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# Assessment of non-biting synanthropic flies associated with fresh markets

**Khoso FN, Wong SK, Chia SL and Lau WH**

**Abstract**
This study was conducted to assess the composition of non-biting synanthropic flies in different fresh markets. To achieve this goal, four fresh markets – Pasar Borong, Pasar Seri Kembangan, Pasar Bukit Serdang and Pasar Taman Seri Serdang – were surveyed in Serdang, Selangor, Malaysia. Non-biting synanthropic flies from different spots, i.e. middle of the market, grocery shops, food stalls, garbage piles and vacant places within these markets were collected. A total of 1,158 flies from 15 fly species were collected during the study period. The highest number of species was found from the family Muscidae, while individuals of the family Calliphoridae were the highest in number, of which the most prominent was *Chrysomya megacephala.* The highest number of flies (52%) and species (12) were found in Pasar Borong and the most populated sampling spot was garbage piles. A significant difference between Pasar Borong and all other markets ($p$= 0.0002) was observed. A significant difference was observed in all the sampling spots at different markets except the food stalls. The study shows that fresh markets can be potential places for breeding of disease spreading flies if proper sanitation practices are not applied.

**Keywords:** Synanthropic flies, Calliphoridae, Muscidae, Sarcophagidae, wet markets, Sanitation.

## 1. Introduction
Flies are important insects in medical, agricultural and forensic studies. They are capable of adopting human surroundings and tend to transmit pathogens, either mechanically or biologically, through their living style [1]. These types of flies are known as synanthropic flies. They are largely linked to sanitation practices and their population increases in both urban and rural areas when sanitary practices are not followed [2]. These flies are well appointed with sensory cells on their appendages so that they can detect compounds, such as ammonia and carbon dioxide emitted from faeces and other decomposing organic materials [3]. An easy approach to animal manure, trash, human excrement, and other decaying materials ensures that they are charged with disease causing organisms on their mouthparts, body hairs and the sticky pads of their feet, stomach, faeces and vomit [4]. In addition, their access to food items, cutlery, kitchens, and human beings allows them to transmit disease-causing agents [5-6].
Evidence regarding the transmission of pathogens by non-biting synanthropic flies have been reported worldwide [2, 7-9]. Several studies showed that non-biting synanthropic flies carry different stages of helminths and protozoan parasites [6, 10-11]. According to Sulaiman *et al.* [7], and Fetenea and Workub [11], the eggs of *Ascaris lumbricoides*, *Trichuris trichiura* and *Necator americanus* were isolated from *Chrysomya*, *Sarcophaga* and *Musca* fly species collected from garbage and peridomestic sites. Houseflies carry the eggs of *Enterobius vermicularis*, *Toxocara canis*, *Strongyloides stercoralis* and cysts and trophozoites of *Entamoeba coli*, as well as *Giardia* and *Trichomonas* spp. [12-14].
Besides helminths and protozae, non-biting synanthropic flies are carriers of disease causing bacteria and viruses, such as *Shigella dysenteriae* and *Escherichia coli* [15], *Aeromonas hydrophila* and *Pseudomonas aeruginosa* [16]. Viral pathogens transmitted by domestic flies include poliovirus, coxsackie virus, enteroviruses [2, 17-18], H5N1 virus [19] and Bovine papillomavirus [20]. Non-biting synanthropic larvae are also myiasis-producing agents in humans and animals [21-22].
In Malaysia, non-biting synanthropic flies have been reported in cafeterias, food courts, abattoirs and garbage spots [23-26]. On the other hand, studies in Malaysia showed that insects, such as *Musca domestica, M. sorbens* and *C. megacephala* are capable of carrying rotavirus, *Burkholderia pseudomallei*, *Klebsiella oxytoca*, *K. pneumonia*, *Aeromonas hydrophila* and *Salmonella* sp, which cause diarrhoea, melioidosis, nosocomial infections, pneumonia, gastroenteritis and typhoid, respectively [3, 27-28]. This study was conducted

to investigate the species of fly present in wet markets. In Malaysia, many people go to fresh markets to buy their food and groceries. The presence of these flies may contribute to food poisoning if proper handling of food is not practiced.

## 2. Materials and Methods

### 2.1. Sampling location

Non-biting synanthropic flies were collected from four wet markets in the district of Serdang, Selangor, Malaysia; namely, Pasar Borong, Pasar Seri Kembangan, Pasar Seri Serdang and Pasar Taman Seri Serdang. Five sampling spots were selected and labelled as (A) centre of market, (B) grocery shops, (C) vacant area, (D) garbage area and (E) food stalls (Figure 1). The data were collected in three replications during January to October 2013.

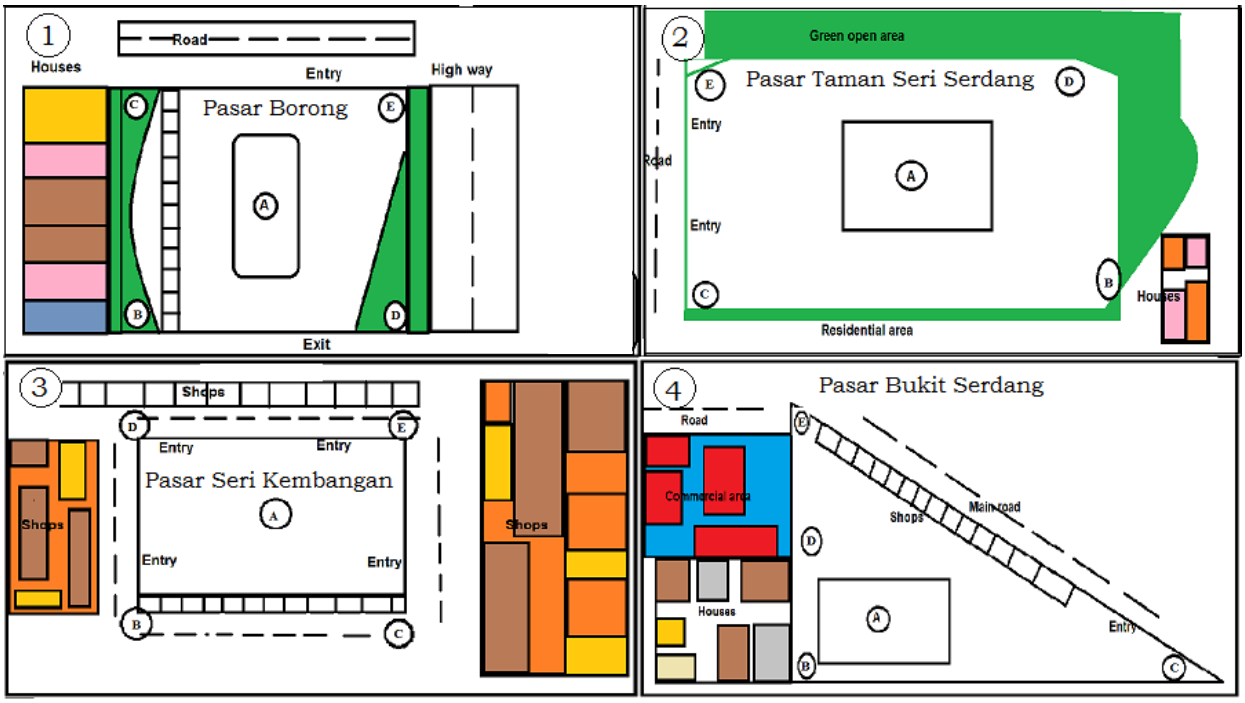


**Fig 1:** An eagle eye view of fresh markets in Serdang District. (1) Pasar Borong, (2) Pasar Taman Seri Serdang, (3) Pasar Seri Kembangan and (4) Pasar Bukit Serdang with collection spots: (A) centre of market, (B) grocery shops, (C) vacant area, (D) garbage area, and (E) food stalls.

### 2.2. Collection of insects

The insects were collected using chicken liver bait (200 g), which was kept overnight at room temperature to allow it to become rotten. Plastic containers (8x10x12 inch) with a small entrance (3x4 inch) for insects were placed at each sampling spot. These containers were exposed for 30 min and specimens were collected. This process was repeated five times. The collection was done between 9 am to 12 pm. The collected insects were then transferred to the Laboratory of Insect Pathology at the Department of Plant Protection, Universiti Putra Malaysia.

### 2.3. Identification

Initial morphological identification was carried out according to Tumrasvin *et al.* [29], Greenberg and Kunich [30], and Sukontason *et al.* [31]. After grouping, the specimens were kept at -20 ˚C for further experimentation. The molecular identification of flies was conducted in detail (unpublished) with phylogenetic studies. The sequence was deposited in GenBank (http://www.ncbi.nlm.nih.gov).

### 2.4. Frequency and dominance of a Species

The frequency and dominance of the non-biting synanthropic flies were calculated according to the equation of Oliveira and Vasconcelo [32]. The equation for frequency of occurrence (FO) was as FO = [Number of sampling spots in which a species X occurs/total number of sampling spots] X 100. Species with FO value ≥ 50% were classified as very frequent, FO value between 25% and 50% classified as frequent, and FO value ≤ 25% classified as infrequent. Dominance was calculated as D = [abundance of the family i/total abundance of the specimens] X 100. When D ≥ 5% = dominant family; 2.5% ≤ D ≤ 5% = accessory family, when D ≤ 2.5% = occasional family. The species were grouped as low (N ≤ 50), Intermediate (50 ≤ N ≤ 100) and high (N ≥ 100).

### 2.5. Statistical analysis

To examine the relationship between the fly species and sampling spot, the raw data were transformed with $LOG_{10}$ (x+1) to normalize the data. One way analysis of variance (ANOVA) and Tukey's HSD test were employed to investigate the relationship of each species with each sampling spot and market location using SAS 9.0 (α=0.05).

## 3. Results

A total of 1,158 flies were collected during the study period. Fifteen species were identified belonging to three dipteran families; namely, Calliphoridae, Muscidae and Sarcophagidae. The most abundant family was Calliphoridae (68%) followed by Muscidae (26%) and Sarcophagidae (6%), as shown in Table 1 and Figure 2A.

**Table 1:** List of species, abundance, frequency and dominance of non-biting synanthropic flies collected from different fresh markets

| Species | GenBank Accession | No. | Abundance | Frequency | Dominancy |
|---|---|---|---|---|---|
| **Calliphoridae** | | | | | |
| *Chrysomya rufifacies* | KC_855273-74, KF_562105, KJ_496779-80 | 67 | Intermediate | Very frequent | Dominant |
| *Chrysomya megacephala* | KC_855270-72,KC_855286, KF_562106,KJ_496781-85 | 588 | High | Very frequent | Dominant |
| *Hemipyrellia ligurries* | KC_855275,KF_562113, KJ_496772-74 | 88 | Intermediate | Very frequent | Dominant |
| *Lucilia cuprina* | KF_562103,KJ_496769-71 | 46 | Low | Very frequent | Dominant |
| **Muscidae** | | | | | |
| *Musca domestica* | KC_855277,KF_562113, KJ_496775-77 | 196 | High | Very frequent | Dominant |
| *Musca ventrosa* | KF_562112, KJ_496778 | 12 | Low | Frequent | Accessory |
| *Atherigona orientalis* | KF562115 | 17 | Low | Infrequent | Dominant |
| *Ophyra chalcogaster* | KC_855281,KF_562114, KJ_496788 | 17 | Low | Frequent | Accessory |
| *Ophyra spinigera* | KC_855280,KJ_496786-87 | 53 | Intermediate | Frequent | Dominant |
| *Synthesiomyia nudiseta* | KF_562117, KJ_496790 | 3 | Low | Infrequent | Dominant |
| **Sarcophagidae** | | | | | |
| *Sarcophaga dux* | KC_855284, KF_562109, KJ_496796-800 | 24 | Low | Infrequent | Dominant |
| *Sarcophaga peregrina* | KC_855282-83, KF_562108,KJ_496791-94 | 24 | Low | Frequent | Dominant |
| *Sarcophaga ruficornis* | KF_562110, KJ_496801-02 | 13 | Low | Infrequent | Dominant |
| *Sarcophaga taenionota* | KC_855285, KF_562107, KJ_496795 | 4 | Low | Infrequent | Accessory |
| *Sarcophaga kempi* | KF562111 | 6 | Low | Infrequent | Dominant |

The highest number of flies was caught from Pasar Borong (52%), followed by Pasar Taman Seri Serdang (22%), Pasar Bukit Serdang (16%) and Pasar Seri Kembangan (10%) (Figure 2B). The highest number of flies was collected from the garbage area (45%) while the lowest was found at the centre of the market (8%). The percentage of flies in the grocery shops, vacant area and near food stalls was 18%, 12% and 17%, respectively (Figure 2C). The most abundant species at all markets was *C. megacephala* (51%), followed by *M. domestica* (17%) and all other species were found to be <5% except *C. rufifacies* (6%) (Figure 2D).

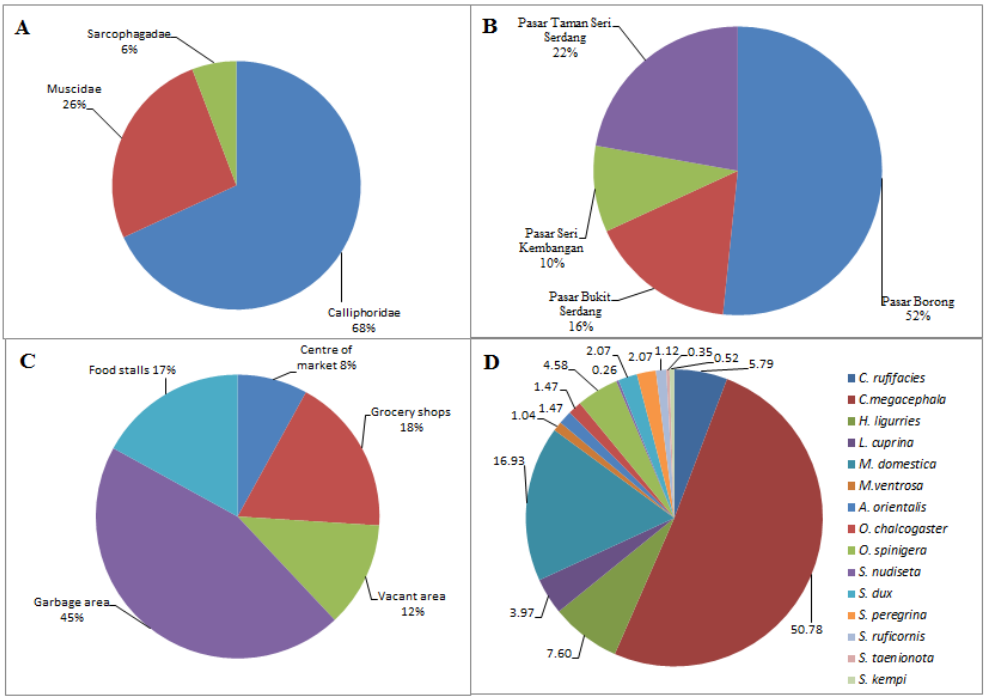


**Fig 2:** Flies population in fresh markets. Percentage of flies are presented according to the (A) Fly families; (B) Fresh markets; (C) Sampling spots and (D) Species.

All species of family Calliphoridae; namely, *C. megacephala, C. rufifacies, Hemipyrellia ligurries,* and *Lucilia cuprina* were very frequent and dominant in all the fresh markets (Table 1). Among the members of Muscidae, *M. domestica* was very frequent and dominant whereas *Atherigona orientalis* and *Synthesiomyia nudiseta* were infrequent but dominant. *Ophyra spinigera*, *M. ventrosa* and *O. chalcogaster* were frequent in fresh markets but *O. spinigera* was more dominant than *O. chalcogaster* and *M. ventrosa*. Members of Sarcophagidae were not abundant or frequent in fresh markets except *Sarcophaga peregrina.*

The composition of flies in various spots of different markets is given in Table 2.

**Table 2:** The mean number (± S.E) of flies collected from all the markets and different sampling spots in different markets

| Markets | Over all | Centre | Grocery shop | Vacant area | Garbage pile | Food stall |
|---|---|---|---|---|---|---|
| | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E |
| Pasar Borong | $39.87^{a}$±6.08 | $13.33^{a}$±1.67 | $43.33^{a}$±8.51 | $55.00^{a}$±6.11 | $64.67^{a}$±14.19 | $23.00^{a}$±7.57 |
| Pasar Bukit Serdang | $12.73^{b}$±3.31 | $3.33^{b}$±1.33 | $6.00^{b}$±2.00 | $7.00^{b}$±1.52 | $33.67^{ab}$±6.23 | $13.67^{a}$±5.81 |
| Pasar Seri Kembangan | $7.47^{b}$±1.28 | $2.33^{b}$±1.20 | $9.33^{b}$±3.18 | $4.67^{b}$±2.02 | $14.00^{b}$±1.00 | $7.00^{a}$±0.58 |
| Pasar Taman Seri Serdang | $17.13^{b}$±3.30 | $10.33^{a}$±0.88 | $11.33^{b}$±3.18 | $5.00^{b}$±2.89 | $37.33^{ab}$±5.548 | $21.67^{a}$±1.85 |

Means followed by the same letters within a column are not significantly different ($P \leq 0.05$) according to Tukey test analysis

The results showed that the number of flies was significantly higher ($p < 0.0001$) at Pasar Borong (39.87±6.08), whereas no significant difference was observed in the other three markets. The results regarding the collecting spots showed that the population of flies in the grocery shops (43.33±8.51) and vacant areas (55.00±6.11) of Pasar Borong was significantly higher than the other three markets where the fly population was not significantly different ($P < 0.001$). The population of flies at the garbage pile (64.67±14.19) in Pasar Borong was the highest ($P < 0.0001$) whereas Pasar Seri Kembangan (14.00±1.008) showed the significantly lowest population. The population of flies did not show a significant difference at the food stalls. The lowest population of flies was recorded at the centre of the markets. Pasar Borong was significantly different from Pasar Bukit Serdang and Pasar Seri Kembangan.
Species richness in all markets is demonstrated in Table 3.

According to the results, the population of *C. megacephala* (20.00±3.66) and *M. domestica* (6.73±0.92) in Pasar Borong was significantly higher ($P < 0.001$) than the other three markets, which showed no significant difference in the population of the two species. A significantly higher population (3.13± 0.43) of *H. ligurries* was observed from Pasar Borong with no population from Pasar Bukit Serdang. The population of *L. cuprina* was significantly higher ($P < 0.001$) at Pasar Borong (2.40±0.46) than Pasar Taman Sri Serdang (0.67±0.25) with no population recorded from the other two markets. The population of *M. ventrosa, O. chalcogaster* and *S. dux* was also recorded from two locations. The population of *M. ventrosa* was significantly higher ($p<0.001$) at Pasar Sri Serdang (0.67±0.29) than at Pasar Borong (0.13±0.13), the *O. chalcogaster* population was significantly higher at Pasar Seri Kembangan (0.80±0.28) than Pasar Borong (0.33±0.15) and the *S. dux* population (1.33±0.49) at Pasar Borong was significantly higher than at Pasar Taman Sri Serdang (0.27±0.15). The significantly lowest population (0.33±0.19) of *O. spinigera* was observed at Pasar Bukit Serdang, whereas there was no significant difference among the other three markets ($p < 0.001$). The population of *C. rufifacies* was recorded from Pasar Borong, Pasar Bukit Serdang and Pasar Taman Sri Serdang with no significant difference. The population of *S. ruficornis* and *S. peregrina* was only recorded from Pasar Borong whereas the population of *S. nudiseta, S. taenionota and S. kempi* was only recorded from Pasar Taman Sri Serdang.
The composition of species at different sampling spots and the comparison among the different markets reveal that at the centre of all markets, the *C. megacephala* population (3.67±0.67) was significantly higher ($p < 0.05$) at Pasar Bukit Serdang (0.67±0.33) (Table 3). A significantly higher population (1.67±0.33) of *C. rufifacies* was recorded at Pasar Taman Sri Serdang than Pasar Borong (0.33±0.33) with no significant difference to the population at Pasar Bukit Serdang. However, no population of *C. rufifacies* was observed from Pasar Sri Kembangan. The population of *M. domestica* (7.67±0.88) was significantly higher at Pasar Borong than at the other markets, which showed no difference with each other ($p < 0.001$).

The population of *H. ligurries* and *L. cuprina* showed no significant difference at the different markets ($p > 0.05$), whereas the population of *M. ventrosa* was only observed from Pasar Taman Sri Serdang. The population of other species was not recorded at the centre of any of the markets.
The population of flies at the grocery shop area of the different markets demonstrated that the highest population of *C. megacephala* (25.67±4.18) was recorded at Pasar Borong whereas no significant difference was observed among the other markets (Table 3). A significant difference ($p < 0.05$) in the population of *C. rufifacies* in the grocery areas of Pasar Taman Sri Serdang (2.00±0.58) and Pasar Bukit Serdang (0.67±0.33) was observed. The population of *H. ligurries* was significantly high at Pasar Borong (3.67±0.88) whereas no population was recorded at Pasar Bukit Serdang. The population of *L. cuprina* was only observed at Pasar Borong (3.00±0.58) and Pasar Taman Sri Serdang (0.67±0.67) with a significant difference ($p < 0.001$). *M. domestica* was recorded at Pasar Borong with a population recorded at 7.00±1.73, whereas the lowest population of *M. domestica* was recorded at Pasar Taman Sri Serdang (0.33±0.33). The population of *M. ventrosa, S. peregrine* and *S. ruficornis* was only recorded at Pasar Taman Seri Serdang and Pasar Borong, respectively. *O. chalcogaster, O. spinigera* and *S. dux* were found at the grocery area of two markets with no significant difference among them. Other species, such as *S. nudiseta, S. taenionota* and *S. kempi*, were recorded in the grocery areas of all the markets.
In the vacant area, the population of *C. megacephala* was significantly different ($p < 0001$) among the markets. The highest number of flies was recorded at Pasar Borong (21.67±2.73) followed by Pasar Bukit Serdang (5.22±1.22), whereas no significant difference was observed among the remaining markets. A significantly higher number of *H. ligurries* was recorded ($p = 0.0123$) at Pasar Borong (4.00±1.00) than Pasar Seri Kembangan and Pasar Taman Seri Serdang whereas no population was observed at Pasar Bukit Serdang. The *M. domestica* population scored the highest ($p < 0.0055$) at Pasar Borong (10.33±2.90) compared to the other markets. *O. spinigera* was only observed at two markets with Pasar Borong (4.67±1.20) showing a significantly higher number ($p < 0.05$) than Pasar Bukit Serdang (0.67±0.67). *O. chalcogaster* was only recorded at Pasar Borong and Pasar Seri Kembangan with no significant difference. *L. cuprina, M. ventrosa, A. orientalis, S. dux, S. peregrina* and *S. ruficornis* were only collected from Pasar Borong, whereas *C. rufifacies* and *S. taenionota* were found at Pasar Taman Seri Serdang. No population was recorded for *S. nudiseta* and *S. kempi* at the vacant areas of any of the markets.

**Table 3:** The mean number (± S.E) of flies collected from all the market with different sampling spots

| Sampling spot | Markets | *C. megacephala* | *C. rufifacies* | *H. ligurries* | *L. cuprina* | *M. domestica* | *M. ventrosa* | *A. orientalis* | *O. chalcogaster* | *O. spinigera* | *S. nudiseta* | *S. dux* | *S. peregrina* | *S. ruficornis* | *S. taenionota* | *S. kempi* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean ±S.E | Mean ±S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E | Mean ± S.E |
| All sites | Pasar Borong | $20.00^{a}$±3.66 | $1.07^{a}$±0.30 | $3.13^{a}$±0.43 | $2.40^{a}$±0.46 | $6.73^{a}$±0.92 | $0.13^{b}$±0.13 | $1.13^{a}$±0.53 | $0.33^{b}$±0.15 | $1.47^{a}$±0.58 | - | $1.33^{a}$±0.49 | $1.27^{a}$±0.41 | $0.87^{a}$±0.50 | - | - |
| | Pasar Bukit Serdang | $8.33^{b}$ ±2.27 | $1.87^{a}$±0.57 | - | - | $2.20^{b}$±0.59 | - | - | - | $0.33^{b}$±0.19 | - | - | - | - | - | - |
| | Pasar Seri Kembangan | $2.47^{b}$±0.41 | - | $1.40^{b}$±0.34 | - | $1.87^{b}$±0.51 | - | - | $0.80^{a}$±0.28 | $0.93^{a}$±0.36 | - | - | - | - | - | - |
| | Pasar Taman Seri Serdang | $8.40^{b}$ ±2.45 | $1.53^{a}$±0.38 | $1.33^{b}$±0.41 | $0.67^{b}$±0.25 | $2.27^{b}$±0.55 | $0.67^{a}$±0.29 | - | - | $1.13^{a}$±0.49 | $0.20^{a}$±0.20 | $0.27^{b}$±0.15 | - | - | $0.27^{a}$±0.20 | $0.40^{a}$±0.27 |
| Centre | Pasar Borong | $2.67^{ab}$±0.88 | $0.33^{b}$±0.33 | $0.67^{a}$±0.67 | $2.00^{a}$±0.58 | $7.67^{a}$±0.88 | - | - | - | - | - | - | - | - | - | - |
| | Pasar Bukit Serdang | $0.67^{b}$±0.33 | $1.00^{ab}$±0.58 | - | - | $1.67^{b}$±0.88 | - | - | - | - | - | - | - | - | - | - |
| | Pasar Seri Kembangan | $1.00^{ab}$±0.58 | - | $0.33^{a}$±0.33 | - | $1.00^{b}$±0.58 | - | - | - | - | - | - | - | - | - | - |
| | Pasar Taman Seri Serdang | $3.67^{a}$±0.67 | $1.67^{a}$±0.33 | $1.33^{a}$±0.88 | $1.00^{a}$±0.58 | $2.33^{b}$±0.88 | $0.33^{a}$±0.33 | - | - | - | - | - | - | - | - | - |
| Grocery shop | Pasar Borong | $25.67^{a}$±4.18 | $1.33^{ab}$±0.88 | $3.67^{a}$±0.88 | $3.00^{a}$±0.58 | $7.00^{a}$±1.73 | - | - | $0.33^{a}$±0.33 | - | - | $0.67^{a}$±0.67 | $1.00^{a}$±1.00 | $0.67^{a}$±0.67 | - | - |
| | Pasar Bukit Serdang | $4.33^{b}$±1.20 | $0.67^{b}$±0.33 | - | - | $1.00^{c}$±0.58 | - | - | - | - | - | - | - | - | - | - |
| | Pasar Seri Kembangan | $3.67^{b}$±0.88 | - | $1.33^{b}$±0.67 | - | $2.67^{b}$±0.88 | - | - | $0.33^{a}$±0.58 | $1.33^{a}$±0.88 | - | - | - | - | - | - |
| | Pasar Taman Seri Serdang | $6.00^{b}$±1.53 | $2.00^{a}$±0.58 | $0.33^{b}$±0.33 | $0.67^{b}$±0.67 | $0.33^{c}$±0.33 | $1.00^{a}$±0.58 | - | - | $0.67^{a}$±0.67 | - | $0.33^{a}$±0.33 | - | - | - | - |
| Vacant area | Pasar Borong | $21.67^{a}$±2.73 | - | $4.00^{a}$±1.00 | $3.33^{a}$±1.45 | $10.33^{a}$±2.90 | $0.67^{a}$±0.67 | $1.67^{a}$±1.20 | $1.00^{a}$±0.58 | $4.67^{a}$±1.20 | - | $2.33^{a}$±0.33 | $1.67^{a}$± .20 | $3.67^{a}$±1.76 | - | - |
| | Pasar Bukit Serdang | $5.33^{b}$±1.20 | - | - | - | $1.00^{b}$±0.58 | - | - | - | $0.67^{b}$±0.67 | - | - | - | - | - | - |
| | Pasar Seri Kembangan | $2.00^{c}$±0.58 | - | $1.00^{b}$±0.58 | - | $0.33^{b}$±0.33 | - | - | $1.33^{a}$±0.88 | - | - | - | - | - | - | - |
| | Pasar Taman Seri Serdang | $2.33^{c}$±1.45 | $0.67^{a}$±0.67 | $0.67^{b}$±0.67 | - | $1.00^{b}$±1.00 | - | - | - | - | - | - | - | - | $0.33^{a}$±0.33 | - |
| Garbage pile | Pasar Borong | $38.33^{a}$±7.44 | $2.33^{b}$±0.67 | $3.33^{a}$±0.33 | $2.00^{a}$±1.53 | $5.33^{a}$±1.45 | - | $4.00^{a}$±1.53 | $3.33^{a}$±0.33 | $2.33^{a}$±1.45 | - | $3.67^{a}$±1.67 | $3.00^{a}$±1.16 | - | - | - |
| | Pasar Bukit Serdang | $23.00^{b}$±4.04 | $5.00^{a}$±1.15 | - | - | $5.67^{a}$±1.45 | - | - | - | - | - | - | - | - | - | - |
| | Pasar Seri Kembangan | $4.00^{c}$±0.58 | - | $2.67^{a}$±0.33 | - | $4.67^{a}$±0.88 | - | - | $1.67^{a}$±0.88 | $1.00^{a}$±0.58 | - | - | - | - | - | - |
| | Pasar Taman Seri Serdang | $25.67^{b}$±3.18 | $3.33^{ab}$±0.88 | $1.33^{b}$±0.33 | $3.33^{a}$±0.33 | $5.00^{a}$±1.15 | $3.33^{a}$±0.33 | - | - | $1.33^{a}$±1.33 | - | - | - | - | - | - |
| Food stall | Pasar Borong | $11.67^{a}$±4.26 | $1.33^{a}$±0.33 | $4.00^{a}$±0.58 | $1.67^{a}$±0.88 | $3.33^{a}$±1.45 | - | - | - | $0.33^{bc}$±0.33 | - | - | $0.67^{a}$±0.33 | - | - | - |
| | Pasar Bukit Serdang | $8.33^{ab}$±3.48 | $2.67^{a}$±1.20 | - | - | $1.67^{ab}$±0.88 | - | - | - | $1.00^{b}$±0.58 | - | - | - | - | - | - |
| | Pasar Seri Kembangan | $1.67^{c}$±0.88 | - | $1.67^{b}$±1.20 | - | $0.67^{b}$±0.67 | - | - | $0.67^{a}$±0.33 | $2.33^{ab}$±1.20 | - | - | - | - | - | - |
| | Pasar Taman Seri Serdang | $4.33^{bc}$±2.33 | | $3.00^{ab}$±1.53 | $1.33^{a}$±0.88 | $2.67^{a}$±0.88 | $1.67^{a}$±1.20 | | - | $3.67^{a}$±1.20 | $1.00^{a}$±1.00 | $1.00^{a}$±0.58 | - | - | $1.00^{a}$±1.00 | $2.00^{a}$±1.00 |

The results regarding the number of flies at the garbage piles showed that a significantly higher ($p < 0.005$) number of *C. megacephala* was collected from Pasar Borong (38.33±7.44), whereas the lowest population was recorded from Pasar Sri Kembangan (4.00±0.58) (Table 3). The number of *C. rufifacies* was significantly higher ($p= 0.0134$) at Pasar Bukit Serdang (5.00±1.15) than Pasar Borong, whereas no difference was observed between Pasar Taman Sri Serdang and the two markets mentioned above. No population of *C. rufifacies* was recorded from Pasar Seri Kembangan. The number of *H. ligurries* was significantly higher ($p <0.05$) at this collection spot at both Pasar Borong (3.33±0.33) and Pasar Seri Kembangan (2.67±0.33) than Pasar Taman Seri Serdang (1.33±0.33) and no population was found at Pasar Bukit Serdang. No significant difference in the population of *L. cuprina*, *M. domestica*, *O. chalcogaster* and *O. Spinigera* was observed from the different markets, whereas *S. peregrina*, *S. dux* and *A. orientalis* were only recorded at Pasar Borong, and *M. ventrosa* only at Pasar Taman Seri Serdang.

The composition of species at the food stall spots of all the markets demonstrate that *C. megacephala* was significantly different ($p < 0.005$) and the highest in number at Pasar Borong (11.67±4.26), whereas the lowest number was recorded at Pasar Seri Kembangan (1.67±0.88) (Table 3). The number of *H. ligurries* was significantly different ($p < 0.005$) at the food stalls of Pasar Borong (4.00±0.58) to Pasar Seri Kembangan and Pasar Taman Seri Serdang, whereas no fly was captured from Pasar Bukit Serdang. The number of *M. domestica* was only significantly different ($p <0.005$) between Pasar Borong (3.33±1.45) and Pasar Seri Kembangan (0.67±0.67). A significantly higher number of *O. spinigera* was recorded at Pasar Taman Seri Serdang (3.67±1.20) from Pasar Borong and Pasar Bukit Serdang ($p = 0.005$). The population of *C. rufifacies*, *L. cuprina. M. ventrosa, S. nudiseta, S. dux, S. taenionota, S. kempi, O. chalcogaster* and *S. peregrina* was either recorded from only one market or with no significant difference from two markets.

## 4. Discussion

In Malaysia, studies have been carried out on non-biting synanthropic flies at different places, such as food outlets [24], village sundry shop [25] and sanitary landfill [26]. Different fly species have been observed in these studies. In the fresh markets of Serdang, flies have been identified belonging to three dipteran families, Calliphoridae, Muscidae and Sarcophagidae. Family Calliphoridae had the highest number of individuals captured, while family Muscidae had the highest number of species. The highest number of flies and fly species was captured from Pasar Borong. This market operates 24 hours, the premises is very large, away from a highly populated area, covered with natural fauna along with a large area for the garbage pile and comparatively less sanitation is being practiced. Pasar Taman Seri Serdang is similar to Pasar Borong except the business runs from 7 a.m. to 2 p.m. and the size of premises is smaller. It receives fewer flies than Pasar Borong. Fewer flies were found at Pasar Seri Kembangan and fewer species were found at Pasar Bukit Serdang. These areas are congested with people and the flies get less chance to settle on the bait. Pasar Bukit Serdang is a newly established market and has very short business hours (4-5hr) and proper sanitation is practiced compared to the other markets; therefore, fewer flies were captured from this market.

*C. megacephala* was revealed as the most abundant non-biting synanthropic fly in the fresh markets compared to the other fly species. The sites with a higher number of *C. megacephala* comprised the grocery shops, food stalls, vacant area, and garbage piles. This finding is in agreement with Gabre and Abou Zied [1], Lertthamnongtham *et al*. [33], Nazni *et al*. [23], Ngoen-klan *et al*. [34] and Chaiwong *et al*. [35] but in contrast to Sucharit and Tumrasvin [36], Winpisinger *et al*. [37], Goulson *et al*.[38], Nurita *et al*. [25], Nurita *et al*. [26] and Adenusi and Adewoga [39], who reported that a higher number of *M. domestica* was recorded at different places. In this study, fewer houseflies (Family: Muscidae) were collected from all the sampling spots compared to the centre of the market. This may be due to the selection of the collection area and the kind of bait used in this study. Nurita *et al*. [25] and Nurita *et al*. [26] used sticky paper bait for the collection of flies from the cafeteria, food court, slaughterhouse and sundry shop. Blow flies (Family: Calliphoridae) are more attracted to carrion bait and soggy, bloody or soiled hair, fur, or wool [26, 34-35] and use these resources as the platform for egg laying and protein sources for the maturation of eggs [40]. The low number of flesh fly species throughout the study period may be due to the baiting system or lower population in these locations.

Besides *C. megacephala*, other Calliphoridae flies were also found to be higher in number, such as *C. rufifacies, H. ligurries* and *L. cuprina.* These insects are primarily necrophagous flies and important in forensic studies [10, 41-42]. The other members of family Muscidae, *M. ventrosa, A. orientalis, O. chalcogaster, O. spinigera, S. nudiseta* were comparatively less in number than *M. domestica*. *A. orientalis* and *S. nudiseta*, and were only found in Pasar Borong and Pasar Taman Seri Serdang. *A. orientalis* is commonly known as the pepper fruit fly or tomato fruit fly. It is reported to lay eggs in oviposition sites of other insects and it is suspected that the larvae of *A. orientalis* feed on the larvae of *Bactrocera* spp. [43] and *Dacus* spp. [44]. *S. nudiseta* has been described as essentially necrophagous and of medico-legal relevance in Brazil [45-47], Egypt [48], south-eastern United States [49], Thailand [16] and Malaysia [25, 50-51].

*Ophyra* sp. (also known as *Hydrotaea* sp.) is frequently associated with livestock and urban garbage and reported as a predator, coprophagous and saprophagous species [52]. The larvae of *Ophyra* sp. are facultative predators of other dipteran larvae, especially the larvae of *M. domestica* [53-54]. They were the last group of fly that appeared at the bait area during the sampling period. This may be due to the presence of female houseflies at the baiting area that lay eggs [55] and provide the opportunity to the *Ophyra* sp. to predate on them [26]. *M. ventrosa* has been reported by Nazni *et al*. [23] in Putrajaya and Kuala Lumpur and was found to be low in number when captured from Pasar Borong and Pasar Taman Seri Serdang in this study. This fly feeds mainly on wounds, sores and bites inflicted by other flies and also visit cow dung for egg deposition [56]. Members of the family Sarcophagidae, *S. dux, S. peregrina, S. ruficornis, S. taenionota and S. kempi*, were also trapped in the bait. These flies are important in forensic studies and veterinary entomology. These flies are difficult to be identified at the adult stage due to a high resemblance in external appearance, but possible through molecular identification [57]. *S. peregrina* is a necrobiodotic fly (larviposition on carrion). Together with *S. dux* and *S. ruficornis*, they are amphibiodotic (larviposition on both faeces and carrion). The class for *S. kempi* and *S. taenionota* is still not established yet [58]. The non-biting synanthropic flies have the potential to breed and disperse to neighbouring areas, where they are not only becoming a nuisance but a threat to public health [59].

## 5. Conclusion

The presence of filth flies in the study areas is a matter of great concern as these flies are potential carrier of different disease-causing agents. Future work on different dimensions of these flies should be carried out in Malaysia. Furthermore, this study also revealed that the contiginous flies are distributed in different fresh markets which can potentially be disperse in the surrounding, where they are not only become nuisance but threat to public health. Finally, this study may gain the attraction of people and authorities to enforce the proper sanitation practices in public places.

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