Review Article

Flies Menaces in Dairy Farm and Its Strategies for Prevention and Control: An Overview

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Abstract

India being a tropical country faces high fly attack problems during summer season that adversely affect dairy animal health and performance. Fly attacks may compromise animal welfare and cause monetary losses due to distress suffered by the animals results in feeding disruptions and decreased milk production. Although conventional insecticides are used for flies control, but safety alarms and buildup of insecticide resistance indicate the need for alternative control strategies. Thus, to deal with the issue of insecticide resistance, many plant extracts and oils (such as Allium, Azadirachta, Cymbopogon, Eucalyptus, Pogostemon, Mentha, Ricinus) composed of bioactive compound are being exploited that can exert different modes of action and averting resistance. Use of non-host semiochemicals and kairomones baited on the traps are the other control methods that are also effective against the various fly species. Therefore, problems of various fly species can be controlled significantly with the appropriate use of botanical extracts, oils, non-host semiochemicals and kairomones, and thereby improving the overall welfare of dairy animals.

Key words: Control, Dairy Farm, Flies Menaces, Prevention, Strategies

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Introduction

Dramatically decreasing in the pasturelands over the last few decades in India has resulted in increase the use of intensive management systems to maximize efficiency and production. Although these systems have allowed for greater control of certain environmental factors and still there are environmental stressors that remain a challenge for producers (West *et al.*, 2003). Environmental stressors can negatively impact production and animal welfare, especially in situations where animals have no opportunities to avoid the stressors (Shutz *et al.*, 2008). Attack of the pest flies are one of the stressors which has economic and welfare concern in dairy cattle production systems. Nuisance flies are typically most active from May to October in northern regions, and are active year-round in warmer climates. Biting and nuisance flies adversely affect animal health and reduce farm profitability (Kunz *et al.*, 1991; Jones, 2002; Taylor *et al.*, 2012). Fly control is always a hot topic with dairy producers because there are not a lot of viable options to alleviate fly pressure. Dairy producers rely heavily on the use of synthetic chemical pesticide for prevention, control, and management of both vector and pathogen. However, this has proved to be costly and unsustainable in a number of ways (Norval *et al.*, 1992). Therefore, use of flies-repellent plant extracts and their essential oils on the hosts and their integration with other off-host or on host flies control measures (baited fly traps) can be practical and provide economic ways of controlling not only livestock flies and ticks' attacks but also arthropod vectors. A number of studies have shown that plant-based repellents can be comparable to N, N-diethyl-3-methylbenzamide (DEET) or even better (Trongtokit *et al.*, 2004). Therefore, core aim of present review is to discuss the common fly species associated with fly menaces in dairy farms, behavioural response of dairy animals, economic effects of flies on farm animals and use of natural plant based essential oils to prevent flies attack.

Common Flies of Dairy Cattle

There are numerous fly species which are considered to be significant pests of both free-ranging and confined cattle.

Table 1: Common characteristics and feeding areas of the flies on cows

	Horn Fly	Face Fly	Stable Fly	Deer Fly	Horse Fly
Identifying Characteristics	Smaller than house fly; 3/16-inch-long	Darker than house fly	Smaller than house fly	Smaller than horse fly, 0.2 inches long	Largest in size, 0.4 to 1.3 inches long
Preferred Host Material	Fresh cattle waste	Fresh cattle waste	Spoiled or fermenting organic material	Mud or saturated vegetation in marshes or near pond or creek	Mud or saturated vegetation in marshes or near pond or creek
Life Cycle	10-20 days	3 weeks	14-24 days	Late spring into summer	Late spring into summer
Feeding and Resting Area on Animal	Back, sides and poll area of cattle	Eyes, mouth and muzzle	Front legs, sides, back and belly	Back and belly	Back and belly
Meals per Day	20-30 times per fly per day	2-3 times a day and remain 2-5 minutes	Feed only during the day and during feeding only	10-30 times per fly per day for 5 min	
Dangerous (Flies/Head)	200 to 250	12 to 14	5	20 to 30	20 to 30
References	Cortinas and Jones, (2006); Foil and Hogsette, (1994)	Van Geem and Broce, (1985); Cortinas and Jones, (2006);	Cortinas and Jones, (2006); Taylor *et al.*, (2007)	Cortinas and Jones, (2006)	Iranpour and Galloway, (2002); Cortinas and Jones, (2006)

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About 20 families of flies are of veterinary importance which are characterized into blood-sucking or biting flies, such as horn flies (*Haematobia irritans*), stable flies (*Stomoxys calcitrans*), horse flies (*Tabanus sp.)* and deer flies (*Chrysops sp*.) (Cortinas and Jones, 2006), and non-blood sucking flies like face flies (*Musca autumnalis*), house flies (*Musca domestica*) (Kumar *et al.,* 2011), cattle grubs and the larva of heel flies (gadflies) (*Hypoderma lineatum, and Hypoderma bovis*). Common characteristics and feeding areas of the flies on cows are given in the Table 1.

Host-Finding Behaviour and Feeding Habits of Flies

In order to design effective fly control strategy, it is essential to know identification of host by flies. Abundance of pest fly can vary greatly on individual animals, even among cattle within the same herd that are located in close proximity to each other (Birkett *et al.,* 2004). Flies are suspected to use specific cues to identify their potential vertebrate's host, by using combination of visual, thermal and olfactory cues (Birkett *et al.*, 2004; Tangtrakulwanich *et al.*, 2011; Kamut and Jezierski, 2014). They use visual signals for flight orientation and as a long-distance attractant. Several flies such as black, horse, deer and horn flies have more preference towards dark colors like black, blue, purple and pink as compared to white, yellow or green colors (Khan and Kozub, 1985; Horváth *et al.,* 2010; Blaho *et al.*, 2012). Similarly, various dipteran species belonging to the families Tabanidae, Muscidae and Simuliidae found more attractive to darker colors than light colors (Duncan and Vigne, 1979; Khan and Kozub, 1985; Rutberg, 1987; Horvath *et al.,* 2010). Horváth *et al.* (2008, 2010) observed coat colors and found that the difference in attraction is due to their polarizing properties. The different coat colors polarize light at different angles, producing different images to animals and insects that can detect polarized light (Horváth *et al.*, 2008). However, odor appears to play a critical role for shorter distance orientation and for eventual contact and landing (Zhu *et al.*, 2015). Birkett *et al.* (2004) used field and laboratory tests to show that the natural differential attractiveness of dairy heifers to pest flies was partly due to volatile semiochemicals emitted by cattle. Variation in carbon dioxide production was likely to found potent individual cattle fly attraction factor (Torr *et al.*, 2006). Furthermore, various workers have reported that attractiveness of flies also depend upon the sex and breed of the animals (Khan and Kozub 1985, Rutberg 1987, Wollard and Bullock 1987, Braverman 1989, Rubenstein and Hohmann 1989, Hallamaa 2009) i.e. flies are more attracted towards the male animals as compared to females as because of their high testosterone hormone secretion (Newport, 2016).

Behavioural Responses of Dairy Cattle to Pest Flies

Dairy animals have developed numerous types of fly avoidance behaviours which expend valuable energy and disturb the daily routine behaviours including feeding and resting behaviour (Dougherty *et al.*, 1993). The fly avoidance behaviours are explained here after:

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Tail Flicking

Most frequent and common fly avoidance behaviour observed in cattle is tail flicking (Dougherty *et al.*, 1993b). Ralley *et al.* (1993) describe tail flicking as a movement of tail to the animal's side or back which is effective in eliminating flies located on the animal's sides, back, and rear legs.

Skin Twitching

Skin twitching is the second most frequently used avoidance behaviour, which is less energy intensive for fly avoidance activity (Mullens *et al.*, 2006). Blight *et al.* (1990) observed that skin twitching is an involuntary reaction to irritation on the animal's skin. Muscles under the skin of cattle and other quadrupeds known as cutaneous trunci muscles, automatically contract in response to stimulus commonly referred to as the panniculus reflex or cutaneous trunci reflex.

Head Throwing

Head throwing behaviour is more energy intensive and less frequently used act performed by the cattle for fly avoidance (Mullens *et al.*, 2006). During head throwing, animal moves its head with a high energy towards either the side or front legs (Ralley *et al.*, 1993).

Leg Stamping

Leg stamping is a fly associated behaviour which is performed against flies which prefer feeding on the legs i.e. stable flies (Dougherty *et al.*, 1993b, c; Ralley *et al.*, 1993). During this behaviour animal stamp foot on the ground in an order to dislodge biting flies (Dougherty *et al.*, 1993b, c).

Group Bunching

Grouping of several animals together i.e. aggregation behaviour of entire herd in an effort to prevent fly attack (Berry *et al.*, 1983; Wieman *et al.*, 1992; Ralley *et al.*, 1993). Schmidtmann and Valla, 1982; Ralley *et al.*, 1993 reported that the animals in the middle of the bunch are subjected to fewer flies than those more exposed on the exterior of the bunch. Ralley *et al.* (1993) found that cattle performed the bunching behaviour in response to horse flies but did not perform the behaviour in response to stable flies and mosquitoes.

Economic Effects of Fly Harassment

The flies cause damage to livestock either directly as parasites and pests, or indirectly as vectors of disease as given in Table 2. The nature of damage depends on the type of fly's mouth parts like blood sucking flies equipped with a mouthpart that can slash through skin and blood vessels (Cortinas and Jones, 2006) and in response animals bunch together for protection which may cause them to stop feeding. This activity causes weight loss and reduced milk flow, and the huddled animals often injure each other by hooking or kicking

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while they are close together for defense as in case of Stable flies which are aggressive feeders that inflict a painful bite. Stable flies cause significant "fly worry" in cattle, causing them to spend energy in avoidance behaviors such as foot stamping and tail switching (Taylor *et al.*, 2012). Cortinas and Jones, (2006) found that the biting mechanism of stable, horse and deer flies are presumed to be extremely painful as their mouthparts tear through skin and blood vessels for a meal. Anti-thrombosis components from horse and deer fly saliva prevent the wound from rapidly clotting and attract other flies to the site such as house and face flies (Kazimírová *et al.*, 2001; Cortinas and Jones, 2006). Perich *et al.* (1986) observed that heifers exposed to an average of 90 horse flies per day had a 0.1 kg reduction in weight gain per day.

Table 2: Diseases transmitted by flies

Fly	Mechanical Vectors	References
Horn fly	Bovine anaplasmosis, Corynebacterium pseudotuberculosis, mastitis-causing agent, Staphylococcus aureus	(Gillespie *et al.*, 1999); (Spier *et al.*, 2004); (Rodriguez *et al.*, 2009)
Face fly	Moraxella bovis (bovine pink-eye), bovine rhinotracheitis (IBR), nematode eye worm, Thelasia sp.,	(Berkebile *et al.*, 1981); (Glass and Gerhardt, 1984); (Postma *et al.*, 2008)
Stable fly	West Nile Virus, bovine leukosis and anaplasmosis	(Weber *et al.*, 1988);(Scoles *et al.*, 2005); (Doyle *et al.*, 2011)
House fly	Anthrax	(Iqbal *et al.* 2014)
Horse and Deer fly	Bovine leukemia virus, bovine anaplasmosis, Lyme disease, Trypanosomes and helminths	(Hawkins *et al.*, 1982);(Magnarelli *et al.*, 1986); (Foil, 1989);(Iranpour and Galloway, 2002)

Similarly, Altunsoy and Kilic (2012) reported weight gains in cattle may be reduced by 0.1 kg per day when the animal attacked daily by approximately 66 individuals of blood-sucking tabanids insects. Various worker further estimated that attacks by dipteran flies can reduce cattle weight gains by up to 18% per year during fly season (Steelman *et al.*, 1993; Dougherty *et al.*, 1993; Sykes, 1994). This reduced feed intake and increased stress or cortisol level further reducing milk production by 20 to 30 percent (Steelman *et al.*, 1991; Byford *et al.*, 1992; Jonsson and Mayer, 1999; Khan *et al.*, 2000; Malik *et al.*, 2007). Similarly, Gerry *et al.* (2007) reported decrease in milk production by cows of up to 1.49 kg per day when attacked by stable flies. Decreased milk production in lactating females has negative consequences for offspring development (Sykes 1994; Mullens *et al.*, 2006; Gerry *et al.*, 2007; Taylor *et al.*, 2012). The indirect damage caused by flies may be due to various livestock disease caused by vectors in two ways, *viz.* through contact and biologically. In the mechanical way flies spread disease-producing organism through contact i.e. some horse and stable flies transmit Trypanosomiasis and Anthrax mechanically from the diseased to healthy animals while feeding on their blood (Weber *et al.*, 1988; Iranpour and Galloway, 2002; Scoles *et al.*, 2005; Doyle *et al.*, 2011). However, in case of biological way, flies transmit the causative organisms that develop or multiply itself inside the fly vector to infect the animals (Foil, 1989; Iranpour and Galloway, 2002).

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Ananda *et al.* (2009) reported that ticks and tick-borne diseases (TTBDs) are the major constraints on profitable livestock production and productivity worldwide, as these may cause death, decreased productivity, lowered working efficiency (Uilenberg, 1995), and increased cost for control measures (Makala *et al.*, 2003). According to the FAO, (2004) around 80% of the world's cattle population is exposed to tick infestation and has estimated the impact of 7.3 US $/head/ year. Earlier various workers had reviewed monetary losses occurred due to TTBD as shown in Table 3 and Narladkar (2018) estimated approximate projected economic losses by citing the examples of five states in Tables 4.

Table 3: Losses due to TTBD reviewed from the literature

Disease transmitted by	Losses	References	Losses as on today in October 2017 $	Losses in October 2017* (1US$= ₹65.07 on (18.10.2017)
In India tropical theileriosis	Annual loss US$ 800 million	Devendra, (1995)	US$1295 million	₹ 8426.7 crore
A recent estimate calculated the costs of control of TTBDs affecting Indian livestock	498.7 million US $ per annum	Minjauw and McLeod, (2003)	US$668.96 million	₹ 4353.0 crore
Total losses due to surra per animal in ND cow, CB cow, and buffalo	ND: ₹ 3, 328.18, CB: ₹ 6, 193 and buffalo: 9,872.33	Singh *et al.*, 2014	ND: ₹183.86 crore CB: ₹ 713.5 crore buffaloes: □11.21 crore	ND: ₹ 183.86 crore, CB: ₹ 713.5 crore, buffaloes: □ 311.21 crore
India suffers losses due to babesiosis in livestock	57.2 million US dollars annually	McLeod and Kristjanson, (1999)	US$ 84.74	₹ 551.54 crore
In India alone, TTBD's have been implicated to cause projected loss	$500 million annually	Ghosh *et al.*, 2007	US$ 595.20	₹ 3873.06 crore
As per the 1997 estimates, the global production loss caused by TTBDs	13.9–18.7 billion US $ annually	Castro, (1997)	21.38–28.76 billion US $ annually	

Table 4: Projected economic losses due to theileriosis in CB cattle in five states of India (Narladkar, 2018)

State	Reference	% Prevalence	Total Crossbred population	Affected population	Loss of milk per litre	Rate of milk /liter @ ₹ 38	Total loss of milk	Total loss in ₹ in crore	Loss per animal in ₹
Gujarat	Vahora *et al.*, 2012	37	1734161	641639	127	38	81488143	309.65	1785.62
Karnataka	Muraleedharan *et al.*, 1994	17.7	2707335	479198	127	38	60858182	231.26	854.2
Kerala	Nair *et al.*, 2011	16	1115375	178460	127	38	22664420	86.12	772.16
Tamil Nadu	Velusamy *et al.*, 2014	13	5467646	710794	127	38	90270838	343.02	627.38
Uttarakhand	Kohli *et al.*, 2014	45.4	416977	189307	127	38	24042058	91.35	2191

Control and Management of Pest Flies

Synthetic insecticides formulated as dusts, sprays, pour-on, feed additives, and insecticide impregnated ear tag were mostly used and relievable management tool against pest flies over the last five decades (Butler

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and Okine, 1999). Concerns over growing insect resistance to conventional treatments because of the over-reliance on insecticides of the same or similar mode of action, environmental and health impacts, (Hogsette *et al.,* 1991; Foil and Hogsette, 1994; Foil *et al.,* 2010; Pitzer *et al.,* 2010) and a lack of new active compounds for insecticides have also created a need for new and unique strategies for pest management (Wall, 2012). Recently, people are focusing towards the organic dairy production and there are no registered pesticides available to use, leaving organic herds particularly vulnerable to high pest fly levels. Therefore, use of organic pesticide (essential oils) (Hieu *et al.,* 2010; Geden, 2012) and mechanical fly repellents (Denning *et al.,* 2014) as an alternative way for natural and effective control of fly's menaces are getting attention with encouraging results.

Insecticidal Plants and their Essential Oil

Natural plant extracts and essential oils are volatile substances found in a wide variety aromatic plants species and have been used as fragrances and flavors and their terpenoid compounds are natural insecticides (Isman, 2006). Plant extracts are obtained using a variety of solvents and techniques, these plants extract have various bioactive compounds such as: nitrogen compounds (e.g., alkaloids), terpenoids, phenolics, proteinase inhibitors, and growth regulators which have pest repelling activity (Tiwari *et al.,* 2011). Various researcher studied the bioassays using exposed human hand and dairy cattle to house flies, stable flies and horn flies where they found that combination of mixtures of essential oils effectively repelled flies (Hieu *et al.,* 2010; Baldacchino *et al.,* 2013; Zhu *et al.,* 2012). Table 5 summarizes some studies dealing with the use of various plant oils or components against various flies.

Essential Oils and Other Bioactive Aspects of Plants are Described here-

Garlic

Allium sativum L. is a widely grown crop that has been reported to have insecticidal and repellent properties against some pests (Showler *et al.,* 2010; 2011). Asmaa *et al.* (2016) studied the effect of combined treatment of garlic-based formula, pour on animal and organic spray around their environment and found significant reduction in the fly count (42.6 and 47.9%, respectively) when sprayed once a week. Similarly, Massariol *et al.* (2011) reported that when cattle were fed garlic at 100 g/cow for 3 d, no repellent or toxic effects observed against horn flies and stable flies.

Neem

Azadirachta indica A. Juss, famously known as Neem, native to the Indian subcontinent (Khater, 2012). Neem contain the active compound azadirachtin, a nortriterpenoid (a type of limonoid), that acts by disturbing endocrine activity, the down regulation of hemolymph ecdysteroid levels that block release of prothoracicotropic hormone or delay ecdysteroid production, an action which inhibits molting and

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malformation result in mortality in insects (Kraus *et al.,* 1985; Khater , 2012). It has been reported that neem and its bioactive compound has antifeedant and deterrent effects against some herbivorous insects (Redfern *et al.,* 1981; Rice *et al.,* 1985; Showler *et al.,* 2004; Greenberg *et al.,* 2005). Although neem has various other bioactive compounds include salannin, salannol, salannolacetate, nimbinen, gedunin, dirachtin, nimbolide, and viselinin derivatives (Jones *et al.,* 1989; Walter, 1999). Neem has been applied against pests as extracts, oil, cakes, and leaves (Schmutterer ,1988, 1990; Showler *et al.,* 2004).

Table 5: Plant essential oils that shown repellency to flies

Scientific Name	Common Name	Insect	Result	References
Acorus calamus L.	Calamus	House fly	80.95% (2h), 82.92% (5h)	(Singh and Singh, 1991)
Ageratum sp.	Whiteweed	House fly	67.44% (2h), 56.10% (5h)	(Singh and Singh, 1991)
Cyprus scariosus R. Br.	Cypriol	House fly	83.33% (2h), 68.29% (5h)	(Singh and Singh, 1991)
Cymbopogon flexuosus	Lemongrass	House fly	33.33%(2h), 33.33% (5h)	(Singh and Singh, 1991)
Cinnamomum tamala	Indian bay leaf	House fly	88.10% (2h), 87.81% (5h)	(Singh and Singh 1991)
Cinnamomum Verum	Oil of cinnamon	Larva	LC50: 159 ppm R (%) b: 77.9; OD(%)c: 60.0; Contact (larva)	(Morey and Khandagle, 2012)
		Adult of stable flies	Repellency Oviposition deterrent	
Nepeta cataria	Catnip	House fly	Significant repellent activity at 20 and 2mg	(Zhu *et al.*, 2009)
Nepeta cataria	Catnip	Stable fly	Significant repellent activity at 20 mg	Zhu *et al.*, 2009
Eucalyptus globulus	Blue gum	House fly	PR[1]: 11.250%	Elbermawy *et al.*, 2011)
Eugenia coryophyllus	Clove (leaf)	House fly	80.68% (24h)	(Chintalchere *et al.*, 2013)
Ocimum basilicum L.	Basil	Horn fly	Significant repellentv activity during 24 hours	(Lachance and Grange, 2014)
Eugenia caryophyllata Thunberg	Clove (bud)	Stable fly	PT[2]: 3.50 hours (0.5 mg/cm2) PT2: 1.20 hours (0.25 mg/cm2)	Hieu *et al.*, 2010)
Eugenia caryophyllata Thunberg	Clove (leaf)	Stable fly	PT[2]: 3.25 hours (0.5 mg/cm2) PT2: 1.17 hours (0.25 mg/cm2)	(Hieu *et al.*, 2010)
Santalum album L.	Sandalwood	Stable fly	PT[2]: 0.27 hours (0.5 mg/cm2)	(Hieu *et al.*, 2010)
Cymbopogon nardus (L.) Rendle	Citronella	Stable fly	PT[2]: 0.26 hours (0.5mg/cm2)	(Hieu *et al.*, 2010)
Rosmarinus officinalis L.	Rosemary	Stable fly	PT[2]: 0.21 hours (0.5 mg/cm2)	(Hieu *et al.*, 2010)
Eucalyptus globules Labillardie´ re	Eucalyptus	Stable fly	PT[2]: 0.13 hours (0.5 mg/cm2)	(Hieu *et al.*, 2010)
Mentha piperita	Peppermint	House fly	Significantly repelled flies for 6- and 3-days posttreatments	(Khater *et al.,2009)*
Mentha piperita	*Oil of peppermint*	House and stable flies	Number of flies on one side of pastured cows: 9.3	(Lachance and Grange, 2014)
Allium cepa	Onion	House fly	Significantly repelled flies for 6- and 3-days posttreatments	(Khater *et al.,2009)*

1. Percentage of Repellency= [(Nc-Nt)/(Nc+Nt)]100

2. Protection Time

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Lemongrass

Cymbopogon citratus, is an aromatic, evergreen, clump-forming, perennial grass native to tropical Asia, but it is also grown in many temperate and tropical areas of the world (Kazembe and Chauruka, 2012). Lemongrass extract contain the monoterpene citral bioactive agent which have insecticidal activity. The essential oil of the lemongrass leaf is primarily composed of citral a and b (78%) and myrcene and limonene (10%); (Paranagama *et al.*, 2002), but the acyclic monoterpenoid components citronella and citronellal have repellent properties against some insects (Bartlett, 1985). Milian (2009) observed the effect of lemongrass extract (ethanol) applied topically on the cattle in a 1:125 aqueous dilution and found that 100% repellency for 30 min, 95% for 12 h, 98% for 24 h, 97% for 48 h, 98% for 5 d, 95% for 10 d, and 69% for up to 15 d post treatment. Barnard (2000) observed the effect of citronella, a constituent of lemongrass against the stable flies and reported that repellency property of the lemongrass was as effect as N, N-diethyl-metatoluamide (DEET). Similarly, Essential oil of lemongrass at 5% each in sunflower oil repelled horn flies from treated areas on pastured and barn-held cows for>6 and 8 h, respectively (Lachance and Grange, 2014).

Eucalyptus

Eucalyptus, large genus (with>600 described species) mostly very large trees, of the myrtle family (*Myrtaceae*), native to Australia, Tasmania, and nearby island and now eucalyptus trees are extensively grown in tropical, subtropical, and temperate regions worldwide (Moura *et al.*, 2012). Juan *et al.* (2011). Eucalyptus oil contains various active ingredients including 1,8-cineole, a-pinene, a-terpineol, 4-terpineol, and p-cymene that are toxic to various flies. Essential oil of *E. polybractea* had the highest knockdown activity of 50% at 3.4 min in an enclosed chamber, and a significant correlation was detected between the content of 1,8-cineole in the Eucalyptus species and toxicity to horn flies (Juan *et al.*, 2011).

Pogostemon

Patchouli, *Pogostemon cablin (Blanco) Benth (Lamiaceae)*, is a bushy herb native to tropical Asia with more widespread cultivation. A dosage of 0.5 mg/cm2 provided 3.67 h of protection from stable flies when treated human hands were used as a biting substrate, but DEET gave 4.47 h of protection (Hieu *et al.*, 2010). When tamanu nut oil (with a protection time of 0.56 h) was added to patchouli oil, protection increased to match that of DEET (Hieu *et al.*, 2010).

Castorbean

Castorbean, is a *Euphorbiaceae* family plant, *Ricinus communis L.* is native to Africa and parts of southern Asia, but it has spread into many tropical and temperate areas of both the Western and Eastern hemispheres (Rana *et al.*, 2012). Castorbean contains ricin which is notably toxic and (Wedin *et al.*, 1986), castor oil

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used at a rate of 473 ml on camels had no effect against stable flies, but 1,892 ml per camel prevented stable flies from landing on and biting camels for 3 d (Cross, 1917).

Cinnamomum, Mentha, Matricaria and Allium

Cinnamomum camphora (Lauraceae) is native to China, Taiwan, and Japan, and it is grown commercially for its essential oil (Frizzo *et al.*, 2000). Khater *et al.* (2009) observed the effect of camphor oil on water buffaloes when applied at 1.4 ml/kg body weight to the backline and found that stable flies were repelled for 6 d. Similarly, dosages of 3.6 ml/kg body weight of peppermint, *Mentha piperita* (Ehrh.) Briq. (Lamiaceae); 3.4 ml/kg body weight of chamomile, *Matricaria chamomilla* (L.) Rydb. (Asteraceae); and 2.9 ml/kg body weight of onion, *Allium cepa* L. (Amaryllidaceae), each repelled stable flies for 6 d (Khater *et al.*, 2009). Lachance and Grange (2014) applied the essential oil of peppermint at 5% mixed with sunflower oil on pastured and barn-held cows and observed that horn flies were repelled from the treated areas for more than 6 to 8 h, respectively.

Sawdust

Schmidtmann (1991) observed that sawdust of the pine reduces larval stable fly population by 46-91 % when used as the livestock bedding material. Pine sawdust might be useful for managing stable fly populations on dairies, but further testing to assess pine species, grades, and quantities of sawdust is needed to ascertain the best for achieving moderate- to long-term repellency.

Non-Host Odor and Semiochemicals

It is a novel approach for the control of flies using host-oriented behavior of disease vectors (mosquitoes, ticks and tsetse flies) which not only dependent on kairomones from preferred vertebrate hosts but also avoid unsuitable or un-preferred animals by means of distinct chemical odors (Fernandez *et al.,* 2015). Various workers analyzed by combined gas chromatography and electroantennographic detection (GC-EAD) analysis that straight chain carboxylic acids, ketones, phenols and a lactone, δ- talactone etc. are effective non-host repellent compounds which can be used in control of flies (Gikonyo *et al.,* 2000; Saini *et al.*, 2014; Bett *et al.,* 2015). Flies use semiochemical to recognize host location and these can also be used as non-host order to repel the pest flies (Hall *et al.*, 1984; Hassanali *et al.*, 1986; Bursell *et al.*, 1988; Gikonyo *et al.*, 2002). Traps baited with semiochemical (1-octen-3-ol) a component of ruminant breath, were reported to increase catches of *Stomoxys spp.* (Holloway & Phelps, 1991; Mihok *et al.,* 1995). Hall *et al.*, 1984 reported that 1-Octen-3-ol, a known element of ruminant breath, is an attractant for tsetse flies. Similarly, Hassanali *et al.* (1986) and Bursell *et al.* (1988) found that some semiochemicals such as phenol, m-cresol and p-cresol are released from cattle urine through microbial degradation, and also influence tsetse fly behaviour. Mixtures including some of these chemicals, when released in a specific ratio, have been

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used successfully in the field to trap tsetse fly populations (Vale *et al.*, 1986, 1988; Torr *et al.*, 1995). Zhu *et al.* (2015) developed a less expensive and more efficacious trap based upon a white panel with the option to add visual and olfactory stimuli (Baited with phenol, *m*-cresol or *p*-cresol) for enhanced stable fly trapping and found that white panel traps caught twice as many stable flies than Alsynite traps. Baiting the traps with synthetic manure volatiles increased catches 2–3-fold.

Other Natural Remedies to Keep Flies Away from Cattle

Home-made Herbal Mixture

We can create an effective herbal mixture and tie it on the cows to keep the flies away (Ingredients needed – RAW turmeric, neem oil, vacha root (*vayampe*), charcoal – coconut shell is preferred). Grind all the above into a mixture, add neem oil and make a paste. Then roll it in a coconut leaf ball or some other porous material and tie it on your cows. Small variety of vacha (*vayampe*) should be preferred and not the bigger variety which is commercially available in ayurvedic stores nowadays. If vacha is in dried form, soak it in water before grinding. This mixture is very effective in keeping flies away for more than a month (Natural farmer 2013).

Soothika Marun enna

The oil left after preparing the soothika marun (medicine) can be stored for a few years and can be liberally applied on any fly bite areas. It is also very effective in keeping flies away. It is also good for worm or bacteria bites normally caused during monsoon (soothika marun is a special medicine given to lactating mothers – similar to chavanprayash, very effective for lactating mothers, it is extremely effective for back pain and other issues related to women health post pregnancy and overall health) (Natural farmer 2013).

Conclusion

Fly infestation can have detrimental effects on welfare and behaviour, daily activity, health and productivity of dairy animals by causing chronic irritation and pain through biting. Animals use various behaviour strategies e.g. individual (tail swishing, head shaking, leg lifting) and social protective behavior (form larger groups or temporary aggregations) to protect themselves against insects attacks. From this study it may be concluded that use of plant extract and their essential oils are the effective fly control measures which can be used either single or in combination with other preventing measures.

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