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Stomoxys calcitrans and its importance in livestock: a review

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ABSTRACT

***Stomoxys calcitrans* (Diptera, Muscidae) is an important haematophagus fly which feeds on the blood of their animal hosts, especially livestock and occasionally on humans. Apart from their direct effects on hosts like disturbance, skin lesions, reduced feed intake, stress and blood loss, *S. calcitrans* acts as mechanical vectors of several bacterial, viral and protozoal diseases of livestock as well as intermediate host of the helminth *Habronema microstoma* and may be implicated in the transmission of *Onchocerca* and *Dirofilaria* spp. Being ubiquitous in nature, *S. calcitrans* might have greater economic impact on livestock than previously thought. This review intends to elaborate the direct and indirect effects of *S. calcitrans* with an overview on the pathogens they transmit including controlling measures of the fly based on existing literature available.**

INTRODUCTION

Stomoxys calcitrans (Diptera, Muscidae) commonly called ‘stable fly’ is a filthy fly with worldwide medical and veterinary importance. It is also called ‘biting house fly’ because of similarity in appearance to house fly and sometimes ‘dog fly’ because of its preference for canine hosts (Taylor et al., 2016). Bos (1934) first recognized *S. calcitrans* as insect of veterinary and medical importance. It is ubiquitous in distribution, having been reported from all over the world except the Polar Regions. These flies are considered important pests of livestock especially

Figure 1. Adult stable fly (Melhorn, 2008).

cattle, horse, poultry and hogs. In large numbers, they irritate the animals causing restlessness and leading to a reduction of weight gain and feed conversion efficiency with a decrease of meat production, milk and eggs (Campbell et al., 2001). Tomberlin (2010) reported that infestation of 50 flies per cow on beef cattle can reduce up to 25% weight gain and in dairy cattle decrease in milk production by 40-60%. Similar production losses have been reported by several other workers (Carn, 1996; Campbell et al., 2001; Costard et al., 2009).

Both male and female flies are blood feeders and although the fly does have feeding preferences, it can subsist and prosper on the blood of a wide variety of warm blooded animals including man. Among the domestic animals horses, cattle, pigs, dogs, cats, sheep and goats appear to be most preferred host. In addition to *S. calcitrans* several other stomoxyine flies such as *S. niger*, *S. sitiens* and *S. indicus* also attack domestic animals (Wall and Shearer, 1997). *S. calcitrans* may also be responsible for specific skin lesions like necrotic dermatitis at the dog's ear tips, exudative dermatitis on the legs of horses and in the 'hair whirlpools' on the back of the calves (Yeruham and Braverman, 1995; Baldacchino et al., 2013).

In addition to this, direct nuisance on hosts like annoyance, toxic effects of saliva, blood loss etc. has been shown and indirect nuisance by carrying transmitting various viral, bacterial, protozoal and helminthic pathogens. This review briefly describes the morphology and life cycle of 'stable fly' along with direct and indirect effects on host vis-à-vis common control measures on existing literature available.

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MORPHOLOGY

In shape and size, the stable fly resembles the common house fly. Although both are members of the family Muscidae, stable fly has a slender, rigid, piercing and sucking proboscis projecting forward (Soulsby, 1982). Adults average 8 mm in length, have a grey body and can be identified by four characteristic, longitudinal stripes on the thorax, of which the lateral pairs are narrow and do not meet up to the end of the scutum (Figure 1). The abdomen is shorter and broader than that of the house fly and bears three dark spots on each of the second and third segments. The proboscis of the stable fly is black, long and protrudes from the mouth. The remaining mouth parts are modified with the labellum having rows of minute sharp rasping teeth in order to pierce the skin of the host (Figure 2). The fly displays sexual dimorphism. There is more distance between the compound eyes in females than males. The wing venation is also characteristic. The M_{1+2} vein curves gently forwards and the R_5 cell is open, ending at or behind the apex of the wing. The third stage larvae look like those of *Musca* and have triangular spiracles. Each spiracle bears 3 'S' shaped slits and the spiracles are sit apart than those of *Musca* (Soulsby, 1982; Taylor et al., 2016) .

LIFE CYCLE

The life cycle of *S. calcitrans* is shown in Figure 3. Their eggs are white, elliptical and measure about 1 mm by 0.3 mm and are laid in small clutches (25-50 at a time) with a total of about 800. The eggs bear longitudinal grooves on either side. Ovipositional substrates contain decaying vegetation, excluding dung unless it is

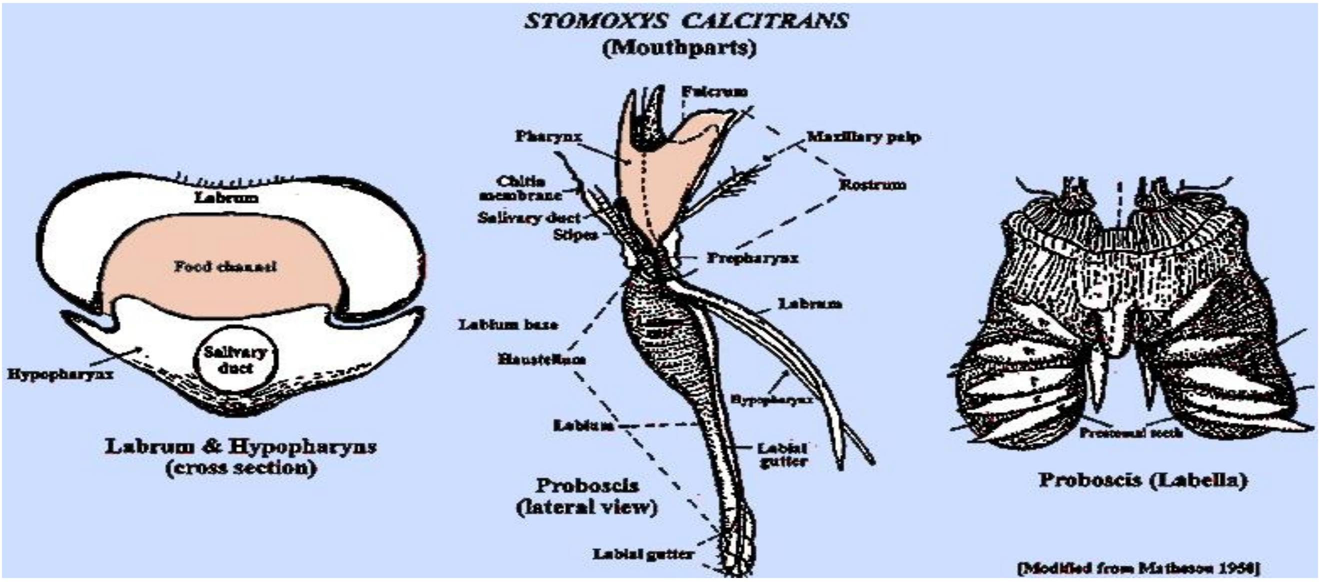

Figure 2. Mouth part of *Stomoxys calcitrans* (Modified from Matheson, 1954).

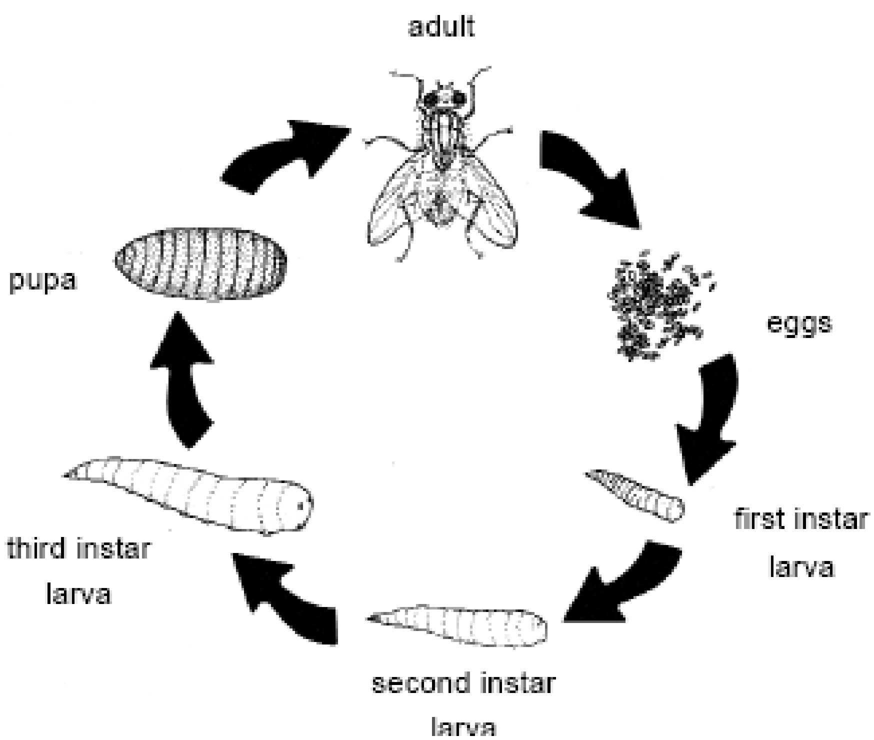

Figure 3. Life cycle of *Stomoxys calcitrans* (University of Maine).

comprised of or mixed with vegetation or dropped onto vegetation (Foil and Hogsette, 1994). The substrate must be moist, and fermentation of the plant matter is particularly conducive for larval development. Examples of substrates in which the pest develops include decaying hay, alfalfa, silage, sugarcane, beached sea grass, lawn cuttings, compost and piles of waste vegetables (Todd, 1964). Depending on the availability of food and moisture the larval development requires 11 to 30 days. The best temperature for development is 25°C, and 35°C proved harmful to larval development (Aguiar-Valgode and Milwared-de-Azevedo, 1992; Gilles et al., 2005a,b). Emergent larvae, or maggots, bury themselves in the oviposition substrate to feed and to prevent desiccation. After 12–26 days (12–13 days at 27°C), third instars enter the drier parts of their habitat and pupate. Most pupae produce an adult in 5–26 days at 21–26°C, and the imago is ready to fly in less than one hour. When fully developed, the outer cuticle hardens to become reddish brown pupa. The pupal stage lasts 6-20 days. Adults begin mating in 3–5 days and females start laying eggs in5–8 days. The whole life cycle may take about 30 days (Foil and Hogsette, 1994; Todd, 1964; Soulsby, 1982; Showler and Osbrink, 2015; Taylor et al., 2016).

DIRECT AND INDIRECT EFFECTS

Annoyances of animals

Normally, stable flies cannot obtain a full blood meal on single attempt because of the defensive movements of the head, ears, skin, legs and tails or hiding behavior. Thus, flies typically cause loss of energy, stress or the reduction of time spent on feeding and the total feed intake. Holloway and Phelps (1991) observed that the flies have a bimodal diurnal feeding pattern identifying the host through carbon di-oxide and octenol. Temperature determines the biting activity. Zumpt (1973) observed greater biting activity at 30°C but the flies showed no attraction to animals at 14°C. It takes about 3 to 4 min for a meal and during that time the flies often changes its position or flies to other animals in order to continue feeding. They prefer a fairly strong light to dark stables or houses and although they are strong fliers, they do not travel long distances.

Blood loss

Schowalter and Klowden (1979) reported that *S. calcitrans* can imbibe an average of 11-15 µl of blood per meal. Although the flies feed throughout the day, highest feeding activity on cattle occurs between 10 am to 4 pm (Hoffman, 1968). In addition to the direct loss of blood from feeding, most amount of blood may come out from the biting site after the mouth parts are removed from the skin. Loss of blood and feeding disturbances may result in a 10-15 percent body weight loss during high population activity. Barre (1981) reported a total loss of 0.5-1 litre of milk per cow per day in highly infested farms while Campbell et al. (2001) observed an average loss of 0.2 Kg body weight in untreated animals compared to insecticide treated ones. Thus direct effects lead to other consequences like immunosuppressive effects on the hosts which are due to a combine effects of stress, energy losses, decrease in food intake and toxic effects of the saliva (Swist et al., 2002). In fact, the direct effects are prone to favour in pathogen transmission and their development (Desquesnes and Dia, 2003).

Indirect effects

Although the stable fly is considered to play the most important role in annoying of animals and human because of their blood feeding habits, the fly has been implicated as vectors of various viral, bacterial, protozoal and helminthic diseases.

Stable fly as mechanical vector

The mode of transmission happens either through contamination of mouth parts or regurgitation of digestive tract contents by the flies. In addition to mouth part contamination, it has been shown that stable flies can regurgitate part of a previous blood meal before taking up another meal (Butler et al., 1977). Several diseases transmitted by stable fly are listed in Table 1.

Stable fly as biological vector

In addition to its role as a mechanical vector of disease agents, stable fly has been reported to act as serve as intermediate host for *Habronema microstoma* (Traversa et al., 2008; Yarmut et al., 2008). The adults of *H. microstoma* are found on the horse stomach mucosa and females of *Habronema* lay embryonated eggs which come out along with faeces. The eggs or larvae in the faecal mass are ingested by the larval stage of *S. calcitrans* within which the larvae reach to third stage. In the adult fly the larvae occur free in the haemocoel and move forward into proboscis (Traversa et al., 2008). The infective fly deposits the L_3 larvae on the lips, nostrils and wounds of the horse when they feed. It is also probable that equine become infected by swallowing flies that fall into water or feed. *S. calcitrans* also acts as intermediate host of the chicken tape worm, *Hymenolepis carioca* (Guberlet, 1919).

CONTROL OF STABLE FLY

A number of methods have been reported for the management of stable fly populations on livestock. These include chemicals, cultural, mechanical, biological, baits and sterile insect technique (Floate et al, 2001; Guglielmone et al., 2004; Kaufman et al. 2005; Mihok and

Table 1. Disease agents associated with *Stomoxys calcitrans* (Baldacchino et al., 2013).

Disease agent	Transmission	References
1. Viruses		
Equine Infectious Anaemia Virus (EIAV)	Mechanical	(Foil et al., 1983)
African Swine Fever Virus (ASFV)	Mechanical	(Mellor et al., 1987)
West Nile Fever Virus (WNFV)	Mechanical	(Doyle et al., 2011)
Rift Valley fever Virus (RVFV)	Mechanical	(Hoch et al., 1985)
Lumpy Skin Disease Virus (LSDV)	Mechanical	(Chihota et al., 2003)
Bovine Herpes Virus (BHV)	Mechanical	(Gibbs, 1973)
Bovine Leukosis Virus (BLV)	Mechanical	(Buxton et al., 1985)
Vesicular Stomatitis Virus (VSV)	Mechanical	(Ferris et al., 1955)
Poliomyelitis Virus	Mechanical	(Anderson and Frost, 1912)
2. Bacteria	`	
Bacillus anthracis	Mechanical	(Schuberg and Boing, 1914)
Pasteurella multocida	Mechanical	(Nieschulz and Kraneveld, 1929)
Erysipelothrix rhusiopathiae	Mechanical	(Wellman, 1950)
Francisella tularensis	Mechanical	(Olsufiev, 1940)
Dermatophilus congolensis		(Richard and Pier, 1966)
3. Rickettsia		
Anaplasma marginale	Mechanical	(Oliveira et al., 2011)
4. Protozoa		
Trypanosoma evansi	Mechanical	(Bouet and Roubaud, 1912)
Trypanosoma equinum	Mechanical	(Lehane, 1991)
Trypanosoma vivax	Mechanical	(Mihok et al., 1995)
Trypanosoma brucei	Mechanical	(Mihok et al., 1995)
Trypanosoma congolense	Mechanical	(Sumba et al., 1998)
Besnoitia besnoiti	Mechanical	(Bigalke, 1968)
Leishmania tropica	Mechanical	(Berbarian, 1938)
5. Helminths		
Dirofilaria repens	Mechanical	(Krinsky, 1976)
Dirofilaria yoemeri	Mechanical	(Krinsky, 1976)
Onchocerca gibsoni	Mechanical	(Krinsky, 1976)

Carlson, 2007; Taylor and Berkebile, 2006).

Chemical control

A number of pesticides and repellants are used for the control of stable fly (Muraleedharan, 2005). However, many of the insecticide are short lived and treatment of large number of animals using pesticides is impractical unless stable fly population is extremely high. Permethrin emulsifiable concentrate (EC) and wettable powder (WP) formulations have been used as contact residuals on unpainted wood in shaded locations (Hogsette et al., 1987). Insecticide impregnated ear tags and ear traps have been found to aid in the reduction of stable fly populations (Greene and Broce, 1985; Hogsette and Ruff, 1986). Unfortunately, overtime stable fly becomes resistant to the pesticides used (Salem et al., 2012).

Cultural control

Cultural control by means of sanitation is the most important method (Greene, 1993). Stacking and burning active rolled hay residues can result in a drastic decrease in adult fly populations. Instead of burning, wet hay residues may be stacked, covered with black polythene and left to compost. Most compatible materials like stale litter may be composted by stacking materials in large piles. Fly development in bedding in calf hutches can be minimized by using materials which tend to remain dry and try improving the drainage system under hutches. Among all the materials tested, saw dust bedding shows the most promising in reducing fly populations (Schmidmann, 1991).

Mechanical control

With the problem of pesticide resistance and concern over the use of synthetic pesticides, renewed interest has been placed on the use of fly traps. Initially considered for the management of fly populations, traps have also been viewed as tools for the elimination of fly. Traps employing electrocution grids are very popular for fly control when combined with ultraviolet and carbon di-oxide as attractants. Several models of solar powered traps which attract both houseflies and stable flies are available commercially (Ose and Hogsette, 2014; Hogsette and Ose, 2017).

Biological control

Biological control of stable flies using natural enemies has been thoroughly investigated. *Spalangia* spp. and other hymenopteran wasps that lay eggs in the pupae of stable flies have been found very potential biological weapon against stable flies (Skovgard and Steenberg, 2002). Although good efficacy has been found in confined poultry operations, results in cattle operations outdoors are disappointing. Another drawback is that although parasitoid wasps offer some measures of control they do not give immediate results. A review of the biology and life history of Macrochelidae with special emphasis on the efficacy of *Macrocheles muscadomesticae* as a biological control indicated that *S. calcitrans* is not as attractive to the mite as *Musca domestica* and seems to lack of nutrients needed by the mite. It has been reported that *M. domestica* could be able to destroy only 3-4 stable fly eggs per day (Axtell, 1967).

Sterile male technique (SMT)

The sterile male technique is an autocidal insect control method. The use of SMT to control insect pests was first used to eradicate the new world screwworm fly (*Cochliomyia hominivorax*) and subsequently used for several other insects including stable fly. Bailey et al. (1973) conducted flight mill studies and release-recapture experiment to evaluate the possibility of using the sterile insect experiment for the control of stable flies.

Integrated pest management (IPM)

Integrated pest management is a pest management system in the manner of utilizing all suitable techniques and methods in as compatible way as possible to maintain pest population at levels below causing unaccepted damage or loss with least reliance on chemical pesticide. The main objective of integrated pest management are to reduce management, lowering environmental pollution and at the same time maintaining ecological balance with minimum disturbance to ecosystem. Anthony (2005) suggested that integrated pest management is the most effective method of control.

CONCLUSION

This review provides background information on the morphology, life history, biology and behaviour, economic importance and control effects of stable fly, *S calcitrans*.
The stable fly has long been known as important pest to the domestic animals. Considering it is almost cosmopolitan in distribution and close association to man, the stable fly has been considered as an increasing serious pest of livestock around animal enclosures, stables, feedlots and paddocks or pastures. Because of its feeding behaviour, the stable fly act as mechanical vectors of various diseases. The fly is the vector of serious livestock diseases including surra (*Trypanosoma evansi*), anthrax (*Bacillus anthracis*) etc. The stable fly can cause substantial losses to livestock especially feedlot cattle and dairy cows especially when it occurs in large numbers. This damage is caused through the combined effects of anaemia, stress, secondary bacterial infections. Different types of control measures have been used against stable flies including insecticides, biological control and management practices. We hope that the information provided in this review will improve on the knowledge of the economic impact and importance of stable fly.

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