

The effect of abiotic factors on fly abundance in earthen and concreted manure settling floors in broiler chicken farm

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ABSTRACT

The association between housefly abundance and poultry farms has long been a topic of concern due to its implications for animal health and hygiene. This study investigated the variation in housefly index in relation to abiotic factors across six open-house broiler chicken farms located in the Kinta district of Perak, Malaysia. Field sampling was conducted to measure housefly abundance alongside various biotic and abiotic factors influencing their presence. The results indicated that the mean housefly index was significantly higher in farms with earthen manure settling floors (7.67 ± 6.55 / 30 seconds) compared to those with concreted floors (6.56 ± 6.27 / 30 seconds), suggesting a positive correlation between floor type and housefly index. Bird age was relatively similar between earthen (12.29 ± 13.63 days) and concreted (11.04 ± 12.87 days) floor types, showing a non-significant positive correlation with housefly index. A negative correlation was observed between breeding ground temperature and housefly index, although temperature was slightly lower in earthen floors (29.14 ± 1.76 °C) than in concreted ones (29.59 ± 1.81 °C). Additionally, a positive correlation existed between ammonia gas concentration and housefly index, even though lower ammonia levels were recorded on earthen floors (0.85 ± 1.18 ppm) compared to concreted floors (0.98 ± 1.03 ppm). Similarly, hydrogen sulfide concentration was lower on earthen floors (0.04 ± 0.06 ppm) but positively correlated with housefly index. Wind speed showed no significant variation between floor types. In conclusion, temperature, ammonia, and hydrogen sulfide concentrations significantly influenced housefly abundance in poultry farm environments.

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1. INTRODUCTION

Malaysia is one of Southeast Asia's leading poultry producers, with broiler chicken production playing an important role in national food security and rural livelihoods. The poultry sector is predominantly intensive, with open-house systems still commonly used in small and mid-scale operations. These systems often utilise earthen or concrete manure settling floors, which differ in terms of maintenance, environmental impact, and effectiveness in controlling vectors.

The accumulation of poultry manure can lead to significant housefly (*Musca domestica*) breeding, particularly in areas with poor overall sanitation and excessive moisture. While houseflies typically prefer manure as their breeding source, they have been observed to breed in moist spilled feed and other warm, decaying organic materials. Beyond the moisture content of manure and the by-products generated during its degradation, several other factors affect the population growth of flies in these two farming systems. These

factors include temperature, humidity, ammonia vapour, and wind speed, all of which influence the breeding of houseflies. Among these, temperature plays the most substantial role and serves as a significant predictor of housefly activity during daytime (Zahn, 2020). Although *Musca domestica* is most active at 33 °C, temperatures between 7 °C to 43 °C are suitable conditions for proliferation (Ajayi et al., 2022).

Wind flow is known to have a substantial impact on the spatial distribution of houseflies in closed-house farming systems. Zahn (2020) reported that the upper limit for the flight speed of adult houseflies is around 2 m/s. When wind speed surpasses this threshold, houseflies will lose their ability for autonomous flight control. In such instances, flying might be constrained to areas close to the ground, where wind velocities remain sufficiently low to enable the flies to navigate autonomously (Zahn, 2020). Furthermore, proper ventilation in poultry houses can help reduce the moisture content of manure and improve air quality by removing gases, such as ammonia, from the barn (Shiell, 2015).

As humidity levels increase, the pace of egg deposition tends to accelerate. Elevated humidity has the effect of rendering the environment moister, thereby making it more enticing for female flies to lay their eggs. Geden et al. (2021) found a reverse correlation between the number of flies and both relative humidity and rainfall. Additionally, Koné et al. (2017) reported a negative correlation between houseflies and relative humidity with high tropical temperatures. Ammonia generation in poultry farms results from the breakdown of nitrogen-containing compounds in poultry manure. Flies are attracted to the smell of compounds containing ammonia, nitrogen, and amino acids that are produced on the farm, and can smell them from a distance. Furthermore, ammonia functions as a lure for egg deposition, potentially leading to an elevation in the egg-laying count (Shiell, 2015). Hydrogen sulphide primarily arises from the breakdown of organic material containing sulfur within faecal matter. In situations where chickens consume amino acids rich in sulfur (e.g., cystine, cysteine, and methionine) and in the presence of digestive system disorders, a significant quantity of hydrogen sulphide may be generated (Ni et al., 2021). Similarly, hydrogen sulphide also serves as an oviposition attractant for houseflies.

Recent studies underscore the urgent need for region-specific vector management strategies in tropical poultry systems, where environmental conditions intensify fly breeding. For instance, biological control using *Hermetia illucens* larvae has shown promise in suppressing *Musca domestica* populations in Malaysian poultry environments (Zainudin & Ling, 2024). Similarly, Integrated Pest Management (IPM) approaches have effectively reduced insect populations in Malaysian highland agriculture, suggesting their potential applicability in poultry systems (Zainudin et al., 2023). Botanical-based repellents and bioinsecticides, including essential oils from star anise and lemongrass (Passara et al., 2024) and plant-derived compounds (Ahyanti et al., 2023), have demonstrated ovicidal activity and behavioural disruption in houseflies across Thailand and Indonesia, respectively. These natural agents offer environmentally friendly alternatives to chemical controls.

Environmental and housing conditions play a crucial role in fly proliferation. Studies from Indonesia highlight that advanced HVAC systems with evaporative cooling pads improve environmental control and reduce ammonia buildup in broiler houses, indirectly limiting fly attraction. In contrast, poor waste and sanitation management have been consistently associated with higher fly densities due to increased organic matter and humidity (Rahayu et al., 2024; Nur et al., 2024). Klakankhai et al. (2024) found that nutrient-rich substrates significantly enhance housefly larval biomass,

indicating a strong link between environmental nutrient availability and fly development. Likewise, Asuncion et al. (2022) demonstrated that fly populations in broiler farms were effectively reduced using insecticide paint-on and scatter methods, although breeding behaviour remained closely tied to environmental factors. Together, these findings highlight the importance of combining ventilation, sanitation, and targeted biological or botanical controls to develop sustainable, tropical-specific fly management strategies.

The selection of abiotic factors (temperature, humidity, ammonia, hydrogen sulfide, and wind speed) in this study is based on their documented influence on fly behaviour and reproductive success. These variables significantly influence microenvironmental conditions in poultry houses and can be modified through design and management interventions. Hence, this investigation was conducted to assess the impact of abiotic and biotic elements on the population of houseflies in both earthen and concrete manure settling floors.

2. MATERIALS AND METHODS

2.1. Farm selection and sampling procedure

Six broiler farms employing open-house systems were selected from the Kinta district in Perak, Malaysia. Farm selection was based on the following criteria: active broiler production during the study period, accessibility for weekly sampling, and consent to participate in data collection. To reduce regional environmental variability, all farms were located within the same district. The study was conducted over 12 months, from July 1, 2021, to June 30, 2022. Of the selected farms, three utilised earthen manure settling floors and three employed concreted floors. Weekly sampling was done consistently across all sites.

2.2. Instrumentation

All instruments were calibrated monthly according to the manufacturers' guidelines. Measurements were taken at three fixed locations within each house to ensure consistency. The data were reviewed weekly for anomalies and any missing or questionable values were flagged and re-evaluated when possible.

2.3. Housefly index

Housefly population sampling was conducted using a Scudder grill, following the protocol outlined by Wolfe et al. (2017). Flies that settled on the grill within 30 seconds were counted. For each farm, three poultry houses were surveyed and ten counts were performed per house. The resulting fly counts were averaged to calculate the fly index. Weekly assessments were conducted in the morning between 09:00 and 11:00 by adhering to standardised timing. To minimise observer bias, all fly counts were done by the same trained individual throughout the study. Observer consistency was

ensured through the use of standardised timing and positioning. However, no formal blinding procedures were applied, which may introduce a potential source of bias in fly enumeration.

2.4. Age of birds and breeding ground temperature

During each sampling session, husbandry data consisting of the age of birds in the sampling houses were recorded. The farm’s breeding ground air temperature was sampled using a TG-501 probe of GreyWolf Sensing Solution at nine (9) locations (three at the north, three at the south, and three at the centre portion) of the house, for a total of three houses per farm. Temperature readings (sampling) were taken approximately 0.5–0.6 metres above the manure settling floor. The sampling technique was modified based on Kucuktopcu et al. (2017).

2.5. Ammonia and hydrogen sulfide reading

Ammonia and hydrogen sulfide levels were sampled using a TG-501 probe of GreyWolf Sensing Solution at nine (9) locations (three at the north, three at the south, and 3 at the centre portion) of the house, with a total of three houses per farm. Ammonia readings (sampling) were taken approximately 0.5-0.6 meters above the manure settling floor. The sampling technique was modified based on Kucuktopcu et al. (2017) and Atapattu et al. (2017).

2.6. Wind speed reading

An anemometer was used to gather data on wind speed reading. Wind speed measurements were taken from the north wall in three locations across the width of the house, for a total of three houses per farm. The wind speed metre was held at arm’s length in front of the reader and away from any obstructions, while adhering to the guidelines from Aviagen (2016) (Aviagen brand: How to measure average air speed in a tunnel ventilation house).

2.7. Statistical analysis

The fly index enumeration, bird age data, breeding area temperature, ammonia, hydrogen sulphide, and wind speed readings were subjected to an independent samples T-test to determine if significant differences were present between concreted and earthen manure settling floor types in poultry farms. It later underwent a Pearson correlation test to evaluate the relationship between fly index and abiotic factors in two different manure settling floor types. The tests were performed using IBM SPSS version 27 with a significance level of $p < 0.05$.

3. RESULT

3.1 Housefly index in concreted and earthen manure settling floor types

The housefly index (fly abundance enumeration) had a very weak positive correlation ($r = 0.087, p = 0.000$) with manure settling floor types (Table 2). Although statistically significant due to the large sample size, the strength of this relationship was minimal.

The independent samples t-test revealed that earthen floors had significantly higher fly indices than concrete floors (mean difference = 1.11 flies; $t(1618) = -3.499, p = 0.000$). The effect size (Cohen’s $d = -0.17$) indicates a small practical difference.

Table 1: Independent samples T-test results comparing abiotic and biotic factors between concreted and earthen manure settling floors in poultry farms.

Factor	Mean ± SD (Concrete)	Mean ± SD (Earthen)	t(df)	p-value	Units	Cohen’s d
Breeding Ground Temperature	29.59 ± 1.81	29.14 ± 1.76	4.781 (1456)	0.000	°C	0.25
Ammonia Concentration	0.98 ± 1.03	0.85 ± 1.18	2.203 (1454)	0.028	ppm	0.115
Hydrogen Sulfide	0.05 ± 0.09	0.04 ± 0.06	2.917 (1456)	0.004	ppm	0.153
Wind Speed	0.95 ± 0.46	0.98 ± 0.50	-0.744 (483)	0.457	m/s	-0.068
Bird Age	11.04 ± 12.87	12.29 ± 13.63	-1.904 (1618)	0.057	Days	-0.095
Housefly Index	6.55 ± 6.27	7.67 ± 6.55	-3.499 (1618)	0.000	Flies/30 sec count	-0.174

3.2 Age of birds

The independent samples t-test revealed that the age of birds kept on earthen floors was higher than on concrete floors (mean difference = -1.25 days; $t(1613) = -1.904, p = 0.057$). The effect size (Cohen’s $d = -0.10$) indicates a small practical difference (Table 1). The bird age records showed a statistically non-significant correlation with both manure settling floor types ($r = 0.047, p = 0.057$) and the housefly index ($r = 0.048, p = 0.053$; Table 2). This finding is further supported by personal observation, where the housefly index does not seem to differ by age of birds among broiler chicken farms with earthen and concreted manure settling floor types, while differences were visually seen based on the sanitation status of the sampling points.

3.3 Breeding ground temperature in concreted and earthen manure settling floor types

The independent samples t-test revealed that concrete floors had significantly higher breeding ground temperature than earthen floors (mean difference = 0.45 °C; t

(1455) = 4.781, $p = 0.000$). The effect size (Cohen's $d = 0.25$) indicates a small practical difference (Table 2).

Moreover, a statistically significant weak negative correlation ($r = -0.131, p = 0.000$) was observed between the breeding ground-housefly index and manure settling floor types with breeding ground temperature ($r = -0.124, p = 0.000$; Table 2). Similarly, a negative correlation was observed between breeding ground temperature and bird age ($r = -0.277, p = 0.000$; Table 3).

3.4 Ammonia and hydrogen sulfide gas concentrations in concreted and earthen manure settling floor types

Ammonia gas concentration showed a very weak negative correlation with the type of manure settling floor ($r = -0.058, p = 0.028$). This indicates that although the relationship is statistically significant, it is practically negligible. The independent samples t-test revealed that concrete floors had significantly higher ammonia gas concentration than earthen floors (mean difference = 0.1283 ppm; $t(1454) = 2.203, p = 0.028$). The effect size (Cohen's $d = 0.12$) indicates a small practical difference (Table 1). Furthermore, a statistically significant positive correlation was observed between ammonia gas concentration and housefly index ($r = 0.395, p < 0.001$; Table 2).

The results also showed a very weak negative correlation between hydrogen sulfide gas concentration and manure settling floor types ($r = -0.076, p = 0.004$; Table 2). The independent samples t-test revealed that concrete floors

had significantly higher hydrogen sulfide concentration than earthen floors (mean difference = 0.01217; $t(1278) = 2.917, p = 0.004$). The effect size (Cohen's $d = 0.15$) indicates a small practical difference (Table 1). Furthermore, there was a weak positive correlation ($r = 0.227, p = 0.000$) between hydrogen sulfide concentration and housefly index (Table 2). Similarly, positive correlation was observed between the concentration of ammonia and hydrogen sulfide gases ($r = 0.291, p = 0.000$; Table 3).

3.5 Wind speed in concreted and earthen manure settling floor types

The wind speed in both manure settling floor types was homogeneous. The independent samples t-test revealed that both concrete and earthen floors had similar wind speed strength (mean difference = -0.0326 m/s; $t(483) = -0.744, p = 0.457$). The effect size (Cohen's $d = -0.07$) indicates a small practical difference (Table 1).

Though a positive correlation ($r = 0.034, p = 0.457$) was observed between wind speed and manure settling floor types, this correlation was not statistically significant. Similarly, a very weak and statistically non-significant positive correlation ($r = 0.066, p = 0.146$) was found between wind speed and housefly index (Table 2). Interestingly, a very weak positive correlation ($r = 0.194, p = 0.000$) was apparent between wind speed and breeding area temperature, with a statistically significant difference observed throughout the study period (Table 3).

Table 2: Significance of correlation (p) between abiotic and biotic factors.

Biotic Factors		Age	Ammonia	Breeding Ground Temperature	Hydrogen Sulfide	Wind Speed	Housefly Index
Manure Settling Floor	Correlation (r)	0.047	-0.058	-0.124	-0.076	0.034	0.087
	Significance (p)	0.057	0.028	0.000	0.004	0.457	0.000
Housefly Index	Correlation (r)	0.048	0.395	-0.131	0.227	0.066	1
	Significance (p)	0.053	0.000	0.000	0.000	0.146	1

Table 3: Significance of correlation (p) between abiotic and biotic factors.

Biotic Factors		Age	Ammonia	Breeding Ground Temperature	Hydrogen Sulfide	Wind Speed
Ammonia	Correlation (r)	0.013	1	-0.168	0.291	-0.027
	Significance (p)	0.628		0.000	0.000	0.558
Breeding Ground Temperature	Correlation (r)	-0.277	-0.168	1	-0.178	0.194
	Significance (p)	0.000	0.000		0.000	0.000
Hydrogen Sulfide	Correlation (r)	-0.008	0.291	-0.178	1	0.072
	Significance (p)	0.762	0.000	0.000		0.116
Wind Speed	Correlation (r)	-0.090	-0.027	0.194	0.072	1
	Significance (p)	0.047	0.558	0.000	0.116	1

4. DISCUSSION

This study revealed that the index of housefly abundance demonstrated reduced levels on concreted manure settling floors in comparison to earthen manure settling floors. However, further personal observation revealed that the mean housefly density was considerably low and approximately showed a similar housefly index across the six

farms throughout the study period, despite being surrounded by poultry farms with continuous broiler production within a 1 to 3 kilometres radius from the study sites. Geden et al. (2021) also outlined the relationship between the fly index and the general level of premise sanitation. Thus, the farm sanitary and housefly control measures implemented at the study sites were good and able to yield a fairly acceptable fly abundance.

Moreover, the housefly index was homogenous between earthen and concreted manure settling floor types when compared with the age of birds. It denotes no correlation between the housefly index in poultry farms with the age of the chicken. However, it is generally assumed by the public and poultry farmers that the housefly population increases with the age of the chicken in poultry farms, as older chickens are expected to produce more manure than younger ones, leading to greater accumulation on the manure-settling floor. This can attract more flies to breed in such a nutritious medium. If the cultural, mechanical, and chemical control measures employed on this farm were not thoroughly maintained at the optimum level, an immediate bloom of housefly density may take place within a week. According to Geden et al. (2021), there is a consensus that inadequate sanitation is strongly associated with the existence of available food sources and appropriate breeding sites. This association contributes to the diverse seasonal patterns observed in tropical regions.

In this study, the earthen manure settling floor recorded lower breeding ground temperature (29.14 ± 1.76 °C) than the concreted manure settling floor (29.59 ± 1.81 °C). This can be best explained by the heat transmissibility nature of the manure settling floor type material. Although the manure settling floor is technically located under the poultry shed and protected from direct sunshine, the concrete floor absorbs heat faster than the earthen floor. As a result, the breeding area temperature at the earthen manure settling floor is often lower than the concreted floor. Given the heterogeneous nature of soil, the heat transfer mechanisms become intricate and can exhibit significant variations as the material's properties undergo changes (Resende et al., 2020). Additionally, Malaysia's hot and humid climate all year round acts similarly as the summer season of the western countries. This phenomenon is elaborated by Cui et al. (2020) in their exploration of soil heat transmissibility. They noted that soil portion offers a warmer environment during winter and a cooler environment during summer, while experiencing less temperature variation compared to the fluctuating ambient air temperature throughout the year. Similarly, Resende et al. (2020) pointed out that the influence of soil can lead to misleading performance analyses. This is due to the soil's significant thermal capacity, which causes it to maintain lower temperatures than outdoor air temperatures during summer and higher temperatures than outdoor air temperatures during winter.

Ammonia is the predominant pollutant in poultry systems (Brouek & Cermák, 2015). The primary cause of ammonia release from animal sources stems from the inefficient conversion of feed nitrogen into animal by-products. This study found that the type of manure flooring affects

ammonia gas concentration, with earthen flooring recording a lower concentration of ammonia (0.85 ± 1.18 ppm) than concreted flooring (0.98 ± 1.03 ppm). The finding is consistent with Popescu et al. (2017) who reported slightly higher concentrations of ammonia (10 to 20 ppm) in barns where manure was deposited on solid floors. Farghly et al. (2018) found that the litter on dirt floor created less humidity, had lower fermentation, and produced less ammonia than solid floor. Additionally, Bist et al. (2023) stated that ammonia levels in animal housing can exceed 25 ppm when lower winter ventilation rates are used and can reach 40 ppm in poorly ventilated buildings or in the manure storage area of high-rise layer houses. Finally, a study by Park et al. (2020) revealed that ammonia concentration was highest in broiler chicken farms (2.6–8.6 ppm) than in poultry manure handling facilities (2.6–57.9 ppm).

The significance of different manure management is further supported by Mendes et al. (2017) who reported that housing design and management determine ammonia emissions rates from livestock facilities. Furthermore, the correlation between ammonia gas concentration and manure settling floor type in the present study indicates that ammonia production is affected by the type of manure settling floor, with earthen floor recording a lower concentration of ammonia gas than concreted floor. Several studies have observed an increase in NH₃ concentrations with the temperature rise in farm buildings. This is because the heat absorbability of the manure settling floor type affects the temperature of the manure surface, which then influences the rate of desorption, urease activity, ammonium, and gaseous fraction of ammonia (Guarrasi et al., 2015). Although the highest ammonia concentration detected in both manure settling floor types was considerably low, the ideal concentration of ammonia in sheds should be below 10 ppm (Naseem & King, 2018; Eugene et al., 2021).

Furthermore, the positive correlation between ammonia gas concentration and housefly abundance in this study can be attributed to the nature of ammonia gas. Additionally, all gas emissions increased with bird age. In chickens, the concentrations of ammonia rise during fattening periods in all seasons of the year (from 0.23 to 10.77 mg/m³). Brouek and Cermák (2015) reported that the total ammonia emissions during the broiler chicken growth cycle (from day-old chick placement until flock harvest) yielded a farm total of 4,415 kg of NH₃ per flock, or 0.016 kg of NH₃ per bird per flock.

Aside from ammonia gas, hydrogen sulfide is also one of the pollutant gases related to chicken manure. Our findings show that the type of manure settling floors affects hydrogen sulfide gas concentration; earthen flooring recorded a lower concentration of hydrogen sulfide (0.04 ± 0.06 ppm)

than concreted manure settling floors (0.05 ± 0.09 ppm). Likewise, Saksrithai and King (2018) documented a peak concentration of hydrogen sulfide reaching 30 ppb in a single out of the three commercial laying barns examined during winter conditions. In comparison, the maximum hydrogen sulphide reading obtained in this study is significantly lower than those of Abba (2023), where the mean concentrations of hydrogen sulphide emitted from poultry buildings were 945 (± 519) ppb for caged layer houses, 603 (± 274) ppb for broiler houses, and 247 (± 184) ppb for layer houses equipped with a manure belt. Similar findings were also observed in poultry farms across nine South Korean provinces (Kim, 2017).

The rationale behind detecting a lower concentration of hydrogen sulfide gas in the earthen manure settling floor is caused by the abundance of microbes readily available on the earth's surface, which aids in the breakdown of sulfuric material in manure. Similarly, Nurzillah et al. (2018) reported no presence of hydrogen sulfide (0 ppm) by multi-gas detector in the environment of two groups of commercial layer open house farms. They also perceive that the absence of hydrogen sulfide could mean that the microbes significantly break down the sulfur-containing compounds in the manure. Moreover, the data from this study indicated that hydrogen sulfide gas production is negatively correlated with the manure settling floor type, while the earthen manure settling floor recorded lower hydrogen sulfide gas concentration. In contrast, Park et al. (2020) reported the absence of hydrogen sulfide in broiler chicken farms, whereas the gas was recorded within a range of 0.7 to 3.4 ppm at the commercial layer chicken farms.

Zwain et al. (2020) provided empirical support for the escalation of hydrogen sulfide emissions into the atmosphere as temperatures rise. They also observed that temperature has a direct effect on the mass transfer of hydrogen sulfide, either dissolved in wastewater or volatilised into the atmosphere. In this context, the differences between manure settling floor types are further affected by the amount of heat that each type absorbs from the environment. Since concreted manure settling floor is a better heat absorber than earthen floor, the heat in the concrete enhances the volatilisation of hydrogen sulfide from the manure accumulated on the manure settling floor. On the other hand, the positive correlation between hydrogen sulfide gas and the housefly index observed in this study is attributable to the relatively low hydrogen sulfide concentration throughout the study period. Furthermore, Saksrithai and King (2018) observed the air quality in a broiler house for 20 minutes during each week of the production cycle. Using 10 ppb as the detection limit, the authors found no detectable hydrogen sulfide, which could be attributed to the difference in the ventilation system. Consequently, it can be inferred that the hydrogen sulfide

concentration encountered in poultry houses remains comparatively low. However, our study indicated an upward trajectory in the population of houseflies with an increase in hydrogen sulfide gas levels.

Generally, wind flow is known to have a substantial impact on the spatial distribution of houseflies in poultry farms. Many studies have documented that an adult housefly can achieve a maximum flight speed of approximately 2 m/s (Zahn, 2020). However, the current study recorded a maximum average wind speed of 0.98 ± 0.50 m/s in a poultry house with an earthen manure-settling floor. Nevertheless, the wind speed records in all six farms were homogeneous. Ventilation rate differs based on geographical location, the presence of windbreaks (e.g., weeds, plants, and crops), the barn's height from the manure settling floor, and the usage of additional ventilators. Since all farms in this study had similar types of barrier-free space around the poultry houses, the location of farm buildings on flat land surfaces rules out the possibility of geographical variations. In contrast, a positive correlation between wind speed and housefly index was observed in this study. The finding is consistent with Zahn (2020) who stated that wind speeds exceeding the maximum flight capability of flying insects can decrease their flight activity. The authors reported that farms, which comprise of buildings and structures, would increase the boundary layer (area of slower-moving air), allowing insects to keep flying even when wind speeds (as recorded by a weather station) are higher than the controlled flight allowable. Therefore, wind speed is most likely to impact flying insects as they move across open country, but it becomes less impactful when they are near to areas with many structures like buildings or tree lines.

In conclusion, broiler chicken farms with earthen manure settling floors had a larger fly abundance than those with concrete manure settling floors. Breeding ground temperature, ammonia gas, and hydrogen sulfide gas concentrations were found to have significant effects on the housefly index. Hence, houseflies can be effectively controlled by adhering to Good Animal Husbandry Practises (GAHP) along with the maintenance of good sanitation and cultural control practices in broiler chicken farms.

5. STUDY LIMITATIONS AND FUTURE DIRECTIONS

Several limitations should be considered when interpreting the findings of this study. First, the research was confined to six poultry farms located within the Kinta district of Perak, Malaysia. While this allowed for logistical consistency and controlled regional variables, the limited geographic scope may reduce the generalisability of the results to other regions with differing environmental, management, or infrastructural conditions. Second, although the data collection

spanned a full calendar year with weekly sampling, the study did not perform stratified analyses based on seasonal variation. Given the potential influence of rainfall, humidity, and temperature fluctuations on housefly dynamics in tropical climates, future studies should incorporate seasonal stratification to better understand temporal patterns. Lastly, several potential confounding factors—including proximity to organic waste sites, prior insecticide usage, and farm-level feed or manure management practices—were not quantitatively assessed. The absence of control for these variables may have influenced fly population dynamics and warrants further investigation in broader, multivariate analyses.

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