CONTROL OF AGGREGATED POPULATIONS OF THE EYE FLY *SIPHUNCULINA FUNICOLA* (DIPTERA: CHLOROPIDAE) USING PYRETHROID AEROSOLS

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Abstract. Three commercially available insecticide aerosol compositions containing cyphenothrin, imiprothrin, cypermethrin, d-tetramethrin and permethrin, in various combinations and concentrations were evaluated for control of the oriental eye flies *Siphunculina funicola* (de Meijere) from their aggregation substrates in two villages in the Chon Buri Province, Thailand. Each aerosol produced almost complete kill of eye flies on most of the treated substrates. Time to reoccupation of each treated substrate was determined at 24, 48 and 72 hours post-treatment. All 3 aerosol preparations killed eye flies on most of the treated substrates and kept most of the substrates free of eye flies for at least 48-72 hours. The effectiveness and longevity of the aerosols varied depending on the type and location of the substrate. Smooth, hairy and polished substrates did not intercept sufficient insecticide; therefore providing low residual activity compared to porous and coated surfaces. Aerosols applied to substrates located at higher levels gave good initial kill, but reoccupation of these substrates by flies occurred relatively quickly (within 24-48 hours) following treatment. Attempts should be made to discharge aerosol flumes closer than 1m from the aggregation substrates.

INTRODUCTION

The oriental eye fly, *Siphunculina funicola* (de Meijere) is a small, dark-colored dipteran (1.5-1.6 mm) in the family Chloropidae. This eye fly species is commonly attracted to humans and animals, feeding on lachrymal and other secretions of body as well as moist surfaces of its hosts (Ayyar, 1917; Syddiq, 1938; Hamilton, 1939). The flies are extremely annoying to human and domestic animal hosts and may serve as potential vectors of various bacterial pathogens to vertebrate hosts (Graham-Smith, 1930; Syddiq, 1938; Greenberg, 1973; Mulla and Chansang, 2007). Adults are typically very active on hot, sunny days, becoming less active when air temperatures become cool and during cloudy conditions (Roy, 1928; Mulla and Chansang, 2007). Large aggregations of adult flies were reported on hanging strings, cords, on cobwebs, and many other items (Syddiq, 1938; Mulla and Chansang, 2007). They commonly rested on thatched roofs, strips of cane and in grass on sunny mornings (Roy, 1928). Very little is known about this important pest and potential disease vector in Thailand. Our current series of studies began in 2006 in Thailand to better understand the behavior and to develop possible management tactics of this fly species (Mulla and Chansang, 2007).

In 2006-2007, we carried out detailed studies on several biological and behavioral

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parameters of this fly in central Thailand. The studies focused on the abundance, host-seeking and aggregation behaviors in open agricultural fields and villages (Mulla and Chansang, 2007). We noted that *S. funicola* prevailed as dispersed populations in open agricultural fields, villages and country club resorts, and a substantial numbers were seen to aggregate on a variety of substrates inside and nearby houses, shelters, decks, etc in villages. These behavioral observations were made for the first time in Thailand (Mulla and Chansang, 2007). We suspected that aggregated populations in and near human habitations may be vulnerable targets for applying control measures in infested areas.

To test this hypothesis, we carried out a series of tests on aggregated populations of eye flies on various common domestic and peridomestic substrates in 2 villages in Chon Buri Province, Thailand in April 2007, a time when eye fly populations reach high densities in the infested areas. Using the procedures we developed in our previous studies (Chansang and Mulla, 2008 submitted), we assessed 3 pyrethroid insecticide formulations applied as aerosols against the eye fly aggregations on various substrates and refined the test procedures further for aerosol testing.

MATERIALS AND METHODS

Study sites

In April 2007, surveys on eye fly populations and their aggregation sites were carried out in 2 villages, Ban Mab Jaroen and Ban Kai Nao, located in Bang Lamung District, Chon Buri Province, Thailand. Following observations on suitable aggregation sites of eye flies, various substrates were selected for insecticide treatment.

Insecticides

The following three commercially available aerosol insecticide products were used to control eye flies by targeting aggregation substrates: ARS RED® (ARS Chemical Co, Pathumthani, Thailand), 0.17% cyphenothrin and 0.04% imiprothrin; Kincho Orange® (Cyberpact Co, Chachoengsao, Thailand); 0.20 % d-tetramethrin and 0.14% permethrin. Mortein Shieldtox® (Beckit Benckiser Co, Bangkok, Thailand), 0.03% imiprothrin and 0.15% cypermethrin.

Assessment procedures

We employed and improved the procedures developed by us for evaluation of insecticide aerosols (Chansang and Mulla, 2008, submitted). Before applying aerosols, the numbers of aggregated flies on selected substrates were carefully estimated. Aggregation areas were then treated with a plume of insecticide aerosol directed at the target from an average distance of 50-100 cm for approximately 3-5 seconds depending on the size and area of the substrates (Fig 1F). Estimation of the numbers of flies reoccupying substrates were made at set time intervals post-treatment by an experienced technician. Environmental conditions from the beginning to end of the tests (*eg*, precipitation, wind speed and ambient air temperature) were noted. Observations were conducted for a minimum of 72 hours post-spray. Individual test substrates were not test replicated as we noted earlier (Mulla and Chansang, 2007) that the eye flies had heterogeneous temporal and spatial distributional patterns.

RESULTS

Four test blocks were carried out using selected aerosol pyrethroid compositions as presented in Tables 1-4. Ambient air temperature measurements were made during each 24 hour observation interval and the temperatures were high (30-35ºC) and relatively stable. All tests occurred during periods of no rain and calm weather conditions. Some examples of aggregation substrates and treatment method are shown in Fig 1 (A-F).

Table 1
Control of *S. funicola* and reoccupation on various aggregation substrates in the village Ban Kai Nao using ARS RED aerosol (cyphenothrin 0.17%, imiprothrin 0.04%).

Aggregation substrate (length)	Estimated fly number pre- and post-treatment			
	Pre-treatment (30ºC)	24 hr post (31ºC)	48 hr post (33ºC)	72 hr post (34ºC)
Electric cord (5 m)	>30,000	0	0	0
Electric cord (20 cm)[a]	2,000	20	2,000	500
Rope (15 cm)	700	0	0	0
Sack strand (8 cm)	113	10	0	0
Sack strand (12 cm)	1,800	600	0	0
Sack strand (10 cm)	500	0	0	0

[a]Too distant from ground level, aerosol did not contact cord completely.

Table 2
Elimination and reappearance *S. funicola* by treating various aggregation substrates in the village Ban Mab Jaroen with Mortein Shieldtox aerosol (imiprothrin 0.03 %, cypermethrin 0.15%).

Aggregation substrate	Treated	Estimated fly numbers pre- and post-treatment			
		Pre-treatment (33ºC)	24 hr post (34ºC)	48 hr post (34ºC)	72 hr post (35ºC)
Bamboo stick-horizontal	Yes	1,500	5	3	1
Cobweb-vertical	Yes	500	0	0	0
Shoe lace, coat hanger, and rusty wire	Yes	5,000	0	6	20
	Mean	2,333	2	3	7
Rusty wire-coil	Control	250	500	15	0
Rope-hanging	Control	100	200	11	60
Rusty wire-horizontal	Control	1,000	1,000	1,000	1,500
Coat hanger	Control	1,200	120	300	800
	Mean	637	455	332	590

Test 1: In Ban Kai Nao Village, 6 aggregation sites were treated with the ARS RED, without matching control sites. On all 6 substrates, eye flies were almost completely eliminated for 72 hours or longer (Table 1). One substrate electrical cord was too distant (50+ cm) from the aerosol to yield good coverage. Relatively large numbers of eye flies reoccupied this substrate between 24-72 hours post-spray. The remaining 5 sites were almost completely devoid of flies for 72 hours (Table 1).

Test 2: In Ban Mab Jaroen Village, sites (3) were randomly selected for treatment with Mortein Shieldtox aerosol and matching sites (4) were left untreated as controls. Eye flies were almost completely eliminated from the 3 treated sites by the aerosol application, and remained free of flies for 72 hours or longer (Table 2). During the observation intervals, control sites witnessed some fluctuation in eye fly populations but remained occupied for the entire 72 hour period (mean number 331 to 637 flies per substrate).

Test 3: Kincho Orange was applied in Ban

Table 3
Elimination and reappearance of *S. funicola* by treating various aggregation substrates with Kincho Orange aerosol (d-tetramethrin 0.20%, permethrin 0.14%) in and around the Community Hall in the village Ban Mab Jaroen.

Aggregation substrate	Treated	Estimated fly number pre- and post-treatment: Pre-treatment (35ºC)	24 hr post (32ºC)	48 hr post (33ºC)
Plastic rope and bird nest strands	Yes	3,000	50	0
Rope, heavy and thin	Yes	12,000	3	0(500)[a]
	Mean	7,500	27	0
Plastic rope	Control	1,500	100	500
Plastic rope and bird nest strands	Control	2,000	700	550
Plastic rope	Control	1,500	400	20
	Mean	1,667	400	357

[a]Intact rope with no resting flies post 48 hours, while thin, hairy strands at the end of the rope had about 500 eye flies.

Table 4
Estimation and reappearance of eye flies *S. funicola* by treating various aggregation substrates in Ban Kai nao with the insecticidal aerosol Mortein Shieldtox and ARS RED, respectively.

Aggregation substrate	Aerosol	Estimated fly number pre- and post-treatment: Pre-treatment (30ºC)	24 hr post (30ºC)	48 hr post (32ºC)
Antenna- parked vehicle	Mortein Shieldtox	4,000	4,300	3,000
Side mirror- parked vehicle	ARS RED	2,000	1,800	2,500
Thatch roof on deck	Mortein Shieldtox	1,500	200	200
Sheaths/thatch roof	ARS RED	10,000	200	200

Mab Jaroen Village, with 2 aggregation substrates serving as treated and 3 sites as untreated controls, all with high populations of eye flies prior to treatment. Eye flies were almost completely eliminated after treatment and remained nearly free of flies for longer than 48 hours (Table 3). One heavily infested site (rope) completely eliminated flies on the heavy, intact central core section, whereas flies reappeared on the distal ends of unraveled strands 24 hour post-treatment (Table 3). It appears that substrates with less surface area may not receive sufficient deposits of the insecticide to provide temporary residual control. Notwithstanding this fact, the elimination of 12,000 flies and the reappearance of 500 speaks for the efficacy of this treatment.

Test 4: Four types of aggregation substrates were treated in Ban Kai Nao Village. A metal radio antenna and support arm of an automobile side view mirror were found heavily infested with eye flies. These two substrates were treated with Mortein Shieldtox and ARS RED, respectively. After treatment practically all resting flies were either killed or rapidly dispersed; however, both metal objects were reoccupied by flies 24 to 48 hours after treatment (Table 4). Metal objects with smooth and

(A) Rusty wire

(B) Nylon rope and electric wire

(C) Metal arm of side view mirror of a Jeep

(D) Cob web

(E) Sheath of a thatch roof with eye flies

(F) Thatch roof

Fig 1–Examples of aggregation sites for *S. funicola* in Chon Buri Province, Thailand, that were included in the tests. (A) A rusty wire in an open shed; (B) A nylon rope and electrical line hanging from a house ceiling; (C) A metal support arm of a side view mirror of an automobile; (D) An abandoned spider webbing hanging from roof beams; (E) A sheath of thatch roof; (F) Insecticide aerosol being applied to the underside of a thatch roof infested with resting eye flies.

polished surfaces appear not to retain sufficient residual insecticide to prevent rapid resettlement compared to most other substrates under test. Mortein Shieldtox was applied to thin sections (1-2 mm) of suspended thatch roofing (Fig 1F) heavily infested with eye flies (Fig 1E). This treatment yielded immediate control of eye flies, an overall reduction from 1,500 pre-treatment to less than 200 flies (Table 4). Palm fronds or split sheaths on the underside of a thatch roof were treated with ARS RED aerosol. This treatment also produced a marked reduction in flies during the 48 hour assessment (Table 4). The number of flies was drastically reduced from the pre-treatment levels of 10,000 to 200 flies, 24 and 48 hour post-treatment.

DISCUSSION

From these studies it can be suggested that commercially available aerosol applications of pyrethroid insecticides can either kill rapidly. or disperse virtually all eye flies from common outdoor aggregation substrates. That re-infestation was prevented for 72 hours or longer on most substrates was noteworthy as small droplet aerosols are primarily designed to kill or facilitate rapid knockdown of flying insects rather than provide any measurable residual activity. However, aggregation substrates consisting of smooth-polished metal did not appear to retain enough impinged residues to prevent rapid re-colonization. We also noted that very thin, non-rigid substrates (< 0.5-1.0 mm thick) do not appear to intercept enough insecticide to provide sufficient residual activity to continue to repel flies up to 72 hours.

It was noted that a local practice to control this common nuisance fly in villages employed the use of high heat or burning of substrates used as aggregation sites. This procedure is an inherently dangerous one that increases the risk of fire to structures. The periodic use of a small amount of aerosolized insecticide provides a much safer alternative for controlling eye flies in and around domestic and peridomestic aggregation substrates. All 3 aerosol products composed of low concentrations of pyrethroids were found to be equally effective for at least up to 48-72 hours post-treatment.

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