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Original Article

SPATIAL VARIATION IN ABUNDANCE OF FORENSICALLY IMPORTANT ENTOMO-FAUNA INHABITING DECOMPOSING CARCASS IN MINNA, NIGERIA

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ABSTRACT

The influence of study locations and mode of killing on abundance of forensically important insect species informed the present study in Minna, North-central Nigeria. Twenty-four pigs with an average weight of 22.30 kg were sacrificed through stabbing, oxygen deprivation and poisoning with zinc phosphate to determine population dynamics of carcass inhabiting insects during the process of decomposition in two locations (College of Education, COE, and Dutsen Kura, DK) during the dry season in Minna. Five stages of decomposition of cadaver were observed in the study, namely; fresh, bloated, active decay, advanced decay and dry decay stages. Though, eight (8) forensically important insect species (*Lucilla sericata, Chrysomya albiceps*, *C. rufaficies, Musca domestica, Hemipyrellia liqurriens, Sarcophaga carnaria, Hermetia illucens* and *Ophyra aenacens*) were observed colonizing the carcases, pigs sacrificed by poisoning witnessed the presence of only two (2) insect species (*L. sericata* and *M. domestica*). A total of 611.70±79.30 insect species were collected throughout the study periods; with stabbed pigs contributing 154.70±21.91 and 152.32±13.83 insects species, respectively, in COE and DK; oxygen-deprived and poisoned pigs contributing 136.62±16.73 and 145.74±17.40, and 12.32±2.83 and 10.00±0.66 insect species, respectively, in COE and DK. There was no significant ($p>0.05$) variation in the number of forensically important insect species encountered in the study sites, however, there was significant ($p<0.05$) effect of mode of killing on the numbers encountered. There was also significant ($p<0.05$) variation in the number of insects collected during each decompositional stage: with active decay stage, consistently, recording the highest number of insect species irrespective of mode of killing. While, *M. domestica* was, consistently, the

most abundant insect species irrespective of mode of killing, decompositional stage and study site, *H. illucens* was the least abundant. *Musca domestica* had range of values of 6.00±4.95 (in COE, for poisoned pigs) to 37.76±3.01 insects/ net sweep (in GK, for oxygen-deprived pigs), while *H. Illucens* had range of values of 4.50±0.71 (in COE, for stabbed pigs) to 5.67±2.36 (in DK, for oxygen-deprived pigs). The study revealed that mode of killing, rather than, study locations had significant effect on abundance of carcass-inhibiting entomo-fauna. The finding of this study will provide baseline information for preparing a forensic template for determining post-mortem interval and cause of human deaths in Minna eco-type settings.
Keywords: oxygen-deprivation, colonization, stabbing, poisoning, Post-mortem-interval
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INTRODUCTION

Today, human population is a drift in the sea of insects (Hall, 2001). In line with this, insects are considered the most abundant animals on earth (Koptal, 2007). Along with humans, insects live in every habitable place on earth except the ocean depths. According to the distinguished Entomologist, Ersner Wilson, "Insects all but own the land"; they are the chief consumers of plants, major predators of plant eaters, play a major role in decaying of organic matter and decomposition of carcass and serve as food for other animals. Knowing this ecological facts and the natural phenomena, that, some insect flies (*Sarcosprophagus*) are very versatile (Hall, 2001), and are able to reach a carcass and oviposit on it within few minutes of death, gave birth to the discipline of science known as forensic Entomology. A branch of entomology that uses the understanding of the life stages and behaviours of insects in medico-legal context (Haskell *et al*. 1997).

The first organisms to arrive on a body after death are usually the insects (Anderson, 2009). They arrive at predictable time during the decomposition process. Each decomposition stage is attractive to a different group of *Sarcophagus* arthropods (Smith 1986). Data collected by Forensic Entomologists on arthropod populations, associated with carcass can be used in a number of ways; for example, to determine the place where death occurred and whether or not there was ante mortem ingestion of toxins or drugs and to identify wound sites. However, the most valuable use of entomological data is the estimation of the post-mortem interval (PMI) or the time that elapsed since death (Hall, 2001).

The presence or absence of an insect species can prove helpful because insect communities typically move from a more complex organization to a simpler community and are attracted to different stages of decomposition (Vanlaerhover and Anderson, 1999). Megnin (1894) was the first to describe the different stages of human decomposition and break them into eight stages, later; Payne and King (1968) have combined the eight stages into five stages. The five stages described by Payne and King using pig (*Sus scrofa L*) as human models, are referred to as fresh, bloat, active decay, advance decay and dry stage. Today, Forensic Entomologists routinely use the five-stage model (Vanlarhover and Anderson, 1999).

The sequence in which insects colonize remains is affected by many parameters. Insect's colonization of carrion is dependent on many factors, but one of the most important is the geographical region or biogeoclimatic zone where the remains are found. The biogeoclimatic zone defines the habitat, vegetation, soil type and meteorological conditions of the area (Anderson 2000).

MATERIAL AND METHODS

Description of the Study Area

The study was carried out in Minna, the Capital City of Niger State in North-central area of Nigeria. The area is situated within latitude 9^0 35' N and longitude $6^0$10' E. Minna has a land area of 88km^2. The mean annual temperature and rainfall in the area are 39 ^{o}C and 1,600 mm, respectively. The area enjoys typical tropical climatic conditions, with two distinct seasons namely; dry (between November and April) and rainy (May to October). The vegetation in the area is typically grass-savannah dominated, and often subjected to annual bush burning. The soil types in Niger are two: the KU and YA soil, and the most dominant soil in terms of texture and particles sizes is sandy loamy and loamy sand soil with a pit range of 5.00-5.80. Types of crime committed in Minna include Armed Robbery, 2.6%, kidnapping, murder 0.6%, rape 2.4%, suicide 6.0%, homicides 2.0%, and assault 9.0% (Jinadu *et al.* 2006).

Description of the Study Stations

Station A (COE) was the Moringa Farm of Niger State College of Education, Minna, Nigeria. This farm lies directly east of a seasonal stream, northwest of a co-pasture and is surrounded by corn, potatoes, beans, yam and groundnut farms, (during the rainy seasons). Grasses, wildflowers and common weeds cover the field. The trees common to that locality are Moringa and mango trees.

Station B (DK) was located in Dutsen Kura, behind the Water Board supply Unit. It is situated 20 meters from a major road that is always busy with movement of people and vehicles. It is a hilly place with its vegetation consisting of mostly of grasses, wildflowers and common weeds with no bigger trees.

Sources, Bio-Data and Handling of Pig Specimens

An average of 22.30 kg pigs were used as human models for adult carcass decomposition (Catts and Golf, 1992). Twenty-four (24) pigs (*Sus scrofa L*) were purchased from a Piggery Farm in a village behind former Mammy Market, Shango, Minna, Niger State. All the pigs were six months old and above and of the same skin colour.

Sacrificing the pigs

Twenty-four (24) pigs (eight pigs per mode of killing) were used in this study. Poisoning was done by administration of zinc phosphide, to mimic food poisoning conditions. Zinc phosphide is a common rodenticide used for killing rats, commonly called Commando. Stabbing was done using cutlass to stab the neck region (jugular); this killing method was to simulate death by cutting and stabbing. Oxygen-deprivation (control experiment) was done to simulate a natural cause of death (Ekrakene and Iloba, 2011).

Duration of the study

The study was carried within the period of two years (2014 and 2015). Two placements were made each year. Whereby three pigs were placed in each study site (December to February) for the

two years. Each site had each of pigs killed using the different modes.

Experimental layout

All the pigs were sacrificed at Niger State College of Education farm. The dead pigs were immediately packed each, in a separate heavy-duty polythene trash bag, labelled and transported to the placement sites; this is to prevent colonization before placement (Ekrakene and Iloba, 2011). At the sites, the pig specimens were placed on the ground and a cage of wire mesh (20 mm mesh size) measuring 80 cm long x 50 cm wide x 60 mm high, was placed over each pig to protect it from large vertebrate scavengers (Stone *et al.* 2005).

Insect collection

Collection were done three times daily, at 6:00am-6:30am, 12.00pm-12.30pm and 6.00-6.30pm from time of placement. Before daily collections, the decomposition state of the carcasses were noted. (Anderson and Vanhaehover, 1986). Adult flying insects were collected by aerial net sweep above and around the carcasses.

Preservation and Sorting of Insect.

Insects collected were preserved in 10% formalin. The insects were later sorted into their taxonomic groups in Zoology Laboratory of Federal University of Technology Minna.

Identification of insects

All collected insects (adult muscids) were identified using aids and taxonomic keys proposed by Carvalho & Cour (2002), other flies were identified using keys described by Calvalho and Mello (2008). The evaluation of the decomposition stages was classified using the terminology of Payne and King (1968).

Ethical Clearance

This research followed ethical clearance from Niger State Veterinary Centre, Ministry of Livestock, Minna, Niger State.

Sacrificing and Placement of Pig Specimens

RESULTS AND DISCUSSION

A mean total of 307.02±35.73 flying insects were collected throughout the study period from the stabbed pig carcasses and is presented in Table 1. A total of 154.32±13.83 and 152.32±13.83 insects were respectively collected at COE and DK. There was no significant ($p>0.05$) difference in the total number of species collected at the two sites for all the insects collected. There was, however, significant ($p<0.05$) variation in the number of insects collected during each decompositional stage; with the active decay stage consistently recording the highest number of insects (98.84±9.05 and 96.67±10.70 for COE and DK, respectively).Dry decay stage having the lowest for the two sites (4.50±0.71 and 5.17±0.94) respectively for COE and DK. *M. domestica* was consistently, the most abundant species of insect colonizing the stabbed carcass at all decompositional stages while *H. illucens* was the least.

Relative abundance of adult insect species with different decompositional stages of pig carcasses sacrificed by oxygen deprivation is presented in table two. A mean total of 282.36±34.13 flying insects were collected. A total of 136.62±16.7 and 145.74±17.40 insects were collected, respectively at COE and DK. There was no significant ($P>0.05$) difference in the total number of species collected at the two sites, except for *M. domestica* and *H. Illucens* where significant variation ($P<0.05$) existed. Further, there was a significant difference ($P<0.05$) in the

number of insects collected at each site within any decompositional stage, with COE and DK having values of 93.63±8.95 and 93.66±4.47 insects/ per net sweep, respectively. Collections during the active decay stage being the most abundant and the dry stage of decomposition with 5.50±0.71 and 7.00±0.00 insects/ net sweep at COE and DK, respectively, the least.

Table 3 shows the relative abundance of Adult insects associated with different decomposition stages of pig carcass sacrificed by poisoning. A total of 22.32±9.43 insect species were collected for the two sites throughout the period of the study. A total of 12.32±2.83 and 10.00±6.60 insects/ net sweep were, respectively, collected at COE and DK during the study period. There was no significant ($p>0.05$) difference between the two sites for the number of insects collected for the two insects that colonized the poisoned pig. There was also significant ($p<0.05$) variation in the total number of insects collected during the decompositional stage with active decay stage recording the highest number insect species at COE (4.33±0.46 insects/ net sweep) and Bloat stage recording the highest in DK (4.00±1.42 insects/ net sweep)

Discussion

M .domestica was observed to be the most abundant insect species, followed by *L. sericata* irrespective of mode of killing and study site. This observation is in agreement with those of Okewelu *et al.* (2005) who reported *M. domestica* providing the highest number of insect species on pig carcass in Southern Nigeria and Nyashamabika and Gilbert (2014) who observed *M. domestica* providing the highest number of flies from colonized carcass in Zimbabwe. However, the observation of this study is contrary to those of Knut (1991), Mohd *et al.* (2015) and Abdelbar and Sawaby (2011) who reported *Chrysomya* species as the most abundance insect species colonizing rabbit carcass. This difference could be as a result of different animal model used. This study observed no disparity in the species and abundance of insect species collected between the two sites and this is in contrary to the observation of Ashraf and Meklafi (2016) who observed disparity in the abundance of insect species colonizing the same animal carcass at different habitats in Egypt. Although, the poisoned pigs witnessed the presence of *M. domestica* and *L. sericata* despite the absence of all the species, a low abundance of this two insect species were recorded compared to their abundance on the pigs killed by the other two methods (stabbing and oxygen-deprivation). This observation could be because of the odour of organophosphate masking the decompositional odour, thereby, repelling the insect species instead of attracting them to the carcass (Deno, 1970).

The pattern of abundance of insect species in relation to different decompositional stages is consistently low abundance at the fresh stage of decomposition, which increased at the bloat stage and dramatically increased and reached the peak at the active decay stage. Meanwhile, the advanced decay stage witnessed a decline in the abundance of insect species and disappearance of Calliphorids flies. This trend is in agreement with that reported by Nyshamabika and Gilbert (2014) who observed active decay stage recording the highest number of insects and the fresh stage recording the lowest in Zimbabwe. Deno (1970) has previously observed active decay stage as recording highest abundance of insect species.

The forensic importance of Muscidae has not been well documented, many researchers recorded their presence and/or abundance but this use to be too variable to be used as a relevant forensic indicator. In contrary, the presence of *M. domestica,* even in the absence of other insect species with the exception of *L. sericata* and its very low abundance even in the active decay stage which recorded the highest abundance of all insect species in this study, tend to call for more investigation on the probability of *M.domestica* been used as a relevant forensic indicator in terms of death by poisoning.

Conclusion

M. domestica is the most abundant insect species colonizing carcass in Minna and there was disparity in the abundance of insect species collected from the two study sites. The poisoned carcass recorded a low abundance of the only two insect species that colonized the carcass.

Table 1: Seasonal Relative Abundance (Per net sweep) of Adult Insects with Different Decomposition Stages of Pig Carcass (*Sus scrofa*) Sacrificed by stabbing in Minna

Species	Fresh		Bloat		Active Decay		Advanced Decay		Dry Decay		Total	
	COE	DK	COE	DK	COE	DK	COE	DK	COE	DK	COE	DK
Luilla sericata	1.99±0.47^{b*a**}	3.33±0.47 $^{c}_{b}$	4.00±0.00 $^{b}_{a}$	4.83±0.71 $^{d}_{a}$	22.67±0.94$^{d}_{a}$	22.67±0.47$^{d}_{a}$	3.33±0.47 $^{b}_{a}$	3.00±0.00$^{b}_{a}$	****	****	34.99±1.88 $^{e}_{a}$	33.83±1.65 $^{e}_{a}$
Chrysomya albiceps	1.00±0.00 $^{a}_{a}$	1.00±0.00$^{b}_{a}$	2.50±0.70 $^{a}_{a}$	2.67±0.94 $^{b}_{a}$	11.00±1.41 $^{c}_{a}$	10.83±0.71 $^{c}_{a}$	1.50±0.71 $^{ab}_{a}$	2.00±0.00 $^{ab}_{a}$	****	****	16.00±2.82 $^{c}_{a}$	16.50±1.65 $^{c}_{a}$
C. rufaficies	1.00±-.000 $^{a}_{a}$	1.00±0.00$^{b}_{a}$	3.00±0.00 $^{a}_{a}$	2.83±0.71 $^{b}_{a}$	10.67±2.35 $^{c}_{a}$	9.67±0.47 $^{c}_{a}$	1.50±0.71 $^{ab}_{a}$	1.00±0.00 $^{a}_{a}$	****	****	15.17±3.06 $^{c}_{a}$	14.50±1.18 $^{c}_{a}$
Musca domestica	3.50±1.65 $^{c}_{a}$	4.66±0.00$^{d}_{a}$	3.50±0.71 $^{b}_{a}$	3.66±0.47 $^{c}_{a}$	22.00±1.41$^{d}_{a}$	21.00±1.41 $^{e}_{a}$	5.33±0.47$^{c}_{a}$	5.67±0.47$^{c}_{a}$	2.50±0.71 $^{c}_{a}$	2.00±0.00 $^{a}_{a}$	36.83±4.95 $^{f}_{a}$	33.32±2.35 $^{e}_{b}$
Hemipyrellia liqurriens	1.00±0.00 $^{a}_{b}$	****	2.50±0.71 $^{a}_{a}$	2.00±0.00 $^{a}_{a}$	13.00±0.00$^{c}_{a}$	13.33±0.47$^{c}_{a}$	3.00±0.00 $^{b}_{a}$	3.17±0.23$^{b}_{a}$	0.00±0.00$^{a}_{a}$	2.00±0.00 $^{a}_{a}$	19.50±0.71 $^{d}_{a}$	20.50±0.70 $^{d}_{a}$
Sarcophaga carnaria	****	****	2.00±0.00 $^{a}_{a}$	1.50±0.71 $^{a}_{a}$	6.00±1.41 $^{b}_{a}$	5.00±1.41 $^{b}_{a}$	0.50±0.71 $^{a}_{a}$	0.50±0.71 $^{a}_{a}$	****	****	8.50±2.12 $^{b}_{a}$	7.00±1.83 $^{b}_{a}$
Hermetia illucens	****	****	****	****	`1.50±0.71 $^{a}_{a}$	1.67±0.23 $^{a}_{a}$	2.00±0.00 $^{ab}_{a}$	1.50±9.71 $^{ab}_{a}$	1.00±0.00 $^{b}_{a}$	2.00±0.00 $^{a}_{a}$	4.50±0.71 $^{a}_{a}$	5.17±0.94 $^{a}_{a}$
Ophyra aenacens	****	****	****	****	12.00±1.42$^{c}_{a}$	12.50±3.53$^{c}_{a}$	5.38±4.00$^{c}_{a}$	7.00±0.00$^{c}_{a}$	1.83±0.24$^{c}_{a}$	2.00±0.00 $^{a}_{a}$	19.21±5.66 $^{d}_{a}$	21.50±3.53 $^{d}_{a}$
Aggregate	8.49±1.65	9.99±0.00	17.50±1.42	17.49±3.54	98.84±9.65	96.67±10.70	22.54±10.07	23.84±2.12	5.33±0.95	8.00±0.00	154.70±21.91	152.32±13.83

*Values followed by same superscript alphabet in a column (for a study site for a stage of decomposition) are not significantly different at $p<0.05$

**Values followed by same subscript alphabet in a row (for a species between study sites in a stage of decomposition) are not significantly different at $p<0.05$

-***= Not encountered at all

-****= Not encountered at decompositional stage

COE = College of Education; DK = Dutsen Kura

Table 2: Seasonal Relative Abundance (Per net sweep) of Adult Insects with Different Decomposition Stages of Pig Carcass (*Sus scrofa*) Sacrificed by oxygen–deprivation in Minna

Species	Fresh		Bloat		Active Decay		Advanced Decay		Dry Decay		Total	
	COE	DK	COE	DK	COE	DK	COE	DK	COE	DK	COE	DK
Lucilla sericata	1.00±0.00 $^{a*}{}_{a**}$	2..00±0.00 $^{bc}{}_{b}$	3.00±0.00 $^{c}{}_{a}$	3.00±0.00 $^{ab}{}_{a}$	20.83±1.65 $^{d}{}_{a}$	20.50±0.71 $^{d}{}_{a}$	3.50±0.71 $^{c}{}_{a}$	2.83±0.24 $^{c}{}_{a}$	****	****	28.33±2.36 $^{e}{}_{a}$	28.33±0.95 $^{d}{}_{a}$
Chrysomya albiceps	0.83±0.24 $^{a}{}_{a}$	1.00±0.00 $^{b}{}_{a}$	1.83±0.24 $^{b}{}_{a}$	2.00±0.00 $^{a}{}_{a}$	11.33±0.95 $^{c}{}_{a}$	11.00±1.41 $^{c}{}_{a}$	1.00±0.00 $^{a}{}_{a}$	2.00±0.00 $^{b}{}_{b}$	****	****	15.01±1.43 $^{c}{}_{a}$	16.00±1.41 $^{b}{}_{a}$
C. rufaficies	0.66±0.00 $^{a}{}_{a}$	1.00±0.00 $^{b}{}_{a}$	1.83±0.24 $^{b}{}_{a}$	1.83±0.24 $^{a}{}_{a}$	11.49±1.18 $^{c}{}_{a}$	11.33±0.95 ^{c}	0.67±0.94 $^{a}{}_{a}$	1.50±0.70 $^{b}{}_{b}$	****	****	14.65±2.36 $^{c}{}_{a}$	15.66±1.89 $^{b}{}_{a}$
Musca domestica	2.66±0.00 $^{b}{}_{a}$	3.33±0.47 $^{c}{}_{b}$	2.83±1.17 $^{d}{}_{a}$	4.33±0.47 $^{b}{}_{b}$	20.00±0.00 $^{d}{}_{a}$	20.00±1.41 $^{d}{}_{a}$	4.50±0.70 $^{c}{}_{a}$	6.13±0.66 $^{e}{}_{b}$	2.50±0.71 $^{b}{}_{a}$	2.00±0.00 $^{a}{}_{a}$	32.49±2.58 $^{e}{}_{a}$	37.76±3.01 $^{e}{}_{b}$
Hemipyrellia liqurriens	0.83±0.24 $^{a}{}_{b}$	0.00±0.00 $^{a}{}_{a}$	2.00±0.00 $^{b}{}_{a}$	2.00±0.00 $^{a}{}_{a}$	12.33±0.47 $^{c}{}_{a}$	12.00±1.42 $^{c}{}_{a}$	2.00±0.00 $^{b}{}_{a}$	2.83±0.70 $^{c}{}_{a}$	****	****	17.16±0.71 $^{d}{}_{a}$	16.83±2.12 $^{b}{}_{a}$
Sarcophaga carnaria	****	****	0.33±0.47 ^{a}	****	4.49±023 $^{b}{}_{a}$	4.50±0.71 $^{b}{}_{a}$	1.00±0.00 $^{a}{}_{a}$	0.50±0.71 $^{a}{}_{b}$	****	****	5.82±0.70 $^{b}{}_{a}$	5.00±1.42 $^{a}{}_{a}$
Hermetia illucens	****	****	****	****	1.33±0.47 $^{a}{}_{a}$	2.17±1.65 $^{a}{}_{b}$	1.00±0.00 $^{a}{}_{b}$	1.50±0.71 $^{b}{}_{b}$	1.00±0.00 $^{a}{}_{a}$	2.00±0.00 $^{a}{}_{a}$	3.33±0.47 $^{a}{}_{a}$	5.67±2.36 $^{a}{}_{b}$
Ophyra aenacens	****	****	****	****	11.83±4.00 $^{c}{}_{a}$	12.16±3.53 $^{c}{}_{a}$	4.50±2.12 $^{c}{}_{a}$	4.83±0.71 $^{d}{}_{a}$	2.00±0.00 $^{b}{}_{a}$	3.00±0.00 $^{b}{}_{a}$	19.33±6.12 $^{d}{}_{a}$	19.99±4.24 $^{c}{}_{a}$
Aggregate	5.98±0.48	7.33±0.47	11.82±2.12	13.16±0.71	93.63±8.95	93.66±12.79	18.17±4.47	22.39±4.43	5.50±0.71	7.00±0.00	136.62±16.73	145.74±17.40

*Values followed by same superscript alphabet in a column (for a study site for a stage of decomposition) are not significantly different at $p<0.05$

**Values followed by same subscript alphabet in a row (for a species between study sites in a stage of decomposition) are not significantly different at $p<0.05$

-***= Not encountered at all

-****= Not encountered at decompositional stage

COE = College of Education; DK = Dutsen Kura

Table 3: Seasonal Relative Abundance (per net sweep) of Adult Insects with Different Decomposition Stages of Pig Carcass (*Sus scrofa*) Sacrificed by Poisoning in Minna

Species	Fresh		Bloat		Active Decay		Advanced Decay		Dry Decay		Total	
	COE	DK	COE	DK	COE	DK	COE	DK	COE	DK	COE	DK
Lucilla sericata	0.83±0.24 $^{a}_{a}$	1.50±0.23 $^{a}_{b}$	1.50±0.71 $^{a}_{a}$	1.50±0.71 $^{a}_{a}$	0.00±0.00 $^{a}_{a}$	1.00±1.41 $^{a}_{b}$	****	****	****	****	2.33±0.95 $^{a}_{a}$	4.00±2.35 $^{a}_{b}$
Chrysomya albiceps	***	***	***	***	***	***	***	***	***	***	***	***
C. rufaficies	***	***	***	***	***	***	***	***	***	***	***	***
Musca domestica	2.33±0.95 $^{b}_{a}$	1.50±0.71 $^{a}_{b}$	3.33±0.47 $^{b}_{a}$	2.50±0.71 $^{a}_{a}$	4.33±0.46 $^{b}_{a}$	2.00±2.83 $^{b}_{a}$	****	****	****	****	9.99±1.88 $^{b}_{a}$	6.00±4.95 $^{b}_{a}$
Hemipyrellia liqurriens	***	***	***	***	***	***	***	***	***	***	***	***
Sarcophaga carnaria	***	***	***	***	***	***	***	***	***	***	***	***
Hermetia illucens	***	***	***	***	***	***	***	***	***	***	***	***
Ophyra aenacens	***	***	***	***	***	***	***	***	***	***	***	***
Aggregate	3.16±1.19	3.00±0.94	4.83±1.18	4.00±1.42	4.33±0.46	3.00±4.24	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	12.32±2..83	10.00±0.66

*Values followed by same superscript alphabet in a column (for a study site for a stage of decomposition) are not significantly different at $p<0.05$

**Values followed by same subscript alphabet in a row (for a species between study sites in a stage of decomposition) are not significantly different at $p<0.05$

-***= Not encountered at all

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