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Original Article

# Comparison of Vavoua, Malaise and Nzi traps with and without attractants for trapping of *Stomoxys* spp. (Diptera: Muscidae) and tabanids (Diptera: Tabanidae) on cattle farms

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ABSTRACT

Insect traps can be used to monitor or collect haematophagous insects. The objective of this study was to compare the efficacy of three insect traps (Vavoua, Malaise and Nzi traps) on two cattle farms in Thailand. In addition, a comparison of olfactive attractants was carried out in pasture. Vavoua traps caught significantly ($p < 0.05$) higher numbers of *Stomoxys* spp. than Malaise and Nzi traps, respectively, with daily means of $69.7 \pm 13.6$, $31.3 \pm 26.6$ and $32.3 \pm 25.8$ stomoxes flies in a stable area in Nakhon Pathom province and $79.67 \pm 23.71$, $46.67 \pm 21.55$ and $58.33 \pm 24.11$ in pasture in Kanchanaburi province. Conversely, Nzi traps caught significantly more tabanids than Malaise and Vavoua traps on both farms. The mean daily numbers of insects caught using traps baited with cow urine mixed with dry straw (CUS) significantly increased in Vavoua, Malaise and Nzi traps, respectively, by $2.2 \pm 0.9$, $1.6 \pm 0.5$ and $1.8 \pm 0.6$ for stomoxes flies, and by $3.6 \pm 1.8$, $3.3 \pm 1.7$ and $1.8 \pm 0.4$ for tabanids. Vavoua and Nzi traps baited with CUS could be used on farm and in pasture to contribute to respective reductions in stomoxes and tabanids adult, biting-fly populations.

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## Introduction

Stable flies and tabanids are serious nuisances to livestock due to their painful bites and blood spoliation and in addition, they can transmit many pathogens to livestock such as *Trypanosoma evansi*, *Anaplasma marginale* and *Bacillus anthracis* (Gutierrez et al., 2010; Baldacchino et al., 2013, 2014). To avoid economic loss, the average stable fly count on heifers in a feedlot must not be allowed to exceed seven stable flies per foreleg per animal per minute (Catangui et al., 1997). *Stomoxys* spp. are one of the most important biting flies of the subfamily Stomoxyinae, which includes 18 species, of which 17 are found mainly in Africa and one is cosmopolitan—the so-called stable fly, *Stomoxys calcitrans* (L) (Zumpt, 1973). In addition, several other stomoxyinae flies readily attack domestic animals, including *S. niger, S. sitiens* and *S. indicus* (Baldacchino et al., 2013). In Thailand, Masmeatathip et al. (2006a, 2006b); Tainchum et al. (2010) Muenworn et al. (2010); Changbunjong et al. (2012); Keawrayup et al. (2012) and Phasuk et al. (2013, 2016) have reported six species of *Stomoxys* consisting of *S. calcitrans*, *S. sitiens*, *S. indicus*, *S bengalensis*, *S. pulla* and *S. uruma*.

Tabanids in livestock are mainly represented by horse flies in the genus *Tabanus* and deer flies in the genus *Chrysops* (Gary and Lance, 2009). Tabanids mechanically transmit the same pathogens as stomoxes to which can be added notably bovine leukaemia virus and equine infectious anemia virus (Baldacchino et al., 2013). Tabanids usually wait for a host in shady areas under bushes and trees (Gábor, 2014). Sight is the main host-detecting mechanism, but carbon dioxide and odor also play a role (Blahó et al., 2013). Moving objects, especially if dark colored, are most prone to attraction (Krinsky, 1976; Foil, 1989; Squitier, 2011).

The Vavoua trap was initially designed to trap the tsetse fly but it was proven effective at capturing *Stomoxys* spp. in Kenya and on La Réunion Island (Laveissiere and Grebaut, 1990; Mihok et al., 1995; Gilles et al., 2007). The Vavoua trap attracts biting insects using phthalogen blue color-stained fabric, whereas black and UV-reflecting white fabrics tend to stimulate landing by the tsetse fly (Green, 1986; Green and Flint, 1986). The Nzi trap was developed by Steve Mihok at ICIPE in Kenya (Mihok, 2002). The trap is secured to

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the ground by three external metal stakes and a central pole. This is the most efficient trap for tabanid biting insects (Bouyer et al., 2015). The Malaise trap was invented by Dr Rene Malaise and is an effective trap to catch general insects (Malaise, 1937; Berner and Oldroyd, 1959; Gressitt, 1962). These researchers have observed that the Malaise trap is the most important trap for collecting day-flying insects such as Hymenoptera and Diptera. The Malaise trap is a special kind of flight-interception trap for collecting insects with positive phototropism that fly upward into the collection bottle (Achterberg, 2009). The Malaise trap is a fine, gauze, tent-like structure made out of either black or black-and-white material and is designed to trap insects by passive interception (Henry, 1972; Hutcheson, 1991).

In order to increase the attractiveness of the traps, natural and artificial olfactive attractants such as octenol, cow urine and phenols can be added (Mihok and Mulye, 2010). Aged cow or buffalo urine can substitute for pure phenols. The appropriate phenols are likely present in most ruminant farm animals (Martin, 1982). Aged urine is more attractive to biting flies than fresh urine due to the development of both phenols and ammonia as the urine ages (Mihok and Lange, 2012). Animal feces especially when mixed with fermenting vegetal matter are also commonly exploited by *Stomoxys* females for oviposition (Jeanbourquin, 2005). The current study aimed to compare the effectiveness of Vavoua, Malaise and Nzi traps in the capture of stomoxes and tabanid on cattle farms, and to evaluate the efficacy of several attractants made using fermented urine in combination with the traps to increase the attraction of stable flies and the other biting flies.

## Materials and methods

### *Study areas*

This study was conducted on cattle farms at two locations in Thailand, namely, Farm 1 being the Rungratsamee Farm, Tamoung district, Kanchanaburi province (GPS coordinates 19° 59′ 35″N, 99° 39′ 34.5″ E) and Farm 2 being the Experimental Animals Unit, Faculty of Veterinary Medicine, Kasetsart University, Kamphaeng Saen campus, Kamphaeng Saen district, Nakhon Pathom province (GPS coordinates 14° 0′ 32″ N, 99° 58′ 17″ E). Observations of flies at these farms were made from May to October 2014.

### *Traps and insect identification*

Vavoua, Malaise and Nzi traps were made locally, using regular white mosquito net and black fabric, while the blue fabric was selected based on a current research project for its attractiveness and similarity to a reference fabric named TDV® (TDV Industries; Laval, France) being 65% cotton and 35% polyester. Traps were set up at 0600 h and cages were collected daily at 1800 h. Each trap type was located at least 50 m apart.

Insect identification used a stereomicroscope and the blood-sucking insect specimens were identified to the species level based on the keys of Zumpt (1973) and Fairchild and Burton (1978).

Two sets of experiments were carried out for trap comparisons inside the stable or in pasture, and one set of experiments was carried out to compare olfactive attractants in pasture, as described below.

*Experiment 1* Comparative studies on the efficacy of Vavoua, Malaise and Nzi traps were carried out in stable areas on the two cattle farms (Fig. 1). The experimental design was a $3 \times 3$ Latin square with three replications. Insect collection was carried out from 0600 h to 1800 h for 9 d in May and June 2014.

*Experiment 2* Comparative studies on the efficacy of Vavoua, Malaise and Nzi traps were carried out in pasture on Farm 1 (Fig. 2). The experimental design was a $3 \times 3$ Latin square with three replications. The collection of insects was carried out from 0600 h to 1800 h for 9 d in July 2014.

*Experiment 3* Comparative studies on the efficacy of Vavoua, Malaise and Nzi traps combined with different attractants were carried out in pasture on Farm 2 (Kamphaeng Saen district). The olfactive attractants used were: 1) Fermented cow urine (CU): cow urine was collected and kept at room temperature (about 35 °C) for 3 wk (Mihok et al., 1995); and 2) Fermented cow urine mixed with goat feces, aged 3 wk (CUG); 200 mL of cow urine freshly collected was mixed with 100 g of fresh goat feces (*Capra* sp.) and kept at room temperature for 3 wk; 3) Fermented cow urine mixed with straw, aged 3 wk (CUS); 200 mL of cow urine freshly collected was mixed with 100 g of dry straw and kept at room temperature for 3 wk.

Liquid phases of CU, CUG and CUS were dispensed through bottles (2 cm diameter aperture) placed at the lower side of each trap. The evaporation rate was 0.2 mL/h. The experimental design

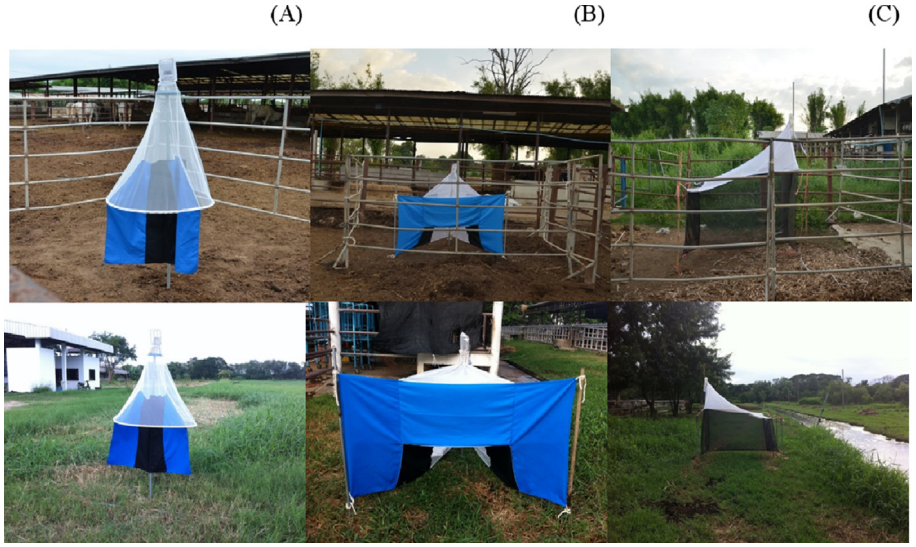



**Fig. 1.** Three types of traps: (A) Vavoua trap (B) Nzi trap and (C) Malaise trap, set up in stable area on cattle Farm 1, Tamoung district, Kanchanaburi province (top) and Farm 2, Kamphaeng Saen district, Nakhon Pathom province (bottom), Thailand.

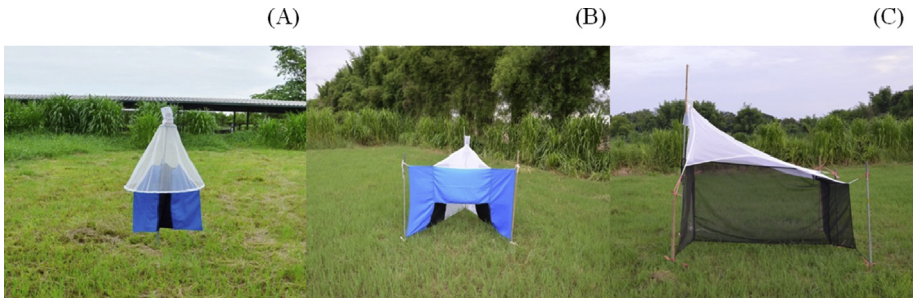



**Fig. 2.** Three types of traps: (A) Vavoua trap (B) Nzi trap and (C) Malaise trap, set up in pasture on cattle Farm 1, Tamoung district, Kanchanaburi province.

**Table 1**
Summary of means and standard deviation of daily fly numbers caught using Vavoua, Malaise and Nzi traps in stable areas on two cattle farms during May to July 2014.

| Trap type | (Mean ± SD)* | | | |
|---|---|---|---|---|
| | Farm 1 | | Farm 2 | |
| | Stomoxes | Tabanids | Stomoxes | Tabanids |
| Vavoua | 36.67 ± 13.01[a] | 3.33 ± 2.30[b] | 69.67 ± 13.57[a] | 3.00 ± 1.00[b] |
| Malaise | 23.33 ± 19.21[a] | 4.67 ± 3.05[b] | 31.33 ± 26.57[b] | 6.33 ± 1.52[b] |
| Nzi | 20.00 ± 4.35[a] | 10.00 ± 27.00[a] | 32.33 ± 25.81[b] | 15.00 ± 4.35[a] |

*Means within a column are not significantly different using Duncan's multiple range test ($p < 0.05$); means within a column followed by different lowercase, superscript letters are significantly different using Duncan's multiple range test ($p < 0.05$).

was a 4 × 4 Latin square with four replications for each trap. Traps were set up at 0600 h and cages were collected at 1800 h for 48 d during August to October 2014. Three sets of experiments were carried out respectively with Vavoua, Nzi and Malaise traps.

*Data analysis*

One-way analysis of variance was used to analyze trap catches (number of flies collected per trap) in the field tests (Gomez et al., 1984). The homogeneity of the variance and normal distribution of the variables were assessed with the tests of Levene (significance was set at $p > 0.05$). Means were compared using Duncan's multiple range test. An alpha value of 0.05 was used for all statistical tests.

## Results and discussion

*Experiment 1* Table 1 presents the means and standard deviations of the three replications of the daily numbers of stomoxes and tabanids in stable areas trapped using Vavoua, Nzi and Malaise traps in 3 × 3 Latin squares on Farm 1 and Farm 2 (Table 2).

The results showed that the Vavoua trap caught the highest number of *Stomoxys* spp., but the differences among the three trap types were not significant for Farm 1 (F = 5.31, df = 4). This result was similar to the results of Gilles et al. (2007) and Solórzano et al. (2015) who reported that Vavoua and Nzi traps exhibited a similar efficacy to catch *Stomoxys* spp. On Farm 2, the Vavoua trap caught significantly higher numbers of *Stomoxys* spp. than the Nzi and Malaise traps (F = 6.69, df = 4). Similarly, Desquesnes (2004) reported that the Vavoua trap was the most efficient to catch *Stomoxys* spp. The Nzi trap caught significantly the highest numbers of tabanids compared to the Vavoua and Malaise traps on both farms (Table 1). Vavoua and Malaise traps catches were not significantly different. These results were similar to Hennekeler et al. (2008) who reported that the Nzi trap consistently caught more tababids and suggested that the Nzi trap would consistently perform better than other traps. Mihok (2002) also reported that the Nzi trap caught significantly more tabanids than the Vavoua trap.

*Experiment 2* Trap comparisons in pasture on Farm 1 revealed that the Vavoua trap caught significantly the highest numbers of *Stomoxys* spp. compared to the Nzi and Malaise traps. The Nzi trap also caught significantly higher numbers of stomoxes than the Malaise trap. This was consistent with Mihok et al. (1995) and Gilles et al. (2007) reporting that a Vavoua trap caught significantly more *Stomoxys* spp. than the other traps.

The Nzi trap caught significantly higher numbers of tabanids compared with the Vavoua and Malaise traps. The catches from the Vavoua and Malaise traps were not significantly different, which was consistent with Rayaisse et al. (1998).

*Experiment 3* The results of the experiments using olfactive attractants are presented in Table 3. The mean number of *Stomoxys* spp. caught in the Vavoua trap associated with CUS was significantly higher than the control and other attractants (F = 32.42, df = 6). Similarly, the mean number of *Stomoxys* spp. caught in the Nzi trap associated with CUS was significantly higher than the control and other attractants (F = 89.07, df = 6). For the Malaise trap, the mean numbers of *Stomoxys* spp. caught in association with CUS or CUG were significantly higher than the control and CU (F = 29.80, df = 6). This was consistent with Mihok et al. (1995) who

**Table 2**
Summary of daily fly numbers caught using Vavoua, Malaise and Nzi traps in pasture on Farm 1, Tamoung district, Kanchanaburi province in July 2014.

| Trap type | (Mean ± SD)* | |
|---|---|---|
| | Stomoxes | Tabanids |
| Vavoua | 79.67 ± 23.71[a] | 3.33 ± 0.57[b] |
| Malaise | 46.67 ± 21.55[b] | 5.00 ± 1.00[b] |
| Nzi | 58.33 ± 24.11[c] | 15.33 ± 5.03[a] |

*Means within a column followed by different lowercase, superscript letters are significantly different using Duncan's multiple range test ($p < 0.05$).

**Table 3**
Mean daily numbers of *Stomoxys* spp. captured in the three types of traps combined with olfactive attractants in pasture on Farm 2, Kamphaeng Saen district, Nakhon Pathom province during August to October 2014.

| Olfactive attractant | Trap type | | |
|---|---|---|---|
| | Vavoua | Malaise | Nzi |
| Control | 25.25 ± 13.59[c*] | 53.00 ± 28.08[b] | 68.50 ± 46.91[c] |
| CU | 29.00 ± 15.97[c] | 59.75 ± 23.06[b] | 80.75 ± 52.59[c] |
| CUG | 41.25 ± 17.84[b] | 74.75 ± 22.73[a] | 106.00 ± 56.86[b] |
| CUS | 55.75 ± 14.72[a] | 83.00 ± 25.93[a] | 123.75 ± 61.57[a] |

CU = fermented cow urine aged 3 wk; CUG = fermented cow urine mixed with goat feces, aged 3 wk; CUS = fermented cow urine mixed with fermented straw, aged 3 wk.
*Means within column followed by different lowercase, superscript letters are significantly different using Duncan's multiple range test ($p < 0.05$).

**Table 4**
Mean daily numbers of tabanids captured with three types of traps combined with olfactive attractants in pasture on Farm 2, Kamphaeng Saen district, Nakhon Pathom province.

| Olfactive attractant | Trap type | | |
|---|---|---|---|
| | Vavoua | Malaise | Nzi |
| Control | $3.50 \pm 1.73^{b*}$ | $4.75 \pm 2.21^{b}$ | $39.50 \pm 17.25^{c}$ |
| CU | $4.75 \pm 2.21^{b}$ | $6.00 \pm 2.70^{b}$ | $50.00 \pm 19.20^{bc}$ |
| CUG | $7.75 \pm 5.67^{ab}$ | $9.50 \pm 6.60^{ab}$ | $57.75 \pm 15.50^{b}$ |
| CUS | $12.50 \pm 11.03^{a}$ | $15.75 \pm 13.67^{a}$ | $71.25 \pm 17.19^{a}$ |

CU = fermented cow urine aged 3 wk; CUG = fermented cow urine mixed with goat feces, aged 3 wk; CUS = fermented cow urine mixed with fermented straw, aged 3 wk.
*Means within column followed by different letters are significantly different using Duncan's multiple range test ($p < 0.05$).

showed that cow urine attracted significantly more *Stomoxys* spp. than other urine types. Jeanbourquin (2005) reported that straw mixed with urine attracts female *Stomoxys* to oviposit because fermented straw releases carbon dioxide.

The Vavoua and Malaise traps associated with CUS caught significantly higher numbers of tabanids than with other attractants (Table 4). The Nzi traps associated with CUS caught significantly higher numbers of tabanids than all other attractants. Nzi traps associated with CUG caught significantly lower numbers than CUS, and were significantly higher than the control, but not significantly different from CU.

Olfactive attractant comparison showed that the mean daily number of insects caught using CUS-baited traps was significantly higher, respectively, in Vavoua, Malaise and Nzi traps by $2.2 \pm 0.9$, $1.6 \pm 0.5$ and $1.8 \pm 0.6$ for stomoxes and by $3.6 \pm 1.8$, $3.3 \pm 1.7$ and $1.8 \pm 0.4$ for tabanids.

The results revealed that the efficacy of an unbaited Vavoua trap to catch *Stomoxys* spp. was greater than for the Malaise and Nzi traps for Farm 2, both inside the stable area and in pasture. Conversely, the Nzi trap caught more tabanids than the Malaise and Vavoua traps in the stable areas of the two farms as well as in pasture on Farm 2. The olfactive attractant study suggested that the performance of all traps can be improved using CUS. Indeed, the mean daily numbers of insects caught using CUS-baited traps were significantly increased by more than double for the Vavoua trap, by 1.6 times for the Malaise trap and by 1.8 times for the Nzi trap, both for stomoxes and tabanids.

The large catches recorded in pasture using the Nzi and Malaise traps baited with CUS suggested that these traps can perform better in open areas due to their large size. The results showed that CUS-baited Vavoua traps would have the highest efficacy in catching stomoxes, while CUS-baited Nzi traps would have the highest efficacy in catching tabanids. However, CUS-baited traps were not compared under similar conditions. Although the performance of the three traps improved when associated with CUS, it is not possible to determine which one would be the best. A complementary study will be necessary to compare CUS-baited Vavoua, Malaise and NZI traps.

The results of the current study suggested that setting up several CUS-baited Vavoua and Nzi traps in stable and pasture areas on a farm might, respectively, contribute to a reduction in the numbers of adult stable flies and tabanids populations, and thus might also help to decrease the risk of animal disease mechanically transmitted by *Stomoxys* spp. and tabanids.

## Conflict of interest

None declared.

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