tabanus rubidus, Tabanus striatus* and *Tabanus tenens*. The tabanids from the warmest climates, where prolonged wet seasons encourage the longest periods of activity, to the most northern parts of Alaska, where their activity peaks only momentarily. Tabanids, which are distributed throughout these diverse environments, offer a highly rich natural variety of over 4,400 species, making it challenging to identify species when beginning to work on native dichotomic identification keys. Usually, this documentation calls for advanced abilities and in-depth understanding of the insects' anatomy (Baldacchino *et al.,* 2014; Wongthangsiri *et al.,* 2019).

Diet and Biting Behavior

While most species' females are blood feeding—that is, they need a blood meal before they can procreate successfully—males and females both feed on nectar. The females bite people and other animals to get blood. The female must locate another host once she has had her blood meal for around six days (Marren and Mabey, 2010). The movement, warmth, and surface texture of a potential host, as well as the carbon dioxide it exhales, appear to draw the flies to it (Horvath, 2008).

Few of the flies are species-specific, although they mostly target big animals, including deer, horses, cattle, and camels. Additionally, they have been seen consuming birds, turtles, lizards, smaller mammals, and even recently deceased creatures. Unlike many biting insects, such as mosquitoes, whose saliva and biting mechanism allow a bite to be overlooked by the host at the moment, tabanid bites are instantaneously irritating the victim, therefore they are often ignored. They may also need to visit many hosts to obtain enough blood. They may transfer infections from one host to another as a result of this activity. Since huge animals like cattle are usually unable to remove the fly, there is little selective benefit for flies to gain a less traumatic bite (Horvath, 2008).

Collection & Preservation

For disease ecology and management, it is crucial to accurately identify tabanid taxa have been involved as vectors of many pathogens (Monti *et al.,* 2007). By means of N-zi traps, tabanids were caught (Mihok *et al.,* 2006; Tunnakundacha *et al.,* 2017). F-traps with 1, 8-octenol were set for 3-5 days close to pastureland, marshy areas, or flowing water locations. (Kuzoe & Schofield, 2005) In tsetse fly trapping process, more tabanids were captured incidentally using NG2G traps attracted with acetone and urine of cow that was less than three weeks old (Mugasa *et al.,* 2018). The insects were then taken to the lab and placed in separate tubes and frozen at -20°C (Wongthangsiri *et al.,* 2019).

Morphological Description

For morphological studies, flies were pinned in entomological boxes and marked with the date and location of collection. A light microscope was then used to examine the flies at X10 and X40 magnification for finer details. Oldroyd's morphological keys from 1952, 1954, and 1957 were utilized. Selected specimens were photographed following morphological identification (Mugasa *et al.,* 2018).

Molecular Characterization of Flies

Currently, morphological clues and literature published are used to identify tabanids (Oldroyd, 1954). Studies of their ecosystem, geographic distribution, and vector-host interactions are restricted by the absence of tangible surveys since 1954. Currently, it is very hard to accurately identify and classify these flies because of the lack of knowledge on their taxonomy (Mugasa *et al.,* 2018). Molecular DNA barcoding techniques are a superior way to get over this obstacle (Ratnasingham & Hebert, 2007).

In varieties of arthropod species, DNA barcoding based on the mitochondrial cytochrome c oxidase subunit 1 (COI) gene sequences can distinguish and it has been used to discover new biodiversity's. Morita *et al.* (2016) used collection of 110 horsefly species and 4 genes set, comprising the mitochondrial COI, to effectively update the phylogenetic framework of the Tabanidae.

Types of species – Description

The morphological and anatomical traits of all three genera of Tabanus—*T. striatus* Fabricius, *T. partitus* (as *T. megalops*), and *T. triceps* Thunberg (as T. tenens)—are quite similar. According to past studies, it might be difficult to identify all Tabanus species, especially *T. partitus* and *T. striatus*, which have the same dorso-abdominal band. The females of *T. striatus* differ from *T. partitus* (based on the animal's large eyes) in lacking the light-colored villi and central stripes on the feathers. The color of the second base plate is discussed in the literature on the problems of striatal chaos and in-depth studies on related animals. It is worth noting that many recent authors have preferred to use the species' name *megalops* instead of *partitus* (Phasuk *et al.,* 2011; Changbunjong *et al.,* 2018). These features are different from female *T. partitus*. In addition, the back and ventral parts of female *T. striatus* are black, while female *T. partitus* is dark brown. In addition, the egg-laying cells of *T. partitus* are distinguished from the egg-laying cells of male *T. striatus* (and females) by having clear cells. The *striatum* is distributed in northern and eastern Thailand, China, Myanmar, Laos, Cambodia, Vietnam, Pakistan, India, Sri Lanka and other places (Grootaert, 2009; Chandra *et al.,* 2015; Changbunjong *et al.,* 2018).

Female Tabanids

The body is dark brownish and ranges in length from 12.5 to 15.5mm. Eye color seems glossy and metallic (red, green). Sub callus has a yellowish appearance. Beards range from white to gray. Two sub lateral longitudinal lines are faint light brown stripes, and the dorsal to thorax is light blackish or gray with one median to the center. The scutellum's rim seems yellow. The ventral portion of the thorax is mostly gray. The tarsi are black, the tibia is yellow to orange, and the femur is grayish. Wings are light-dark and transparent. The abdomen dorsal region is mostly blackish, with a single yellow patch on tergite 1 that is connected to the sublateral band. From tergite 1 until the middle of the abdomen, the sub lateral band emerges. The middle two to three tergites are where one median begins. The abdomen's ventral region appears brown and somewhat black, while the sternite's rim appears yellowish, with the exception of the last sternite, which is blackish (Wongthangsiri *et al.,* 2019).

Etiology - As Disease Vector

A component of the species complex has been implicated in spreading surra, a serious illness that affects horses and cows. Significant financial losses from decreased weight growth, milk output, and reproductive function are caused by Surra; further losses result from the expense of therapy (Phasuk *et al.,* 2011). In fact, tabanids are mechanical carriers of parasites like *Besnoitia besnoiti* and *Trypanosoma evansi*, the surra agent; viruses like bovine leucosis and equine anemia virus, and bacteria like *Bacillus anthracis* and *Anaplasma marginale* (Desquesnes *et al.,* 2013; Baldacchino *et al.,* 2014). Additionally, due to their large mouthparts, tabanids bite during eating, causing discomfort. This distracts the animals from feeding, which lowers growth, milk output, drought tolerance and weight gain, among other benefits. Additionally, animals may be more susceptible to secondary infections at the bite site, which might lower the quality of its hide (Mugasa *et al.,* 2018).

It has been proven that tabanids play a part in the spread of arboviruses like the bovine leukemia virus (Monti et al., 2007). The genus Tabanus has also been implicated in the transfer of bovine leukemia virus from one host to another (Manet *et al*., 1989). Additionally, tabanids of several species, including *Atylotus*, have been reported to mechanically transmit *T. congolense* (Desquesnes & Dia, 2003) and *T. vivax* (Desquesnes & Dia 2004). In fact, the tsetse fly belt in sub-Saharan Africa tabanids is the main cause of *T. vivax*.

Derivation of this injury is twofold, first, the etiology of flies and secondly, the transmission mechanism. It is the very painful bite which goes first and that is why the attention of the victim is attracted. So, the fly may suspend the feed and fly elsewhere or may look for another guest. To complete a meal, a fly must practice more bites, and often on different hosts, a short distance apart. So, that leads to superficial and therefore, mechanical transmission of the pathogen in a way that reminded one of the mechanism of viruses transmitted by stylets by aphids on plants: there is no biological relationship between the pathogen and the carrier, rather the pathogen is acquired by the carrier through accidental contact of the mouthpiece with blood of an infected host and is quickly injected during feeding to the healthy host (Zillikens *et al.,* 2005).

Management and Control

Climatic and ecological changes, national rules on the management of stray dogs and cats, as well as an increase in pet travel and transfer of pet animals, can all have an impact on Europe's current vector-borne illness epidemiology. Rare illnesses may become more common in specific locations, either as a result of an increasing importation of sick animals or when the causative agents and vectors expand to and establish in previously non-endemic areas. Tabanid flies are hard to control. They are often caught using malaise traps, which may be altered by adding attractants and baits like octenol or carbon dioxide. (Kline and French, 1989). They can also be drawn to a black, glossy ball that is strung below them and moves in the breeze. This ball is an essential component of a modified "Manitoba trap," which is most frequently employed to catch and sample Tabanidae (Axtell *et al.,* 1975).

Hematophagous biting insects, such as tabanids, can be controlled using a variety of techniques, such as environmental and zootechnical management, which requires accurate identification of the biting fly species that bother cattle (Baldacchino *et al.,* 2014).

Conclusion

Numerous cattle illnesses are mechanically transmitted by tabanid insects, sometimes referred to as horseflies and deerflies. Many large animal species are greatly irritated by these flies, which are mostly daylight feeders and have severe bites. Although they are not host specific and feed on a variety of animals and people, it's noteworthy to note that tabanids have been shown to choose darker horses due to their affinity to the light-polarizing qualities of their coats. Some diseases and parasites are spread physiologically by tabanids, where the disease agent grows and/or multiplies inside the fly for a while before spreading. Therefore, additional study is needed to fully understand the entire tabanid fly fauna and their environment. To further understand the diversity, frequency, and importance of tabanids in disease transmission, research is needed on topics like climate, diseases that they carry, and the impact of human activities on their distribution. It is challenging to control tabanid flies, and regular use of pesticides and repellents only offers temporary protection (Bradley, 2019).

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