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Insect Fauna Diversity and Abundance in Abattoirs in Enugu North Senatorial Zone, Eastern Nigeria

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ABSTRACT

Insects act as the vector for various microorganisms. They have the potential for spreading diseases in the environment where they are found. Many insects are associated with animal feces and manure, and abattoirs are one of the important sources for such contacts and disease dissemination. We assumed that understanding the diversity of insect fauna might help to shade light on vector insect-borne diseases, prevalence and transmission rates in abattoir communities. Here we randomly selected three (Orba, Ikpa, and Obollo-afor) abattoirs in Enugu senatorial zone and surveyed for insect fauna abundance, diversity, and distribution. The sampling was carried out over a period of eight weeks, using sweep net and hand picking as the collection methods. Overall 12 species were recorded, Orba had the lowest species diversity with 7 species while Obollo-afor and Ikpa recorded 10 and 9 species respectively. Dipteran and Coleoptera were the most diverse and abundant order observed with *Musca domestica* (Diptera: Muscidae) being the most abundant species encountered. Equitability index of evenness revealed that *Calliphora vomitoria*, *Blattella orientalis*, *Monomorium minimum*, *Dermestes lardarius*, *Lucilia caesar*, *Musca domestica*, and *Calosoma scrutator* were evenly distributed. While the lowest evenness was recorded in Ikpa. The information generated from this study will provide the much needed assistance in disease monitoring and guideline in health policy decision making in the study area.

INTRODUCTION

Insects represent well over 90% of the animal life forms on Earth and can be found in nearly all environment (Erwin, 1997). They are the most diverse groups of existing organisms and more than one million species have been described (Wilson, 2009). Insects are long-lived and tolerates temporal changes in abundance; and they possess the ability to integrate into varying conditions accounting for one of the reasons for their evolutionary success. Insects feed on secretions, from man and wastes from animal making them perfect vectors for transmitting several pathogenic diseases. Many bacterial diseases, infantile diarrhea, typhoid fever, shigellosis and cholera are spread by various insects including food poisoning caused by *Staphylococcus* spp. (Cohen *et al*., 1991; Dahlem, 2009; Olowoporoku, 2016). There are about 1,400 species of infectious microorganisms of human, out of which around 617 are of zoonotic viruses and bacteria origin and are most likely to be transmitted by insect vectors (Abdullahi *et al*., 2016).

An abattoir is a special facility designed and licensed for receiving, holding, slaughtering and inspecting meat animals and meat products before release to the general public (Alonge, 2005). Stinking water, excreta, carcasses and steal blood from slaughtered animals are one of the main sources of attraction of insects to abattoir, particularly the flying insects. Prior research on abattoir workers revealed that about 19.1% of pathogenic infection contracted by abattoir workers are often transmitted to human through repeated contacts with infected animals (Abdullahi *et al*., 2016; Cook *et al*., 2017). For instance, Fasanmi (1997) reported that individuals who are working in close proximity with livestock stock, meat inspection, and processing of foods of animal origin are much more prone to zoonotic infections than other individuals. Studies by Awosile *et al*. (2013) have also shown that in the livestock sector, zoonotic bacteria and viruses are usually seen hiding under the animal hides, blood, and even in the animal holding pens, while Swai and Schoonman (2012) proposed that the occurrence of skin and respiratory diseases suggests that the workers were most likely in close contact with pathogenic microbes without clothing and proper face mask therefore absorbing as well as inhaling the microorganisms. According to WHO (1995)

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report workers carrying out animal slaughtering and processing the meat in abattoir are prone to diseases like Rift Valley fever, leptospirosis, brucellosis, toxoplasmosis, and anthrax.

Literature exist on the various pathogenic infections associated with the polluted environment of most abattoirs in the developing world (Olowoporoku, 2016; Chew *et al.*, 2000) but very little is known about the insect diversity and distribution. In Nigeria, available data on the diversity of insect fauna and macro-invertebrates of abattoirs are quite insufficient and in the study area there was no record of any existing information on the case study, and information such as this are very essential as it has health implications. Consequently, the goal of this present survey is to identify insect species composition and diversity in different abattoir ecosystem, to determine species equitability and abundance. It is anticipated that the results from the study will provide the much-needed information for the purpose of public health disease surveillance and control strategies as well as policy health guidelines

MATERIALS AND METHODS

Study area

The study was carried out in Enugu North Senatorial Zone, eastern Nigeria about 60km northwest of Enugu, in Enugu state, covering about 146km^2, sitting at 223m (732 ft) above sea level. The mean temperature in the hottest month of February is 87.16 °F (30.64 °C), while the lowest temperatures occur in the month of November, reaching 60.54 °F (15.86 °C). The study was conducted at three sites, Ikpa, Orba and Obollo-afor. Ikpa abattoir is in Nsukka town, Nsukka Local Government Area (LGA) in Enugu North. It is located at 6° 52' 40" N, 7° 23' 08"E. Orba abattoir is also located in Nsukka LGA, at the geographical coordinates 6° 51' 0" N, 7° 27' 0" E. Obollo-afor abattoir is located in Udenu LGA, with geographical coordinate of 6° 53' 0" N, 7° 38' 0" E (Fig. 1).

Sampling methods

Sampling was carried out every fourth night for a period of eight weeks in each of the abattoirs. Samples were collected at random to ensure appropriate coverage of the study area. Sampling was performed for one hour between 10.00 and 11.00 am. Two sampling techniques were used, sweep net for flying insects and hand picking for the non-flying insects (ground /crawling insects). The sweep net was made of thick white cotton mesh with a round frame measuring 92cm around the edge, with a wooden handle and curved tip to prevent insects from escaping. Ten random sweep strokes were made in air in each location per sampling day to collect flying insects. The non-flying insects were collected from abattoir slabs, dry wastes and semi-liquid wastes with forceps and directly by hand wearing hand gloves. The insects were kept in insect jars and transferred to a glass insect jar containing 10% formalin and transported from abattoir site to Entomology Laboratory at Department of Zoology and Environmental Biology, University of Nigeria for species identification and classification. They were later transferred to specimen vials after identification and labelling for proper storage.

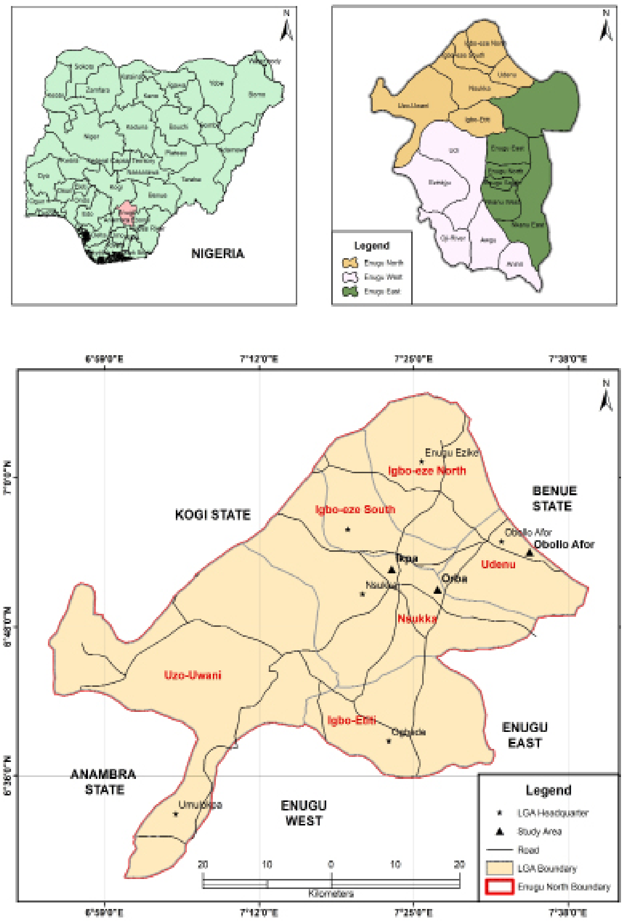

Fig. 1. Map of Enugu North senatorial zone showing sampled locations.

Data analysis

Relative abundance of insect species was computed as proportion of number of organisms per species to total number of insects collected (n/N x 100) and expressed in percentages. Diversity of the insect fauna was determined using Shannon-Wiener index. Expressed as:

$$H' = \sum_{i=1}^{R} p_i \ln p_i$$

The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. In the Shannon index, p_i is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations and s is the number of species.

Equitability index (E_H) of evenness was also applied to calculate the relative diversity or equitability. It was expressed as:

$$E_H = H/H_{max} = H/lnS$$

Where: E_H = diversity evenness, H = diversity index (Shannon Weiner) and Hmax = $Log_e S$.

Simpson index was also employed to determine most dominant among the sampled species. Expressed as:

$$D = \sum_{i=1}^{s} P^2$$

In the Simpson index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), Σ is still the sum of the calculations, and s is the number of species.

Green index of dispersion is expressed as:

$$C_x = \frac{s^2/m - 1}{nm - 1}$$

Where C_x = dispersion index, s^2 is the sample variance, m is the mean and n is the number of observations

RESULTS

Overall 1,527 insects were collected from different locations across the three different abattoirs. Four (4) orders (Diptera, Coleoptera, Dictyoptera and Hymenoptera) comprising eleven (11) families and twelve (12) species were identified (*Musca domestica, Lucilia caesar, Calliphora vomitoria, Megaselia scalaris, Calosoma scrutator, Dermestes lardarius, Monomorium minimum, Lema* spp.*, Blattella orientalis, Apis mellifera, Cullicoides murnei* and *unidentified* sp. *Musca domestica* was the most abundant insect species encountered with 30.4% relative abundance; followed by *M. scalaris* 26.8%. The least abundant insect species encountered were *Culicoides murnei,* unidentified sp. and *Apis mellifera* each having 0.07% relative abundance. The others were *C. scrutator* (18.3%), *Lema* spp. (7.6%), *M. minimum* (6.9%), *L. caesar* (6.7%), *D. lardarius* 2%, *C. vomitoria* (0.7%), and *B. orientalis* (0.4%) (Table I). Figures 2 and 3 shows the total number of insect species across the three abattoirs.

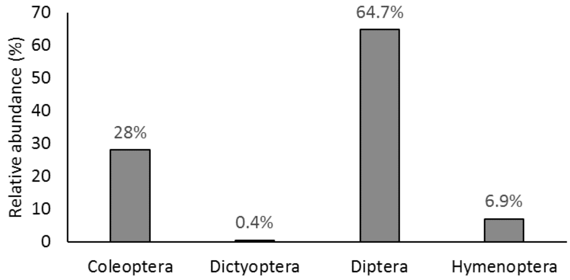

Fig. 2. Relative abundance of insect orders colleted from the three abattoirs (Obollo-afor, Orba and Ikpa).

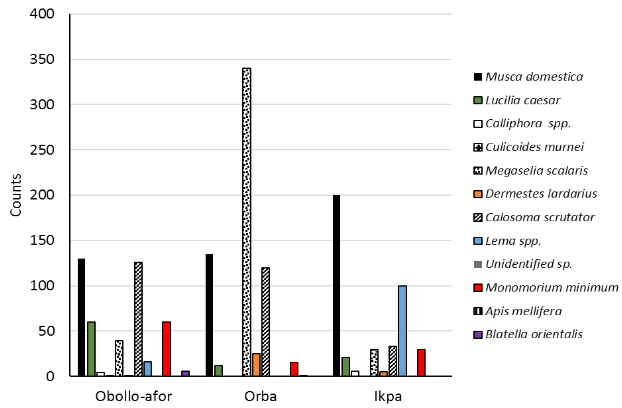

Fig. 3. Relative abundance of insect speceies colleted from the three abatoirs (Obollo-afor, Orba and Ikpa).

Table I. Percentage abundance of insect fauna of the abattoirs.

Insect order	Species	Number of individuals collected	Percentage abundance
Diptera	*Musca domestica*	465	30.4%
	Lucilia caesar	103	6.7%
	Calliphora vomitoria	10	0.7%
	Culicoides murnei	1	0.07%
	Megaselia scalaris	409	26.8%
Coleoptera	*Dermestes lardarius*	31	2%
	Calosoma scrutator	279	18.3%
	Lema spp.	116	7.6%
	Unidentified sp.	1	0.07%
Hymenoptera	*Monomorium minimum*	105	6.9%
	Apis mellifera	1	0.07%
Dictyoptera	*Blatella orientalis*	6	0.4%
	Total	1527	100

Calculation of diversity indices for species collected from the three sites indicates that Obollo-afor had the highest species diversity which was demonstrated by the highest Shannon index (H^I = 1.71). The Shannon index for Ikpa abattoir was second (H^I = 1.55) while Orba was the least diverse (H^I=0.99). Though diversity was highest at Obollo-afor, the highest number of insects was collected at Orba (N = 645, Table II). Orba also recorded the highest species dominance and dispersion of insect fauna (D = 0.325, C_x = 0.301).

Table II. Total number of insects (N), Species diversity (H^1), equitability (E_H), dominance or richness (D) and dispersion (C_x) indices of the insect species sampled at the different abattoirs.

Abattoir	N	H^1	E_H	D	C_x
Ikpa	422	1.550	0.036	0.300	0.219
Orba	645	0.990	0.153	0.325	0.301
Obollo-afor	460	1.710	0.270	0.213	0.138

DISCUSSION

The current study documented twelve (12) insect species, viz: *Musca domestica, Lucilia caesar, Calliphora vomitoria, Megaselia scalaris, Calosoma scrutator, Dermestes lardarius, Monomorium minimum, Lema* spp., *Blattella orientalis, Apis mellifera, Cullicoides murnei,* unidentified sp. These belong to eleven (11) families and four orders. Fewer numbers of species were reported by Ewuim (2002) at Awka abattoir; he documented eight species belonging to five families. We reasoned that the discrepancies might be as a result of the focus of his research which was based only on the Dipteran order. More so other factor such as sampling time, human activity in the area, physical geographical location and seasonal changes might have impacted on the findings as suggested by previous studies of McElravy and Wolda (1982). The survey further showed that the abundance and distribution range of insect species in the three sampled abattoirs was not static but changes with location as shown in the result section. These results support the observations made by Hanski (1998) and Holt *et al*. (2005) that a species distribution range is not static, but dynamic, fluctuating by dispersal of individuals or by extinction of species subpopulations. However, the distribution pattern of the insect fauna in all the sampled abattoirs in Enugu north did not show any major differences, indicating that all the insect fauna species are able to populate slaughtered meat and its by-products irrespective of the location. This similar distribution pattern might be explained by uniformity in the environmental conditions across the sites. Diptera and Coleoptera which are the two most abundant insect order of forensic importance were also observed in the abattoirs visited and this is consistent with other research studies (Smith, 1986; Goff, 2001).

The research revealed high level of biodiversity of insect species with great health implication, which implies that the abattoirs environment though quite rich in insect fauna, human health is at risk. According to work done by Abdullahi *et al.* (2016), abattoir workers are infected by diseases which are carried by parasites, bacteria and viruses, and most of these transmissible agents are carried by some insect vectors. For instance, *M. domestica*, which is a known vector for various microorganisms such as Shigella, infantile diarrhea, typhoid fever, cholera (Cohen *et al*., 1991; Dahlem, 2009), and staphylococcal food poisoning and also has the potential for spreading of microbes in the environment like abattoirs. This suggests that there might be high prevalence of diseases caused by *M. domestica* in the study area. Abattoirs working surface are significant fonts of infections by the houseflies with fungi due to dirt, body discharges and excreta from animals and blood. These were some of the features witnessed in the abattoirs visited in the study sites, and we assumed that they might have contributed to the high abundance of the flies in the area.

Furthermore, synanthropic insects are abundant in urban and rural areas where unsanitary conditions prevail and are usually scarce when sanitary conditions are enforced. Enforced fly control is equally associated with reductions in the number of such cases (Greenberg, 1973). A lot of these synanthropic flies have been reported to be associated and involved in dissemination of human entero pathogens in the environment (Dahlem, 2009). These flies breed in animal manure, human excrement, garbage, animal bedding, and decaying organic matter (Ebeling, 1978; Abdullahi *et al*., 2016). During this study, the insect species were found in the abattoir slabs, fall-off and decay carrion, bones, dung, and waste water (semi-liquid). The Diptera flies were found generally on the slabs, carrion, blood and fresh bones; while the Coleoptera were found on the bones (dry and fresh), dung and decay carrion. Hymenoptera (*Monomorium minimum*) were found on the dry wastes and dry blood, in the abattoir and among the dry wastes. Generally, one will assume that abattoirs with cleaner working surfaces and well drained environment will record few insect species in their fauna, but such hygienic condition was not the case at the study sites. Most slabs were covered with blood and semi-fluids from slaughtered animals and provided a perfect haven for files. These findings were in support of earlier research by (Olowuporoku, 2016; Cook *et al*., 2017). About 21 species of synanthropic insects have been recorded by regulatory public health agencies as being instrumental to gastrointestinal diseases in human due to their anthropophilic affinity and endophilic behaviour (Greenberg, 1973). In the study area, over 90% of the insects sampled were in close association with human. Their feeding methods and filthy breeding behaviours make them efficient vectors and transmitters of human enteric protozoal parasites, example of such insects incudes flies, cockroaches, and coprophagic beetles, particularly the domestic filth flies (such as some species of flesh flies, house flies, latrine flies, blow flies and bottle flies) which have evolved to live in close association with humans as irritating and pestiferous scavengers (Ebeling, 1978).

Furthermore, percent abundance during the study period showed that three species were abundant in the study area, these are *Musca domestica* (family: Muscidae) (30.4%), *Megaselia scalars* (Phoridae*)* (26.8%) and *Calosoma scrutator* (Carbide) (18.3%). It was assumed that this is so due to ever-present fall-offs and decaying spilled blood from carcass at the abattoirs; this markedly contributed to the presence and preponderance of the *M. domestica.* Although the *Muscidae* and *Phoridae* were the popular flies encountered at the study area, the constant availability of decaying fall-offs from carcass at the abattoir may have favored the existence of *Calliphora vomitoria*, and *Lucilia caesar* (Callophorids) which were not as abundant as *M. domestica*. This result is in contrast to Smith (1986) who reported that Calliphoridae are the most abundantly-studied carrion species; probably because carcass size is a determining factor for the attraction of Calliphorids. The study also revealed that the highest proportion of insect fauna captured in most study site was Diptera and the increased capture success rate of the Diptera was not just attributed to the sweep net but also as a result of their feeding behavior. They were virtually perching everywhere in the abattoir including rumen of slaughtered animals, bones, semi-liquid wastes and other slaughter house by-products. The slaughterhouse by-products, whose availability is assured by regular slaughtering of animals at the abattoir are often not properly disposed and are usually at various stages of decay at the sites. In addition, the significant difference existing in the trapping of the Diptera, with majority of the insects trapped from the abattoir is no doubt not only related to their increased relative abundance at the abattoir, but also to their locomotory activity. This observation is in line with Chapman (2000) who noted that the relatively low speed of locomotion is associated with crawling movement in Diptera larvae, which is often affected by changes in body shape rather than legs.

It has been demonstrated that insect richness has a positive correlation with plant diversity (El-Moursy *et al*., 2001) and that insect diversity might also be due to distance and elevation between two locations (El-Hawagry *et al*., 2013). Also, the capacity of insect species to scatter between areas might be affected by height (Fisher, 1996) resulting to differences in community. More so other abiotic factors such as temperature, and relative humidity could affect pattern of insect distribution (El-Hawagry *et al*., 2013). Considering the diversity of the insect fauna in collected from the three abattoir sites Obollo-afor had the highest diversity ($H' = 1.71$) and closely followed by Ikpa ($H' = 1.55$). Orba has the least diverse insect fauna ($H' = 0.99$). The highest fauna diversity observed at Obollo-afor abattoir might be attributed to its physical geographical position and perhaps due to the impact of high commercial activities such as buying and selling observed there. On the other hand, Ikpa which was close to the outskirts of market had little commercial activity and had the lowest species abundance and richness higher than that of Orba. Orba had the highest species abundance but low species richness. The overall differences observed in the abundance and species richness may be due to the slight variations in physical geographical location and human activities as well as minor changes in abiotic factors like temperature rainfall and even relative humidity as has been documented by other researchers (El-Hawagry *et al*., 2013). This explains that species have to contend with environmental changes and biological interaction, which may produce significant alterations in overall community structure. In addition, Obollo-afor recorded the highest species evenness validated by the Equitability index of $E_H = 0.270$, accounting for the reason why it had the highest diversity value. Similarly, Orba was evenly distributed with $E_H = 0.153$, whereas the equitability index value of the species in Ikpa was $E_H=0.036$ resulting to an uneven distribution.

CONCLUSIONSANDRECOMMENDATIONS

The survey revealed high level of biodiversity of insect species, which implies that the abattoirs environment is quite rich in insect fauna. Most of the insects specied encountered in the study sites were synanthropic. Their feeding and filthy breeding habits make them efficient vectors and transmitters of human enteric protozoal diseases.

Meat and meat products are an essential part of our daily body requirement therefore it is very crucial that care is taken during the processes that involves meat handling. At such the sanitary state of environment where meat and meat related products are managed should be taken very seriously. Individual involved in meat handling should be well aware of the health risk involved in processing meat in sub-sanitary conditions. Maximum sanitary care should be considered when setting up a meat processing facility and strictly adhere to in these abattoirs. The authorities and governmental bodies responsible for parasite and disease control must ensure that modern hygienic conditions are fully upheld as a way of actively stemming diseases in the food industry. To this end it is their responsibility to ensure proper sanitation in abattoirs within their dominion and that sites mapped out meant for construction of slaughter houses must undergo environmental impact assessment before approval is granted. We also suggest that the regulation of the slaughter industries should not only target to improve hygiene and control the contamination of meat and spread of disease but should equally aim at ensuing regulatory policies that will safe guard the abattoir workers physically and otherwise.

Statement of conflict of interest

The authors have declared no conflict of interest.

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