

## Comparison of blue cotton and blue polyester fabrics to attract hematophagous flies in cattle farms in Thailand

Sathaporn Onju<sup>1</sup>, Kornkanok Thaisungnoen<sup>2</sup>, ROUNGTHIP MASMEATATHIP<sup>1✉</sup>, Gérard Duvallet<sup>3</sup>, and Marc Desquesnes<sup>2,4,5</sup>

<sup>1</sup>Department of Entomology, Faculty of Agriculture at Kamphaeng Saen, Kasetsart University, Nakhon Pathom 73140, Thailand, fagrtrtm@ku.ac.th

<sup>2</sup>Department of Parasitology, Faculty of Veterinary Medicine, Kasetsart University, Bangkok 10900, Thailand

<sup>3</sup>Centre d'Écologie Fonctionnelle et Évolutive (CEFE), Université Paul-Valéry Montpellier, France

<sup>4</sup>Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Unité Mixte de Recherche (UMR) InterTryp, Bangkok 10900, Thailand

<sup>5</sup>InterTryp, University of Montpellier, Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Institut de Recherche pour le Développement (IRD), Montpellier 34398, France

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**ABSTRACT:** Tabanids and stable flies are important nuisances to livestock and sometimes humans. Nzi, Vavoua, and Biconical traps or insecticide-impregnated blue screens are commonly used to attract and catch these flies. Such devices are made of a specific cotton or cotton-polyester phthalogen blue fabric acting as a visual attractant. However, the cost of cotton fabrics is high, and they are no longer available due to toxic dyes. The present study compared four blue polyester fabrics produced in Thailand with a reference blue cotton-polyester fabric made in France by TDV® to attract hematophagous flies. Vavoua traps and blue screens covered with a sticky film made with the five different blue fabrics were compared. The TDV® had the highest trapping scores; however, there was no significant difference between TDV® and some polyester fabrics. Among the tested polyester fabrics, CR Solon No.41 was nearly as effective as the TDV® in attracting biting flies. The mean attractivity indices of CR Solon No.41, NS No.1469, Globe 2000 No.21, Globe 2000 No.34 were 0.86, 0.79, 0.69, and 0.39, respectively. Thus, we recommend that CR Solon No.41 would be the appropriate fabric for the further development of low-cost and optimized screens and traps in Thailand and other countries. *Journal of Vector Ecology* 45 (2): 262-268. 2020.

**Keyword Index:** Attractivity, biting flies, phthalogen blue fabric, reflectance, sticky screens, vavoua traps.

### INTRODUCTION

Tabanids, stable flies, *Stomoxys calcitrans* (Linnaeus, 1758), and hematophagous *Musca* species such as *Musca crassirostris* Stein, 1903 are serious pests of livestock in many countries (Desquesnes et al. 2019, Hogsette and Farkas 2000). Adult flies are persistent in their attempts to obtain a blood meal, and their populations frequently exceed the acceptable economic damage thresholds (Campbell et al. 1987). Blood-sucking insects are a direct nuisance to livestock due to their annoyance, painful bites, and blood despoliation (10–150 mg of blood/insect). They are also carriers of several pathogens, including bacteria, viruses, and parasites (Baldacchino et al. 2014). Topical cutaneous insecticides, such as baths, sprays, and pour-on, are currently used to control biting flies, with low efficacy (Olafson et al. 2019), potential contamination of animal food products by pesticide residues, and high negative impact on non-target fauna (Fikadu 2020).

Several research programs have investigated new, environmentally friendly, and sustainable methods without using pesticides. In Africa, tsetse fly control was successfully attempted using traps such as the Vavoua trap, Biconical trap, and Nzi trap. These traps have been evaluated for the capture of other biting insects, including tabanids and stomoxids (Gilles et al. 2007). Beresford and Sutcliffe (2006) studied the

effectiveness of coroplast and alsynite sticky traps for sampling stable flies. The Vavoua trap seems well suited for the capture of *Stomoxys* species and some tabanids, such as *Chrysops* spp. (Mihok et al. 1995, Gilles et al. 2007), while the Nzi trap is quite efficient at catching horse flies as well as stomoxids (Laveissiere and Grebaut 1990, Mihok 2002, Masmeatathip et al. 2006). All these traps have a specific blue fabric as the main attractive component, which has a peak of reflectance in the range 450–460 nm (Rayaisse et al. 2012). Biting flies perceive ultraviolet light exceptionally well (Briscoe and Chittka 2001, Stavenga 2002). The blue and black fabrics in these traps act as attractants for biting flies (Foil and Hogsette 2004) and the netting acts as a cage to catch the flies. Traps have been made from different blue fabrics based on the materials locally available; however, from one place to another, blue fabrics differ in nature, texture, and color, and it has been shown that they have different levels of attractivity to flies. Considerable efforts have been made to determine the characteristics of the best blue fabric to attract biting flies, especially tsetse flies, tabanids, and stomoxids (Mihok 2018).

The best-performing fabric so far has been a phthalogen blue cotton fabric called “Santiago,” widely used in West Africa and produced in the Ivory Coast. However, the manufacturer no longer makes it and several attempts have been made to substitute various types of natural or synthetic fabrics such

as polyester, acrylic, cotton-polyester, or polyester-viscose (Mihok et al. 2006, Rayaisse et al. 2012). In recent studies carried out in France, Burkina Faso, and Thailand, a blue fabric made of 65% cotton and 35% polyester, reference TDV S 250/Azur 023 (250 g/m<sup>2</sup>) made by TDV® (43 Rue du Bas des Bois, 53012 Laval, France) proved to be the best candidate to replace the reference phthalogen blue in several assays published or not yet published (Rayaisse et al. 2012). However, cotton or majority cotton fabrics are quite expensive (US\$6–15/m<sup>2</sup>) and are heavy materials for their potential use as insecticide-impregnated targets. They also require a large amount of insecticide due to the sponging effect of the natural cotton fibers compared to synthetic fabrics (100% cotton, size 50×50 cm can absorb 100 ml of water while a 100% polyester fabric of the same size absorbs only 50–60 ml of water). Additionally, the phthalogen blue dyes are toxic and have been banned in Europe. For these reasons, it is now necessary to identify synthetic fabrics that can compete with the cotton reference fabric but be much less expensive (US\$ 0.5–1.0/m<sup>2</sup>), use non-toxic dyes and be suitable for low-cost, insecticide impregnation or trapping methods.

The present study was designed to evaluate the efficacy of four polyester blue fabrics produced in Thailand to attract hematophagous flies, using a previously characterized blue cotton-polyester fabric made by TDV® as a reference control. All reference and candidate fabrics were used under two types of devices: Vavoua traps and blue fabric screens covered with sticky film.

## MATERIALS AND METHODS

### Study area

Two cattle farms (arbitrarily labeled 1 and 2) were in the Central Thailand, Kamphaeng Sean, Nakhon Pathom Province. Farm 1, called “Kamphaeng Sean Beef Breeders Association,” located at 14°02'37.8"N, 99°56'52.0"E had 40 cattle and Farm 2, named “Saengsawang Farm,” located at 14°02'27.1"N, 99°58'54.6"E had 22 cattle. All cattle were kept in the fence paddock. Traps and screens were placed surrounding the stables and experiments were carried out in the rainy season from June to August, 2016.

### Blue fabrics

Based on Rayaisse et al. (2012) and unpublished results obtained by a consortium of researchers from Burkina Faso, France, and Thailand (the FlyScreen Consortium), a reference blue fabric made in France by TDV® (sergé 2/1, weight 250 g/m<sup>2</sup>, color reference Azur 023) was selected, being 65% cotton and 35% polyester. Four different 100% polyester blue fabrics produced in Thailand were selected from Sampeng fabric market, Bangkok. Fabrics were selected based on their color being similar to the reference TDV® fabric, on the ability of the factory to sustain the manufactured fabric for a foreseeable future, and on their low price. Images of fabrics were taken using a Sony Cyber-shot DSC-RX100 equipped with a Carl Zeiss objective camera (Japan). Reflectances of these different fabrics were measured at CEFE-Montpellier (France) using a Jaz, Ocean Optics, Inc. (U.S.A.) spectrometer (Figure 1).

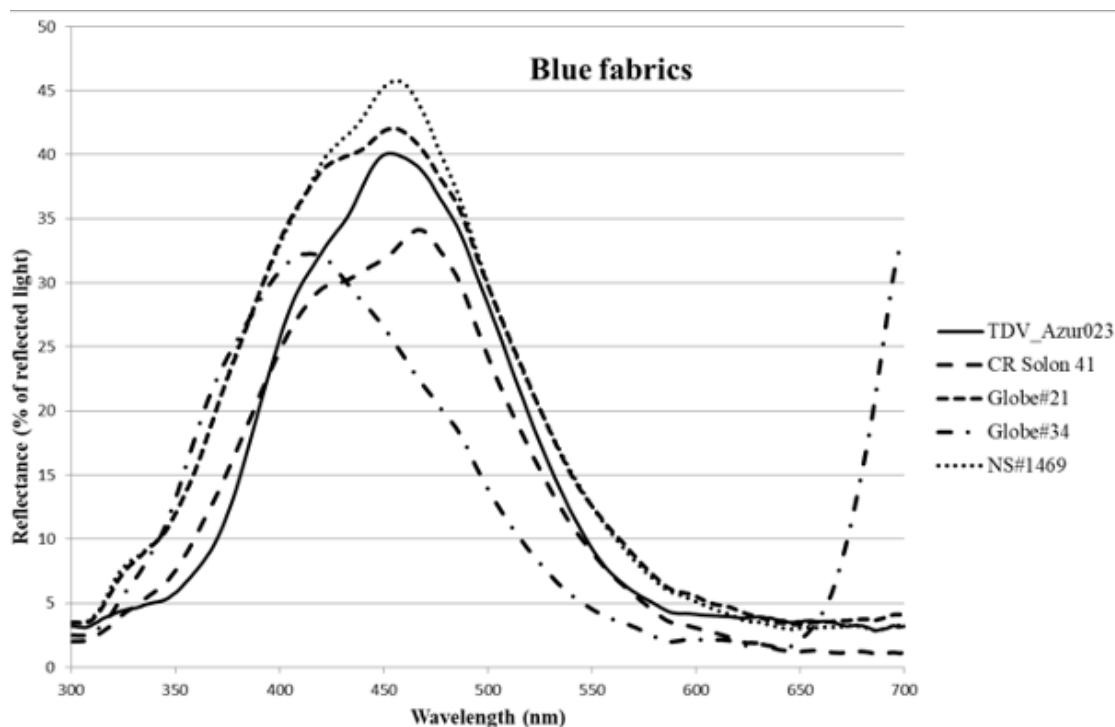


Figure 1. Reflectance of the different blue fabrics. Measures made with a Jaz, Ocean Optics, Inc. (U.S.A.) spectrometer.

Table 1. Fabric details and manufacturers or providers.

Fabric name	Wavelength at peak of reflectance	Fabric composition	Supplier details
TDV S 250/Azur 023	455 nm	Polyester 35% cotton 65%	TDV Industries/ 43 Rue du Bas des Bois, 53012 Laval, France
CR Solon No.41	469 nm	Polyester 100%	Mun Ying/ Chai Rung Textile/ Potaram, Ratchaburi province, Thailand
NS No.1469	458 nm	Polyester 100%	NC/ Lim Chua Kee Co., Ltd. (LCK)/ 352, Phahurat Rd., Wang Buraphapirom Phra Nakhon, Bangkok, Thailand
Globe No.21	456 nm	Polyester 100%	Globes 2000/ Jiamsamarn Co., Ltd./ 165–167 Vanich1 Rd., Chakkaward Sampantawong, Bangkok, Thailand
Globe No.34	415 nm	Polyester 100%	Globes 2000/ Jiamsamarn Co., Ltd./ 165–167 Vanich1 Rd., Chakkaward Sampantawong, Bangkok, Thailand

### Traps and screens

Vavoua traps were made from the five blue fabrics. The other parts of the traps just used black cotton fabric and a nylon mosquito net, according to the pattern design previously described (Laveissiere and Grebaut 1990). Cages with iron frames covered with mosquito net to hold captured flies were set up on top of the traps in the morning and collected in the evening as described below.

Blue screens, 60×60 cm, were made of each of the five fabrics and fixed on an acrylic board (60×60 cm). To set up the blue screens on the farms, the empty boards faced east-west and the eastern side was covered with the blue fabric. The fabric (east side) was then completely recovered by a commercially available transparent plastic sticky film (Rentokill, FE217 Luminos rolls) to capture the attracted flies. This sticky film proved to be the best for this purpose based on results from other studies (Mihok et al. 2007). After each trapping period, sticky films with captured insects were covered with a non-sticky transparent film to protect both insects and film. Insects were then identified and counted under a binocular microscope and a digital HD microscope camera.

### Biting fly identification

Stomoxys flies were identified using a reference key (Zumpt 1973) and previous descriptions made in Thailand (Masmeatathip et al. 2006). Tabanids were identified using reference keys (Philip 1960, Burton 1978), and *Musca crassirostris* individuals were identified using a key for *Musca* spp. from Thailand (Tumrasvin and Shinonaga 1978). Identification was made to species for flies obtained from the Vavoua trap. With sticky screens, identification was made to the genus level, except for *M. crassirostris*, that was identified at the species level. For analysis, only insects from three hematophagous groups consisting of *Stomoxys* spp., tabanids, and *M. crassirostris* were used.

### Experimental design

#### Experiment 1

The efficacy of the five different blue fabrics in the form of Vavoua traps was evaluated using a Latin square design on Farm 1. Traps were at least 20 m apart and 15 m from the cattle stalls. After traps were serviced each day, they were moved to the next location. A rotation by the same trap through all five trap locations was considered as one replication and the study was replicated five times (125 data points).

Table 2. Mean numbers of hematophagous insects trapped daily ( $\pm$  95% confidence intervals) using Vavoua traps.

Blue fabric used to make traps	<i>Stomoxys</i> spp.	<i>M. crassirostris</i>	Tabanids	Total hematophagous insects
TDV S 250/Azur 023	47±6.1 <sup>a</sup>	15±2.3 <sup>a</sup>	1.68±0.3	63±7.9 <sup>a</sup>
CR Solon No.41	35±5.3 <sup>ab</sup>	13±2.5 <sup>ab</sup>	1.24±0.2	49±7.2 <sup>ab</sup>
NS No.1469	32±4.9 <sup>ab</sup>	11±2.3 <sup>ab</sup>	0.84±0.2	44±6.7 <sup>ab</sup>
Globe No.21	36±5.6 <sup>ab</sup>	11±2.3 <sup>ab</sup>	1.44±0.2	49±7.4 <sup>ab</sup>
Globe No.34	26±3.7 <sup>b</sup>	8±1.9 <sup>b</sup>	0.68±0.1	35±4.9 <sup>b</sup>

Means in columns with different lowercase superscript letters are significantly ( $p < 0.05$ ) different (LSD test, R Core Team, 2005).

Table 3. Mean numbers of hematophagous insects trapped daily ( $\pm 95\%$  confidence interval) using sticky screens.

Blue fabrics used to make screens	<i>Stomoxys</i> spp.	<i>M. crassirostris</i>	Tabanids	Total hematophagous insects
TDV S 250/Azur 023	16 $\pm$ 5.3 <sup>a</sup>	1.30 $\pm$ 0.4	1.20 $\pm$ 0.3	18 $\pm$ 5.5 <sup>a</sup>
CR Solon No.41	15 $\pm$ 4.1 <sup>a</sup>	1.05 $\pm$ 0.4	0.90 $\pm$ 0.3	17 $\pm$ 3.9 <sup>a</sup>
NS No.1469	15 $\pm$ 5.7 <sup>a</sup>	0.70 $\pm$ 0.3	0.85 $\pm$ 0.3	16 $\pm$ 5.7 <sup>ab</sup>
Globe No.21	10 $\pm$ 2.2 <sup>ab</sup>	0.55 $\pm$ 0.2	0.60 $\pm$ 0.2	11 $\pm$ 1.9 <sup>ab</sup>
Globe No.34	3 $\pm$ 0.6 <sup>b</sup>	0.65 $\pm$ 0.2	0.50 $\pm$ 0.2	4 $\pm$ 0.6 <sup>b</sup>

Means in columns with different lowercase superscript letters are significantly ( $p < 0.05$ ) different (LSD test, R Core Team, 2005).

### Experiment 2

The efficacy of five different blue fabric screens was evaluated using a Latin square design at five locations on both farms with five repeats (125 data points). Screens were serviced daily and spaced 20 m apart.

### Data analysis

This study was performed to compare the blue fabrics of traps and screens in two study locations, Farm 1 and Farm 2. From each device, the mean numbers of flies were calculated and their 95% confidence intervals compared. Data were subjected to analysis of variance (ANOVA) using a Latin square model and means were separated with the Least Significant Difference (LSD) test at a significance level of 5% (R Core Team 2005). Indices of fabric attraction were calculated, taking TDV<sup>®</sup> as the reference (Index = 1). If the mean number of trapped flies was below five flies/trap or five flies/screen/day, the records were removed to avoid statistical bias.

## RESULTS

### Blue fabrics

The blue fabric details are presented in Table 1. Figure 1 shows the reflectance of each of these fabrics, or the percentage of reflected light for wavelengths between 300 and 700 nm. All the fabrics except Globe No. 34 show a peak of reflectance around 460 nm.

Figure 2 shows the different fabrics presented under natural light and using a flash to highlight their apparent characteristics. Visual observation showed that Globe No. 34 was clearly darker than the other fabrics. Globe No. 21 and NS No. 1469 were shinier and reflected more white light when using a flash than the others.

### Experiment 1

A total of 5,980 hematophagous flies was caught during the 25 trapping days, with *Stomoxys* spp. predominating with 4,403 specimens (73.6%), followed by 1,430 of *M. crassirostris* (23.9%) and 147 tabanids (2.5%). The mean apparent density per trap was as high as 47.8 hematophagous insects/trap/day.

TDV S 250/Azur 023 had the highest number of hematophagous insects trapped ( $63 \pm 8$ ), accounting for 26.3% of the total catch (Table 2). This was followed in decreasing order by: both CR Solon No. 41 and Globe No.

21 = 20.4%, NS No.1469 = 18.3% and Globe No. 34 = 14.6%. Only Globe No.34 had consistently and significantly lower scores than the reference TDV. The reference trap, TDV S 250/Azur 023, captured the most flies, but its mean was not significantly different from the three best polyester traps, and the best synthetic fabric traps were those made with CR Solon No. 41 and Globe No. 21.

Indices of attractivity of the fabrics under Vavoua traps were calculated using TDV as the reference with a value of 1: TDV S 250/Azur 023 = 1, CR Solon No. 41 = 0.78, NS No.1469 = 0.70, Globe No. 21 = 0.78 and Globe No. 34 = 0.56.

### Experiment 2

The last repeat of this experiment produced mean trapping scores below five flies /screen/day, so these data were not included and only four repeats were considered in the analyses. In total, 1,312 hematophagous flies were caught during the 20 trapping days, *Stomoxys* spp. were more abundant with 1,146 specimens (87.3%), followed by only 85 *M. crassirostris* (6.5%) and 81 tabanids (6.2%). The mean apparent density per screen was only 13.1 hematophagous insects/screen/day. The analysis of variance showed that the screens had significantly different numbers for *Stomoxys* spp. and hematophagous flies only, so the LSD test was applied to them (Table 3).

For this experiment, we gathered two replications carried out in Farm 1 and two replications from Farm 2. The mean numbers of hematophagous flies trapped and their 95% confidence intervals are indicated in Table 3. TDV S 250/Azur 023 had the highest score of hematophagous insects caught ( $18 \pm 5.5$ ), accounting for 27.3%, followed by the other traps in decreasing order: CR Solon No. 41 = 25.8%, NS No. 1469 = 24.2%, Globe No. 21 = 16.7%, and Globe No. 34 = 6.1%.

Again, only Globe No. 34 had significantly lower scores than the other fabrics. Although the other four fabrics were not significantly different, they grouped differently, with TDV and CR Solon No. 41 in the same statistical group. The reference screen S 250/Azur 023 had the best performance, but the mean scores were not significantly different from the best polyester screens; the best synthetic fabric screen was CR Solon No. 41. Indexes of attractivity of the fabrics used as screens under blue sticky films were calculated using TDV as reference with a value of 1: TDV S 250/Azur 023 = 1, CR Solon No.41 = 0.94, NS No.1469 = 0.89, Globe No.21 = 0.61,



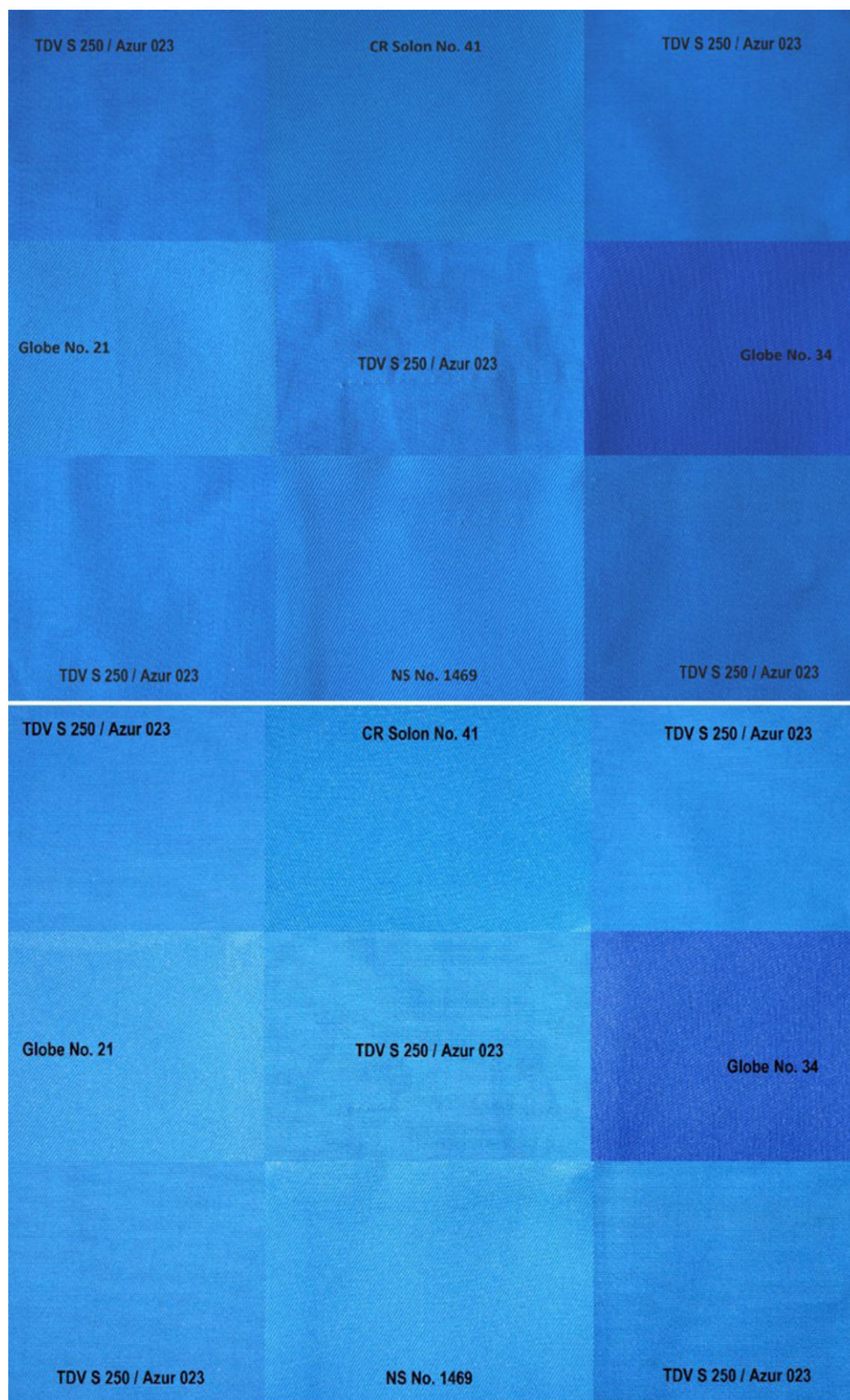


Figure 2. Visual aspects of five fabrics under natural light (upper nine squares) and a flash (lower nine squares) where the flash images help to show whitish reflectance of some synthetic fabric.

and Globe No.34= 0.22.

Combining the results obtained from the traps and screens experiments, the overall average index of attractivity for each fabric was calculated using TDV as the reference producing: TDV S 250/Azur 023 = 1, CR Solon No. 41 = 0.86, NS No.1469 = 0.79, Globe No.21 = 0.69, and Globe No. 34= 0.39. Consequently, the CR Solon No. 41 ranked first among the polyester fabrics.

## DISCUSSION

The present experiment was performed to compare four synthetic fabrics made in Thailand to a fabric (65% cotton, 35% polyester) made in France and used as a reference in traps or sticky screens to catch hematophagous flies.

The reference TDV S 250/Azur 023 fabric gave the best scores overall in all tests and experiments but the difference with the best synthetic fabrics was not statistically significant. This observation probably reflects the fact that stomoxids and other hematophagous insects caught in the studies were less sensitive than tsetse flies regarding the exact wavelength of the reflected light from the fabric. Indeed, for tsetse flies in all previous studies on blue-attracting fabrics, slight differences in the fabrics provide significant differences between the real cotton phthalogen blue fabrics and any of the polyester fabrics tested (Lindh et al. 2012, Rayaisse et al. 2012). For *Stomoxys*, the most attractive wave lengths are different from tsetse flies (Cilek 2003), as shown by Beresford and Sutcliffe (2006) who demonstrated that white coroplast, and even gray ones, were more attractive to *Stomoxys* than blue coroplasts. Attractivity of stable flies may even be greater with the light reflected by some alsynite traps than that of colored targets (Ose and Hogsette 2014).

Among the four polyester fabrics identified on the local market, one was clearly darker in color (Globe No. 34) and had significantly lower performances in all tests and experiments, compared to TDV and some of the other polyester fabrics. The other three polyester fabrics tended to have quite similar visual aspects, but their performances were not similar, which might be accounted for by the different light reflectance values they exhibited (Figures 1 and 2, especially under a flashlight). Indeed, the aspects of NS No. 1469 and Globe No. 21 were more brilliant and whitish. In the trap experiments, two fabrics, CR Solon No. 41 and Globe No. 21, proved to be the best, each with an index of 0.78, compared to the index of 1 for TDV. These two fabrics could be used to make traps. However, in the screen comparisons, CR Solon No. 41 had significantly better results than the other polyester fabrics, with an index of 0.94, being quite close to that of the reference TDV, while the other fabrics had indices below 0.90, with values of 0.89 for NS No.1469, 0.61 for Globe No. 21, and 0.22 for Globe No. 34.

Overall, the local polyester giving the best performance, both in traps and screen experiments, was the CR Solon No. 41 (Mun Ying Co., Ltd., Potaram, Ratchaburi province, Thailand), with a global index of 0.86. This product was regularly available from the manufacturer and costs around US\$1/m (150 cm width) which is around ten times lower than

the cost of the reference fabric TDV S 250/Azur 023. Moreover, it must be mentioned that the reference fabric TDV S 250/Azur 023 was no longer available in 2019. Consequently, CR Solon No. 41 can be recommended as the best local polyester fabric to build traps and screens for hematophagous insects in Thailand and in other countries. Using this fabric will help generate better standardized entomological studies on hematophagous flies.

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