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Stable Fly (Diptera: Muscidae) Distribution in Thailand

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ABSTRACT

Diurnal sampling of stable flies (*Stomoxys* spp.) was carried out in ten localities throughout Thailand in 2007. Vavoua traps were used to lure and capture flies in ten provinces of the country, representing four major ecological settings: six small local dairy farms; two large industrial dairy farms; one national park; and one wildlife conservation area. Six species of stable flies were identified: *Stomoxys calcitrans* (91.5%), *S. bengalensis* (4.7%), *S. uruma* (2%), *S. indicus* (1%), *S. sitiens* (0.6%) and *S. pullus* (0.2%). The number of stable flies collected differed significantly among different collection sites, with greater numbers from dairy farms ($\chi^2 = 360.15$, df = 3, $P< 0.05$).
Key words: stable flies, distribution, Vavoua traps, species, Thailand

INTRODUCTION

The genus *Stomoxys* (Muscidae: Stomoxyinae) contains 18 described species (Zumpt, 1973). They are obligate, bloodsucking insects with some species considered significant economic pests of livestock and other warm-blooded animals in many parts of the world (Zumpt, 1973; Mullens *et al.*, 1988; Masmeathathip *et al.*, 2006). *Stomoxys calcitrans* is the most important and cosmopolitan species. In addition to *S. calcitrans*, several other stomoxyine flies also readily attack animals in high densities, including *S. niger* (Afrotropical), *S. sitiens* (Oriental) and *S. indicus* (Asian) (Wall and Shearer, 1997). Both male and female stable flies feed on blood, once each day and they are often aggressive and persistent feeders; they will attack humans in extreme conditions or in the absence of preferred hosts. Although they are most active and problematic around livestock farms, they are also a nuisance insect at coastal beaches and in residential areas used for or near agricultural production (Newson, 1977). Adult flies have a typical flight range of 1.6 km. The biology of stable flies is described in Labrecque *et al.* (1975), Berry *et al.* (1976) and Smith *et al.* (1985).

Stable flies may cause a severe problem in dairies and feedlots, where they breed in moist soil and similar substrates (Meyer and Petersen, 1983). Severe biting activity can result in a reduction in animal weight and milk production. Significant economic losses due to loss in the anticipated gross weight gain of up to 227 g and a 30-40% decrease in milk yields have been observed (Hall *et al.*, 1982; Mullens *et al.*, 1988).

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In the United States of America, the estimated economic loss to the beef and dairy industry is nearly USD 400 million annually (Smith *et al*., 1987). The high number of flies biting cattle and other affected animals may have a direct influence on the epidemiology of communicable diseases. Several stable fly species have been implicated as mechanical vectors of anaplasmosis (*Anaplasma marginale*), trypanosomosis (*Trypanosoma* spp.), bovine leucosis virus and bovine herpesvirus-2 in dairy cattle (Buxton *et al*., 1985; Mihok *et al*., 1995; Torr *et al*., 2006).

Stomoxys species have been found to have a wide host range (Warnes and Finlayson, 1987). In Egypt, domestic donkeys and horses are the preferred hosts (Hafez and Gamal-Eddin, 1959). Warnes (1984) found that *S. calcitrans* preferred to feed on cattle and horses in the United Kingdom. Numerous host factors appear to influence the long-range olfactory responses of stable flies that include age, size, sex and nutritional state. Kairomones produced by cattle also play a factor in attracting some stable flies (Torr *et al*., 2006).

Surveys of adult stable fly populations can be assessed using several different techniques. Many studies have employed the use of direct counts or collections from host animals, especially leg counts to assess fly densities (McNeal and Campbell, 1981; Berry and Campbell, 1985). Various trapping devices and techniques have been developed to collect flies (Gersabeck and Merritt, 1983; Foil and Hogsette, 1994). These include sticky traps (Williams, 1973; Broce, 1988) and the Vavoua trap (Laveissiere and Grebaut, 1990), originally designed for tsetse fly collections, which has proven very efficient for capturing various *Stomoxys* sp. in many regions of Africa (Holloway and Phelps, 1991; Mihok *et al*., 1995) and on La Reunion Island (Gilles *et al*., 2007).

In Thailand, relatively little is known about stable fly species, their distribution and biology. Recently, Masmeatathip *et al*. (2006) described the seasonal abundance of *Stomoxys* species, but the study was limited to one location and did not compare the density/species diversity among different ecological settings. In the present study, stable fly species were surveyed and identified from ten provinces, representing four different habitats throughout Thailand, so that the increase in scientific knowledge might support more effective, stable fly, control programs in the private and government sectors.

MATERIALS AND METHODS

Collection sites

Stable fly collections were made in ten geographical locations of Thailand, including monthly stable fly collections from June 2007 to May 2008 in two locations (the Dairy Farming Promotion Organization of Thailand, Saraburi province and the Khao Kheow Open Zoo, Chonburi province) (Figure 1). The approximate geographical coordinates and a brief description of collection sites are provided in Table 1.

Vavoua trap

At each collection site, nine Vavoua traps were randomly placed around the sampling area, approximately 10 m apart. Each trap was made from blue and black cotton cloth with white polyester insect netting. Trap design has been described by Laveissiere and Grebaut (1990).

Stable fly collection

Stable flies were collected at each site from 0600 to 1800 h over a two-day period (Table 1). The monthly stable fly collection was undertaken from June 2007 to May 2008 on two consecutive days per month. Four Vavoua traps were used from 0600 to 1800 h. Stable flies were captured at two-hour intervals, preserved in 95% ethanol and recorded by date, hour of capture and location. The specimens were brought back to the Department of Entomology, Faculty of

Agriculture, Kasetsart University, Bangkok, Thailand for identification according to Zumpt (1973). Air temperature and relative humidity were also recorded.

Data analysis

Spatial and temporal data (time, date, place, species, number of specimens and environmental conditions) were used in the analysis as appropriate. A Chi-square test was used to evaluate the differences in the number of stable flies among categories of collection sites using the SPSS program package (version 13, SPSS Inc., Chicago, IL, USA). A difference was considered significant at $P < 0.05$.

RESULTS

A survey of stable fly species was made in ten locations within six geographical regions

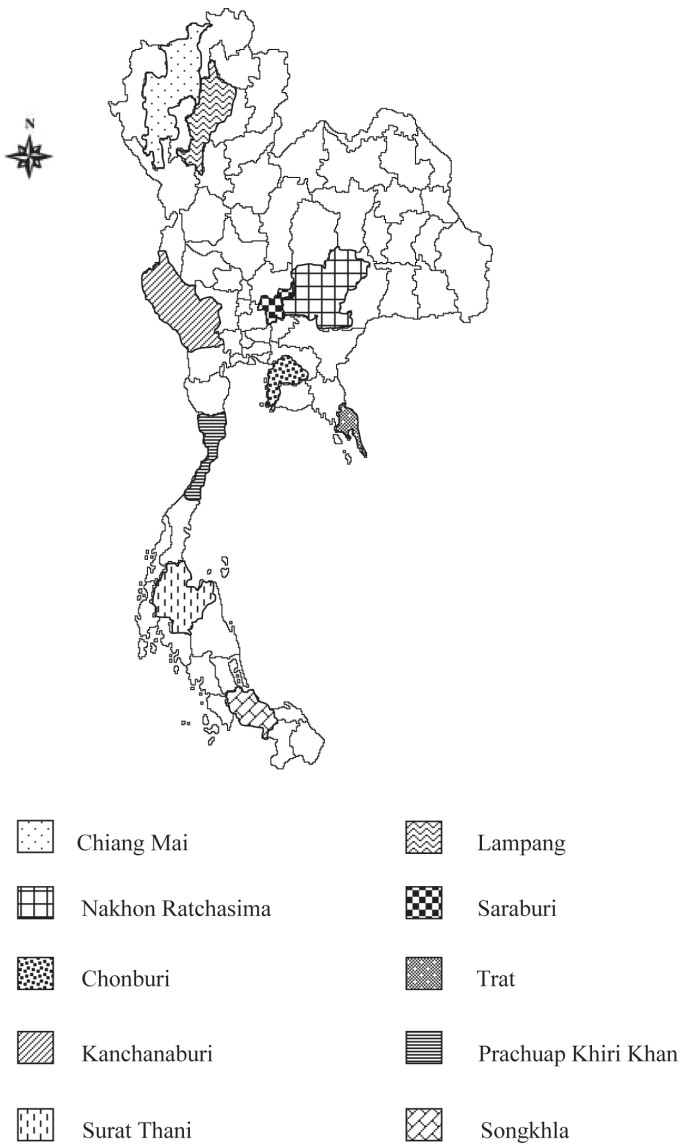

Figure 1 Collection sites of stable flies in Thailand.

of Thailand: 1) Chiang Mai and Lampang (north); 2) Nakhon Ratchasima (northeast); 3) Saraburi (central); 4) Chonburi and Trat (east); 5) Kanchanaburi and Prachuap Khiri Khan (west); and 6) Surat Thani and Songkhla (south) (Figure 1). Four potential *Stomoxys* habitats were investigated at industrial and local dairy farms (8 farms), an elephant conservation center and a national park (Table 1).

Stable fly captures from March to September 2007 are summarized in Table 2. During the seven-month collection period, 811

Table 1 Stable fly collection sites.

Collection sites	Reference Points	Characteristics	Date of collection
Nong Han, San Sai, Chiang Mai	18° 48′ N, 98° 58′ E	Industrial dairy farm located in Mae Jo University. Approximately 80 cows.	April 2007
Wiang Tan, Hang Chat, Lampang	18° 17′ N, 99° 28′ E	Thai elephant conservation center located in the Thung K wian Forest Park. Approximately 40 elephants.	April 2007
Thai Samakkhi, Wang Nam Kheow, Nakhon Ratchasima	15° 0′ N, 102° 6′ E	Local dairy farm located in Wang Nam Kheow District, Nakhon Ratchasima Province. Approximately 40 cows.	March 2007
Mit Taphap, Muak Lek, Saraburi	14° 31′ N, 100° 52′ E	Industrial dairy farm Dairy Farming Promotion Organization of Thailand. Approximately 200 cows.	March 2007
Bang Phra, Sri Racha, Chonburi	13° 24′ N, 101° 0′ E	National park located in Khao Kheow Open Zoo. A variety of natural and resident wild life.	May 2007
Pong Kanang, Mueang, Trat	12° 13′ N, 102° 30′ E	Local dairy farm located in Bo Rai District, Trat Province. Approximately 20 cows.	May 2007
Tha Sao, Sai Yok, Kanchanaburi	14° 1′ N, 99° 31′ E	Local dairy farm located in Military Development Office. Approximately 30 cows.	April 2007
Huoy Sat Yai, Hua Hin, Prachuap Khiri Khan	11° 49′ N, 99° 47′ E	Local dairy farm located among Dairy Farming Cooperatives. Approximately 20 cows.	April 2007
Makham Tia Mueang, Surat Thani	9° 8′ N, 99° 19′ E	Local dairy farm located in Mueang District, Surat Thani Province. Approximately 20 cows.	September 2007
Nam Noy, Hat Yai, Songkhla	7° 0′ N, 100° 28′ E	Local dairy farm located in Hat Yai District, Songkhla Province. Approximately 20 cows.	September 2007

specimens, representing six different species of stable fly were identified, with *S. calcitrans* being the most prevalent and geographically diverse. *S. calcitrans* represented approximately 91.5% of the total collection, followed by five other species: *S. bengalensis* (4.68%), *S. uruma* (1.84%), *S. indicus* (1.11%), *S. sitiens* (0.61%) and *S. pullus* (0.24%) (Table 2).

S. calcitrans was the only species found at all collection sites throughout the country. Collectively, (with the exception of the southern reaches), *S. calcitrans* samples were captured approximately in the same proportion from each region of the country, with the greatest proportion recorded from the western provinces of Kanchanaburi and Prachuap Khiri Khan (30.3%), followed by 22.9% from northern Thailand, 20.1% northeast-central and 22.5% from the east of the country. The smallest proportion was observed from Surat Thani and Songkhla (southern province) at 4.1%.

Collectively, 81.5% (661) of stable flies were captured from dairy farms, 12.9% (105) from the National Park in Chonburi and 5.5% (45) from the elephant conservation center in Lampang Province. Among the eight dairy farms (industrial and local dairy farms), *S. calcitrans* was the most abundant species, representing 92.4% (611/ 661), whereas *S. pullus* was relatively rare (0.3%). All six species of stable fly were recorded on the six local dairy farms, whereas only three species (*S. calcitrans, S. indicus,* and *S. bengalensis*) were captured from the two industrial dairy farms. *S. calcitrans* was the predominant species seen at the national park (85.7%), compared to the other two species collected, *S. bengalensis* (13.3%) and *S. indicus* (1%). The prevailing species at the elephant center was *S. calcitrans* (91.1%) followed by very small numbers of *S. bengalensis and S. uruma* (Table 3). Chi-square tests comparing collection sites found highly significant differences in the number of stable flies among the different categories ($\chi^2 = 360.15$, df = 3, $P< 0.05$).

DISCUSSION

In this study, *S. calcitrans* was found to be the most widely distributed species and strongly associated with both small and large dairy farms in Thailand. There were only two small local businesses in the eight dairy farms where the overall fly numbers were low.

The comparatively high numbers of stable flies, *S. calcitrans* in particular, collected on dairy farms was likely the consequence of the relatively high host density for blood-feeding

Table 2 Number of stable flies collected at ten collection sites.

Collection sites	*S. calcitrans*	*S. indicus*	*S. bengalensis*	*S. uruma*	*S. pullus*	*S. sitiens*	Total
Chiang Mai	129	0	1	0	0	0	130
Lampang	41	0	2	2	0	0	45
Nakhon Ratchasima	9	2	0	9	0	0	20
Saraburi	140	2	4	0	0	0	146
Chonburi	90	1	14	0	0	0	105
Trat	77	4	13	0	0	0	94
Kanchanaburi	111	0	1	1	0	1	114
Prachuap Khiri Khan	114	0	2	0	0	1	117
Surat Thani	28	0	1	3	2	3	37
Songkhla	3	0	0	0	0	0	3
Total	742	9	38	15	2	5	811

adults and suitable soil and environmental conditions for stable fly larvae to complete their life cycle. Such a combination appeared to play a significant role in stable fly abundance. In addition, the mixture of manure with silage and spilled feed in dairy farms appeared to be a highly favorable medium for developing stable fly larvae (Masmeatathip *et al*., 2006). However, stable fly larvae were generally not strongly associated with a direct cow-manure microenvironment when compared with other sites where the cow manure was sufficiently mixed with other soil types or deposited on vegetation for sufficient decomposition to take place (Masmeatathip *et al*., 2006). Romero *et al*. (2006) found that female stable flies are attracted to oviposition sites by stimuli caused by bacteria present in manure nearby.

Stable fly abundance and peak densities are the consequences of appropriate environmental conditions, involving moisture, light intensity, rainfall and temperature to maintain acceptable breeding habitats, and may be species-specific. Mullens and Meyer (1987) observed a single seasonal peak of *S. calcitrans*, which was the most prevalent during the summer season from May to June, whereas marked bimodal and trimodal peaks have been documented in other locations in the United States, presumably influenced by the ambient temperatures in more temperate climates (Lysyk, 1998). In Thailand, Masmeatathip *et al*. (2006) reported a wet season peak density of *S. calcitrans* associated with rainfall. In the current study, the majority of adult stable flies were captured during the tropical summer period from April to June (Masmeatathip *et al*., 2006).

The sample findings at the national park were conspicuously different from the dairy farm settings. The park contains a large open area and most warm-blooded animals may either rest or otherwise be absent during the daytime, resulting in poor food availability for adult stable flies. Furthermore, the park's environment may have lacked sufficient and suitable media for stable fly propagation. In a similar situation, Mihok and Clausen (1996) monitored stable flies with Vavoua traps on a single day in a forested area of the Nairobi National Park, Kenya and found a fairly robust number of species (6) but all at very low densities.

Similarly, the elephant conservation center appeared not to be an ideal ecological setting for stable flies considering the low numbers of stable flies captured. Only *S. calcitrans* was present in any meaningful number. It was suspected that a feedlot and livestock area located near (approximately 3 km distance) the elephant center was the primary breeding habitat for *S. calcitrans* in the area. Foil and Hogsette (1994) reported that stable flies could disperse up to 5

Table 3 Number of stable flies among four categories of collection sites.

Categories of collection sites	*S. calcitrans*	*S. indicus*	*S. bengalensis*	*S. uruma*	*S. pullus*	*S. sitiens*	Total
Industrial dairy farms (2)	269	2	5	0	0	0	276
Local dairy farms (6)	342	6	17	13	2	5	385
National park (1)	90	1	14	0	0	0	105
Elephant conservation center (1)	41	0	2	2	0	0	45
Total	742	9	38	15	2	5	811

km or more in search of blood meals.

The current study had several limitations. Firstly, fly collections between the different sites were not conducted contemporaneously; therefore, seasonal and temperature differences between sites may have greatly influenced collection numbers. Secondly, only one trapping method was used and it is unclear if this single method favored one *Stomoxy*s species over another. Thirdly, most of the wild mammals were nocturnal and not accessible to diurnal flies. Perhaps other species of *Stomoxys* do exist in such areas, but would be captured best using light traps during the night or via traps in the canopy (Duvallet, pers comm.). Further investigation will be carried out on diurnal biting activity related to different ecological settings, the use of multiple trapping methods and mark-release-recapture studies of *Stomoxys* species, particularly *S. calcitrans*, the most abundant and important species of stable fly in Thailand.

CONCLUSION

A survey of stable fly species was made at ten locations within six geographical regions of Thailand from March to September 2007. During the seven-month collection period, 811 specimens in six species of stable flies were identified in the following proportions: *Stomoxys calcitrans* (91.5%), *S. bengalensis* (4.7%), *S. uruma* (2%), *S. indicus* (1%), *S. sitiens* (0.6%) and *S. pullus* (0.2%). All six species of stable fly were recorded from the six local dairy farms sampled, whereas only three species (*S. calcitrans, S. indicus,* and *S. bengalensis*) were captured from the two industrial dairy farms in the sampling program. *S. calcitrans* was the predominant species seen at the national park (85.7%), compared to the other two species collected (*S. bengalensis*, 13.3% and *S. indicus*, 1%). The prevailing species at the elephant center was *S. calcitrans* (91.1%) followed by very small numbers of *S. bengalensis and S. uruma*. Chi-square tests comparing collection sites found highly significant differences in the number of stable flies among the different categories (χ^2 = 360.15, df = 3, $P< 0.05$).

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