Tropical Biomedicine 33(2): 359–365 (2016)

Influence of imported horse food on housefly *(Musca domestica* Linnaeus*)* population densities around horse barns and stables in Terengganu equestrian resort (TER)

Wahizatul, A.A.[1*], Faridah, M.[1] and Nur Farhah, A.S.[1]
[1]School of Marine and Environmental Sciences, Universiti Malaysia Terengganu,
21030 Kuala Terengganu, Terengganu, Malaysia.
[*]Corresponding author e-mail: wahizatul@umt.edu.my
Received 22 November 2014; received in revised form 17 January 2015; accepted 28 February 2015

Abstract. *Musca domestica* Linnaeus or house fly is one of the well-known cosmopolitan pests. Poultry farms, horse stables and ranches are some of the main habitats for house flies to extend their interference and disturbance. Since 1999, large number of fly population around horse stables and barns in Terengganu Equestrian Resort (TER) was detected and still persists till today. Imported horse food are speculated to be the main cause for the increasing number of these flies. The current study was conducted to determine the effect of imported horse food (i.e. chaff, pallet and alfalfa) and the food conditions (wet and dry) on house fly population densities. Commercial sticky papers were used for trapping house fly distribution around the horse stables and barns in TER from October 2013 to January 2014. A total of 36,751 flies were caught during the eight week study period. The highest number of flies (2,843 individuals) was caught when using 'wet alfalfa + chaff' whereas the lowest catch was when using 'dry alfalfa' (1,652 individuals). Generally, the wet food treatments captured higher flies compared to dry food treatments. The total number of captured flies was found to be influenced by relative humidity. Higher mean number of flies was captured during lower weekly humidity. Our findings conclude that the wet condition of imported horse food in TER increases the house flies population densities. Thus, urgent action should be taken as soon as possible and may need special management considerations in order to reduce the impact of house flies on the horse industry in Malaysia.

INTRODUCTION

The house fly, *Musca domestica* Linnaeus is a well-known cosmopolitan pest that is always found in association with food, wastes and feces of humans and animals (Sanchez-Arroyo & Capinera, 1998). House flies account for nine out of every ten flies that inhabit homes and other building that are used by humans such as poultry farms, horse stables and ranches (Albarrak, 2009). *Musca domestica* continues to be a nuisance and potential disease transmitter in urban and agricultural areas. High fly populations are not only an irritant to farm workers but can be a public health problem. They are considered to be pests and often exterminators will need to be called in order to deal with a large infestation of houseflies within a home or farm.

Food given to livestock may increase fly densities. Usually, flies are attracted to wet food conditions as organic matters in wet conditions provide ideal place for the development of the house fly (Peters & Barbosa, 1977). Most studies were conducted at farms of cattle, sheep and poultry (i.e Burg & Axtel, 1984; Hogsette *et al.*, 1993; Albarrak, 2009) but very little is known about the house fly population in horse stables and barns.

Terengganu Equestrian Resort (TER) which is located in the state of Terengganu in Malaysia ia a world class equestrian park and resort. The complex has 116 horse stables

and also provides training centre, polo field, resort, hall, sport centre and other facilities. The management is concerned with the increasing number of flies around their complex within the last five years, and associate it with the introductiom of imported horse food (i.e. horse pallets, chaff and alfalfa) since 1999. Improper manure management is also expected to be one of the factors that might cause the drastic increment of fly populations in TER. To date, many common approaches to control the fly populations including fogging and pest control services were not effective. In order to address this problem in TER, the fly populations needs to be monitored in relation to a few factors. In this study, the effect of imported horse food (i.e. chaff, pallet and alfalfa) and food conditions (wet and dry) on house flies population densities in TER was studied.

MATERIALS AND METHODS

Study site

The study was conducted at horse stables and barns in Terengganu Equestrian Resort (TER), Kuala Terengganu from October 2013 to January 2014. TER is located in Kuala Ibai (N 04° 54.029', E 103° 22.304') which is in the Kuala Terengganu district. TER offers a wide range of horse riding activities, training centre, polo field, resort, hall, sport centre and other facilities. There are about 116 horse stables which placed personal horses, polo horses, pony horses and many more. Besides equestrian park, the area includes a mixture of residential, retail, horticulture and grazing land. In general, the climate in Kuala Ibai is hot and humid, with average year-round temperatures of ~25°C. There is a rainy season from November to March, and another relatively dry season from July to September.

Experimental Design and Trap Installation

Extensive weekly sampling for monitoring the house fly populations in three selected horse stables were done for 8 weeks from October 2013 to January 2014. The experiments were using Complete Randomized Design (CRD) with 16 treatments and was replicated 3 times. The factors that were tested were food types (i.e. pallet, alfalfa and chaff) and food conditions (wet and dry). The 16 treatments (8 were in wet condition (W), and another 8 in dry (D) condition) were as follows:

1) Pallet + alfalfa + chaff (W, D)
2) Pallet + alfalfa (W, D)
3) Pallet + chaff (W, D)
4) Alfalfa + chaff (W, D)
5) Chaff (W, D)
6) Pallet (W, D)
7) Alfalfa (W, D)
8) Control / Empty trap (W, D)

The house fly abundances were monitored weekly in each stable with 16 fly traps (19 cm X 14 cm commercialized sticky paper produced by ECI Sdn. Bhd.). The fly traps were positioned under the shade of the stable rafter and not exposed to direct sunlight in order to obtain a sustained and uniform release of the food bait in the environment. All fly traps contained 3 g of finely ground food bait which were put evenly on the fly trap. Each fly trap was placed on the ground and the distance between traps was around 5 cm. The experiment was conducted from 0900 to 1000 hours as the times were found to be the most effective times for foraging activity of *M. domestica*. The fly traps with different food baits were left in position for 1 hour in the selected horse stables. Further addition of water was done from time to time to avoid the wet food treatments from drying out. After that, the fly traps were removed, transferred into properly labeled ziplock bag and taken back to the laboratory for analysis. The ziplock bags then were labeled with date of collection, time of collection and number of individual. Overall, 15 times of samplings were conducted in this study and a total of 1,440 fly traps were installed throughout the sampling period to provide representative coverage of the study site.

Environmental parameters

Environmental parameters such as minimum/maximum temperature (°C) and relative humidity (%) were recorded daily throughout the study period using the RH

meter. The rainfall data was provided by the Meteorological Department of Malaysia.

Statistical analysis

Two-way ANOVA was used to determine the differences of total abundance of flies between types of food and conditions of food over weeks. Data were log(x+1) transformed to ensure normality in calculation of means and ANOVAs. Where there were significant differences, the Duncan Post-hoc test was applied to determine which means were most alike (or different) and to test the equality of means for each pair of variables. T-test was used to compare mean paired samples between dry food treatments and wet food treatments. The Spearman Correlation analysis was used to determine the influence of environmental parameters on the total number of flies captured. All statistical analyses were conducted with SPSS 20.0 statistical software.

RESULTS

After 8 weeks of trap installation, a total of 36,751 house flies were captured in Terengganu Equestrian Resort (TER). Overall number of captured house flies in each food bait treatment is shown in Figure 1. There were significant differences between total catches of flies and food treatments (F = 1.914, d.f. = 15, p = 0.002). Traps of wet alfalfa + chaff treatment caught the highest flies (2,843 individuals), followed by wet pallet + alfalfa (2,793 individuals), wet pallet (2,751 individuals) and wet pallet + chaff (2,661 individuals) treatments. The lowest catch of flies was the dry alfalfa treatment which was 1,652 individuals. In general, all treatments of wet food caught significantly more house flies (20,622 individuals) than dry food treatments (16,129 individuals) (t-test = 1.933, p = 0.023).

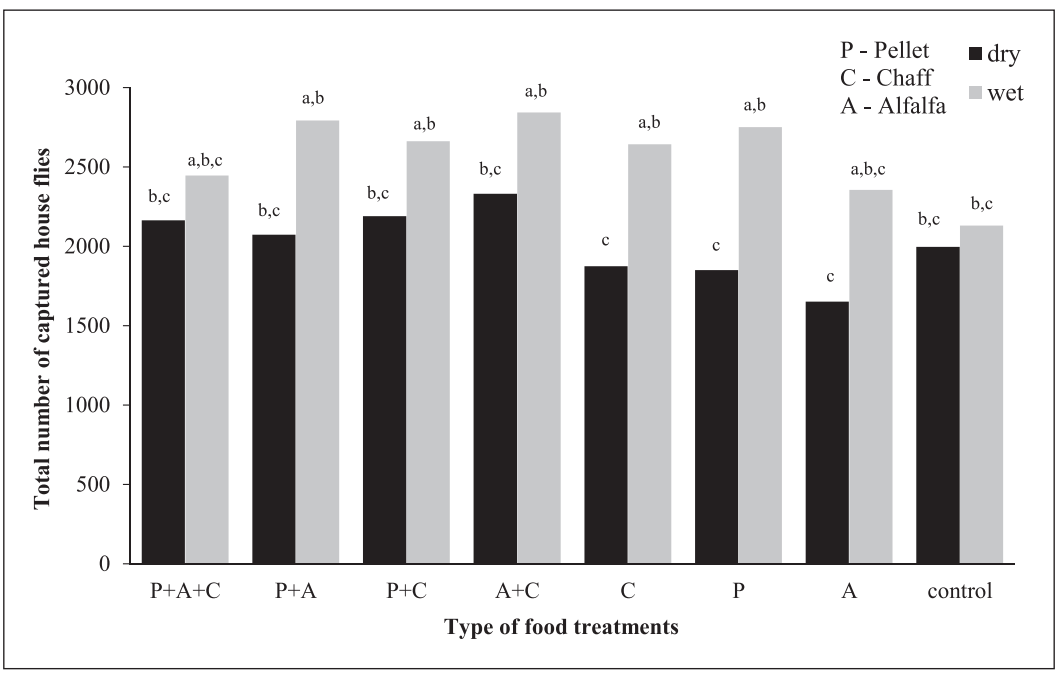

Figure 1. Total number of captured *Musca domestica* for each treatment during the 8 weeks of trap installation at selected horse stables in Terengganu Equestrian Resort (TER). Bars with the same alphabets were not significantly different (Duncan Post-hoc test, p < 0.05).

In terms of weekly catches, there was significant difference in total number of captured flies (F = 12.921, d.f. = 7, p = 0.005). Week 3 captured the highest mean catches of flies (146 individuals/week) compared to other weeks (Figure 2). The number of mean catches were gradually increased from Week 1 (84 flies/week) to Week 3 (146 flies/week), but then decreased drastically to 71 flies/week from Week 4 to Week 5. The weekly mean catches increased back to 116 individuals/week in Week 7 but dropped again to the lowest mean catches in Week 8 (64 individuals/week). However, based on two-way ANOVA, the effect of food treatments on total number of captured flies did not differed significantly over weeks (F= 0.761, d.f. = 105, p = 0.946).

The average weekly rainfall in the area was approximately 14.59 mm/week, with an average maxima temperature of 27.95-34.50ºC during hot sunny days and average humidity was 83.98%/week. Mean weekly catches revealed that low number of houseflies were collected during high rainfall and the numbers increased during hot sunny days and low humidity (Figure 3). However, based on Spearman Correlation Analysis, weekly humidity was negatively correlated with the total number of captured flies (r = -0.651, p = 0.02) (Figure 4), whereas weekly temperature and rainfall showed no correlation to the total number of captured flies. This pattern could be seen clearly in Week 3 where the humidity was the lowest (63.9%) and highest flies catches was recorded especially on wet food treatment (~490 individuals/week).

DISCUSSION

Under field conditions, the effect of imported horse food and food conditions on house flies population densities in TER revealed clear responses to all the food treatments tested. All treatments of wet food were more attractive compared to dry food treatments. The finding was supported by a control wet food treatment where the fly traps were still

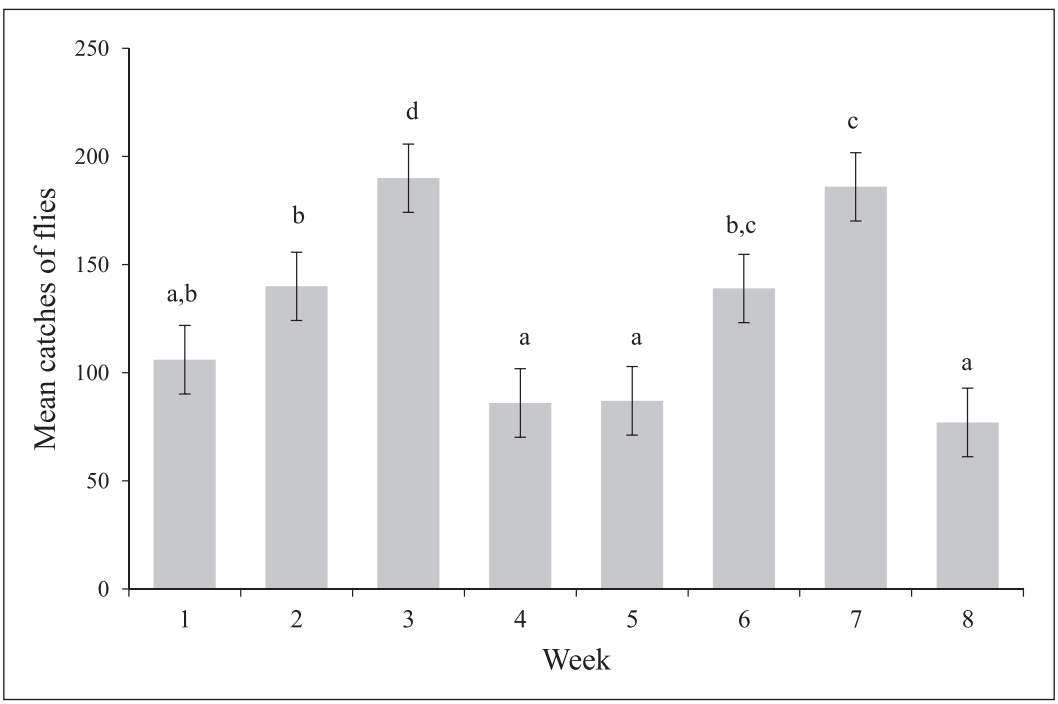

Figure 2. Mean weekly catches of *Musca domestica* at selected horse stables in Terengganu Equestrian Resort (TER). Bars with the same alphabets were not significantly different (Duncan Post-hoc test, $p < 0.05$).

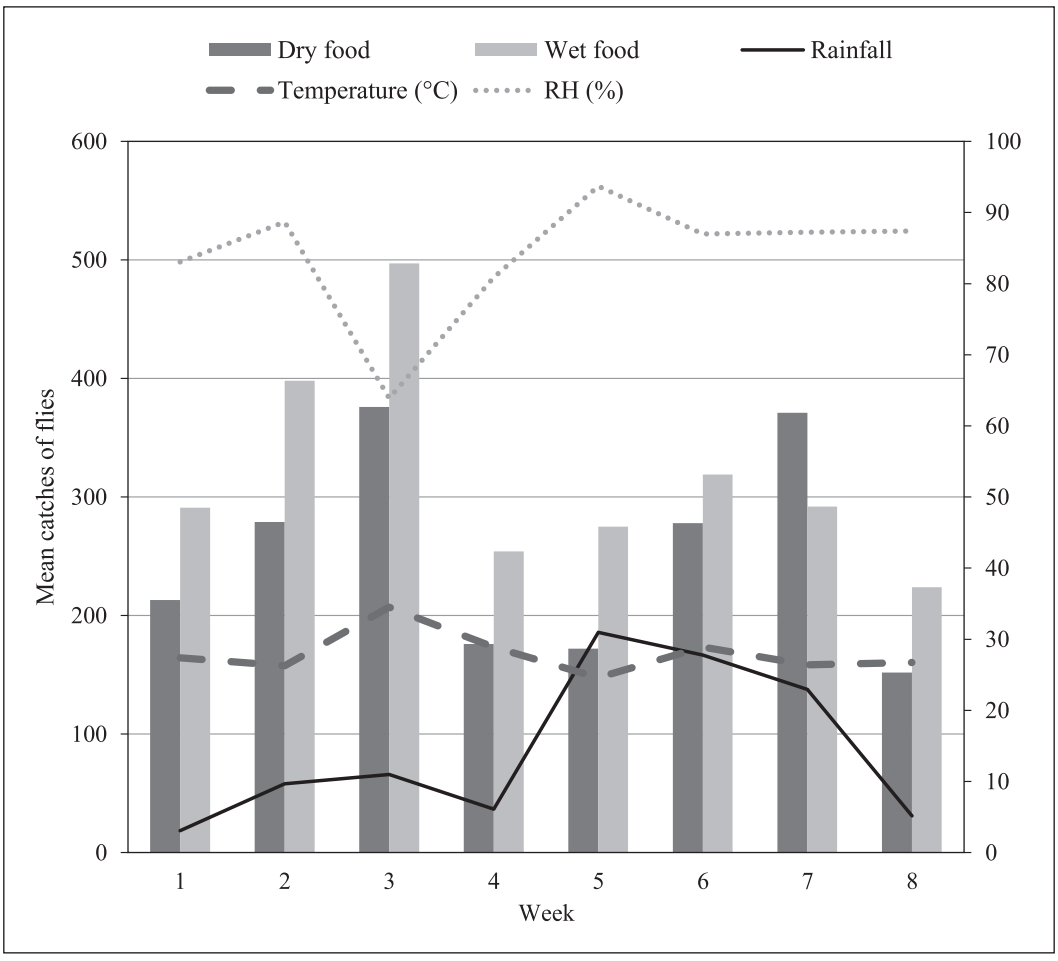

Figure 3. Total mean of *Musca domestica* catches among weeks in relation to mean ambient humidity (%), temperature (°C), and rainfall (mm) at TER.

able to attract the house flies even though without food baits. According to Peters & Barbosa (1977), the eggs of house flies must remain moist or they will not hatch. Female flies are attracted to rotting and moist material, where they lay their eggs in batches (around 50 to 100). Immature stages of house flies ussually occur in fermenting organic material or vegetable origin and are often associated with the dung of herbivorous mammals (Kettle, 1995). The eggs can hatch within 12 hours, and the larvae burrow into the soft moist material and feed for several days before turning into pupae, which then produce adult flies (Gullan & Cranston, 2010). Thus, it shows that wet food conditions provide suitable breeding places for the flies especially under warm moist organic matter. In TER, all food were given to the horses in wet condition. However, the wet condition attracted more presence of flies as the moist organic matter is a favorable condition to the house fly (Loftin *et al.*, 2001). Thus, it shows that to control flies, the conditions of the horse stables and barns must be dried in order to reduce the amount of eggs where flies breed.

In TER, pallet, chaff and alfalfa are three types of commercialized imported horse food given to the horses. Pellets and extruded feeds are usually highly digestible because the grains have been ground up into small particles. Pellets are a good choice if horse has dental problems especially the very young and very old, because it can be soaked to create a soft, easy-to-chew mush (Briggs, 2002). Chaff can be made of any type of hay,

whereas for alfalfa, oat and timothy are the most common. Some chaff is mixed with molasses or oils to aid palatability. It can also be added to grain rations to add bulk and increase chewing time in order to slow down horses that bolt their feed.

In this study, treatment of wet alfalfa + chaff caught significantly higher number of flies compared with other food bait treatments. Based on the observation, alfalfa usually produced strong odor compared to pallet and chaff. The strong odor released especially when the alfalfa was soaked into the water. Flies detect odours with their antennae which are dense of olfactory sensory nerve cells (Gullan & Cranston, 2010). These nerve cells are sensitive to volatile chemicals and in this study, the olfactory cells were optimized towards detecting strong odor produced by wet alfalfa and chaff compared with other food treatments. Therefore, it is suggested that the horse stables should be cleaned at least once a week to eliminate the wet moist organic debris produced from the wet alfalfa, chaff and pellets.

Several environmental parameters such as temperature, relative humidity and rainfall might influence the number of fly populations (Peters & Barbosa, 1977, Diclaro *et al.*, 2012). Malaysia has a tropical climate with high temperature, rainfall and humidity throughout the year. Day time temperatures rise above 30°C (86°F) year-round and night-time temperatures rarely drop below 20°C (68°F) (Meteorological Department of Malaysia, 2013). The environmental conditions play a major factor that might influences the total captured of flies throughout the study period. Since this study was performed from October 2013 to January 2014 which include of both dry and wet seasons, the number of flies captures was expected to be influenced by some of the environmental factors.

Among all the environmental factors, relative humidity was identified to be the strongest factor affecting the house fly densities in hourse stables of TER. The fly catches were significantly increased with decreasing of relative humidity especially in Week 3 where the total number of flies captures were significantly higher than other weeks. However, temperature and rainfall showed no correlation with weekly mean of flies catches.

Humidity is important for egg hatching activity and development. House flies are typically sensitive to moisture levels. Generally low humidity adversely affects the rate of oviposition, which increases as humidity increases. The rate of development may be decreased by extremes of moisture content, or development may be halted together. Extremes of environmental moisture content directly influence many of the activities of insects, including feeding, reproduction, and development (Payne, 1965). Many of dipteran species will not complete development if the breeding areas are too dry (Wahizatul & Lim, 2013).

Therefore, it can be suggested that the seasonally changing weather patterns could be associated with the house flies life cycles and very useful for future forecasting and prediction of house flies population dynamics. Thus, it is important to understand the characteristics of the tropical climate and environmental factors such as rainfall, light intensity, temperature, humidity, etc., which play a critical role in the implementation of house flies control and management in order to reduce the impact of house flies on the horse industry of Malaysia.

Acknowledgements. We would like to acknowledge School of Marine and Environmental Sciences, Universiti Malaysia Terengganu for the financial support of this study, Mr. Halim H. and Mr. Nasir K. for giving permission to conduct this study in Terengganu Equestrian Resort (TER) and the Meteorological Department of Malaysia, for providing the weather data for the state of Terengganu.

REFERENCES

Albarrak, A.S. (2009). Comparative studies on house fly, *Musca domestica* L population in different animal farms in relation to attractants and control at Hail Province, Saudi Arabia. *Pakistan Entomology* **31(2)**: 142-148.

Briggs. K. (2002). Buying prepared horse feed. In http://www.equisearch.com/horses_care/nutrition/feeds/eqfeed3132/. [26 April 2014].

Burg, J.C. & Axtell, R.C. (1984). Monitoring house fly, *Musca domestica* (Diptera: Muscidae), populations in caged layer poultry houses using a baited jug-trap. *Environmental Entomology* **13**: 1083-1090.

Gullan P.J. & Cranston P.S. (2010). The Insects: An Outline of Entomology (4th ed.). Blackwell Publishing, Oxford, UK.

Diclaro II, J.W., Hert, J.C., Welch, R.M., Koehler, P.G. & Pereira, R.M. (2012). Integration of Fly Baits, Traps, and Cords to Kill House Flies (Diptera- Muscidae) and Reduce Annoyance. *Journal of Entomological Science* **47(1)**: 56-64.

Hogsette, J.A., Jacobs, R.D. & Miller, R.W. (1993). The Sticky Card: Device for Studying the Distribution of Adult House Fly (Diptera: Muscidae) Populations in Closed Poultry Houses. *Journal of Economic Entomology* **86(2)**: 450-454.

Kettle, D.S. (1995). Medical and veterinary entomology. 2nd Edition. CAB International. Wallingford. U.K.

Loftin, K.M., Hopkins, J.D. & Steelman, C.D. (2001). Biology and Control of flies in Poultry Facilities. University of Arkansas. In http://www.uaex.edu. [16 November 2013].

Meteorological Department of Malaysia (2013). Weekly data of environmental parameters (October 2013 to January 2014). Government Press, Malaysia.

Payne, J.A. (1965). A summer carrion study of the baby pig *Sus scrofa* Linnaeus. *Ecology* **46**: 592-602.

Peters, T.M. & Barbosa, P. (1977). Influence of Population Density on Size, Fecundity, and Developmental Rate of Insects in Culture. *Annual Review of Entomology* **22**: 431-450. DOI: 10.1146/annurev.en.22.010177.002243

Sanchez-Arroyo, H. & Capinera, J.L. (1998). *Features Creatures (Musca domestica Linnaeus (Insecta: Diptera: Muscidae). University of Nebraska-Lincoln.* Florida. In http://entnemdept.ufl.edu/creatures/urban/flies/house_fly.htm. [26 October 2013].

Wahizatul, A.A. & Lim, S.P. (2013). Comparative Study of Dipteran Species Diversity and Their Succession on Rabbit Carrion in Two Different Mangrove Areas of Peninsular Malaysia. *Journal of Insects* **2013**: Article ID 398159. http://dx.doi.org/10.1155/2013/398159