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Dynamic of the community of the cadaveric entomofauna of domestic pigs (*Sus Scrofa Domesticus* Linnaeus, 1758) corpses place at a littoral zone: Case of the open air of Ndogbong-Douala, Cameroon

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Abstract
Forensic entomology is a sub-discipline of forensic science that examines insects and other arthropods in a forensic setting. To gain a deeper understanding of the diversity and dynamics of cadaveric entomofauna in the littoral zone of Cameroon, a study was conducted on the carcasses of five domestic pigs (*Sus scrofa domesticus,* Linnaeus, 1758) on Campus 2 of the University of Douala, at Ndogbong from August 26 to November 16, 2024. A wooden protective cage was constructed to protect the carcass place on a layer of sterilized soil. Specimens were collected once a day, at 12 o'clock, until the end of the 83-day experiment. The observation of the physical changes that appear on the corpse during the degradation process allowed us to note five stages of decomposition: fresh, bloated, putrefied, dried and skeletonized. The sampling of the cadaveric entomofauna yield 5373 insects divided into 12 orders, 28 families, 22 genera and 40 species. Individuals of the Calliphoridae family, the first colonizers of the remains, were the most abundant with 4614 (85,87%) of the total number. This dominant family was followed respectively by Mites with 183 individuals (3,41%) and Muscidae with 164 individuals (3,05%). This study is the first forensic research carried out at the littoral zone of Cameroon to census the cadaveric entomofauna in view of their possible using later in solving criminal cases in court.
The Shannon index shows the family Calliphoridae at the skeletonized ($H'_{skeletonized}$ = 0.89) and putrefied ($H'_{putrefied}$ = 1.09) while the Berger-Parker dominance index shows that family diversity is high at the bloated stage (bloated ID = 0.26) followed by the dried stage (dried ID = 0.34). The Simpson index value confirms these data (bloated ID = 0.84; dried ID = 0.81). At the fresh (fresh ID = 0.51), putrefied (putrefied ID = 0.74), and skeletonized (skeletonized ID = 0.80) stages, family diversity is significantly lower. The Chao-1 non-parametric estimator shows that 12 out 14 "true" species were captured. The Margalef index shows that the decomposition stages richest in species are dried, followed by putrefied, while skeletonized, the fresh stage and the bloated are the least rich.

Keywords: Dynamic, littoral zone, Cameroon, insects' succession, forensic entomology

Introduction
Medico-legal/Forensic entomology is the use of the results obtained from the study of insects associated with a corpse for legal purposes [1-3]. It is commonly used to estimate the time elapsed since death called post-mortem interval (PMI) [4, 5], as well as other elements related to death such as the fact that the body was moved after crime, detection of toxins or drugs in corpses, abandonment of people elderly [6-8].
The determination of the date of the death of an individual becomes difficult and imprecise in the event of advanced putrefaction, of particular conditioning of the body or even a particular climatic influence [9].
With regard to our documentation, very little study related to the interest or the role of insects in determining the parameters surrounding a death were carried out at a Littoral zone of Africa in general and of Cameroon in particular. Since 2012, several research works have been carried out with various animals' dogs, rats and domestic pigs, in Cameroon [10], but no particular document is available on drilling entomology in general on domestic pig corpse carried out at a littoral zone.

Materials and Methods
1. Study site
The present study was carried out from August 26th to November 16th, 2024 on Campus II of the University of Douala, more precisely 100m from the Animal Organism Biology unit (9°44'36,342" E, 4°3'20,298" N) located in Ndogbong in the Douala Municipality. The vegetation is mangrove characterized by a muddy ground rich in root, abundant rainfall and tropical climate with two distinct seasons, a short dry season from mid-November to mid-March and a long rainy season from mid-March to mid-November. The average annual rainfall is 3,174 mm in October and the hottest month is February [11] (figure 1).

2. Biological Material
The biological materials used were 5 months-old corpses of five domestic pigs (*Sus scrofa. domesticus,* Linnaeus*,* 1758), weighting 40kg placed on a 20cm thick layer of sterilized soil contained in a 40cm^3 contenainer. These materials were protected by five wooden cages (120cm x 120cm x 120cm) with 2cm mesh to allow access to carcass by entomofauna while protecting it from scavengers. The cages were separated by at least 200m each other to avoid cadaveric entomofauna interference between carcasses. Five pigs were sacrificed according to the method emphasized by Feugang Youmessi *et al*. [12].

3. Sampling of the cadaveric entomofauna colonizing the domestic pigs (*Sus scrofa domesticus*) corpses
After the placement of the carcass inside the cage, the cadaveric entomofauna was collected at 12:00 GMT, each session lasting 20 minutes until the end of decay process. Collections were made using an entomological sweeping net and the captured insects were stunned by spraying 70% alcohol and stored in labeled pillboxes containing 70% alcohol. Crawling insects were also collected using pitfall

traps placed around the carcass in the four corners of the cage as perform by Szpila [13].

4. Preparation and identification of the cadaveric entomofauna collected

The insects stored inside the pillboxes were removed and placed on an absorbent paper for five minutes to remove excess alcohol, then taken and pint vertically (figure 2) on the dorsal surface of the prothorax, very precisely in the tergite to avoid damaging structures that could serve as identification characteristics and the wings were spread out. The pin was inserted at approximately the upper ¾ of its length. Small insects were glued to the end of the straw and the pin was pushed into a height of approximately ¾ of its length. This assembly was then fixed to polystyrene plates (5 cm x 20 cm x 30 cm) (figure 2). The insects were left to dry for two hours before being identified.

The first phase of insect's identification was carried out using a binocular microscope (Wild M3Z, Herbrugg Switzerland, 10x magnification) at the Zoology Laboratory of the University of Yaounde I, using the identification keys proposed by Delvare and Alberlenc [14]; these allowed us to determine all families of organisms collected on/and around the corpse.

The identification of the genera and/or species level, was carried out using the identification keys of Couri [15], Kurahashi and Kirk-Spriggs [16], Lin Long *et al*. [17], Rognes and Paterson [18] and Rochefort *et al.* [19].

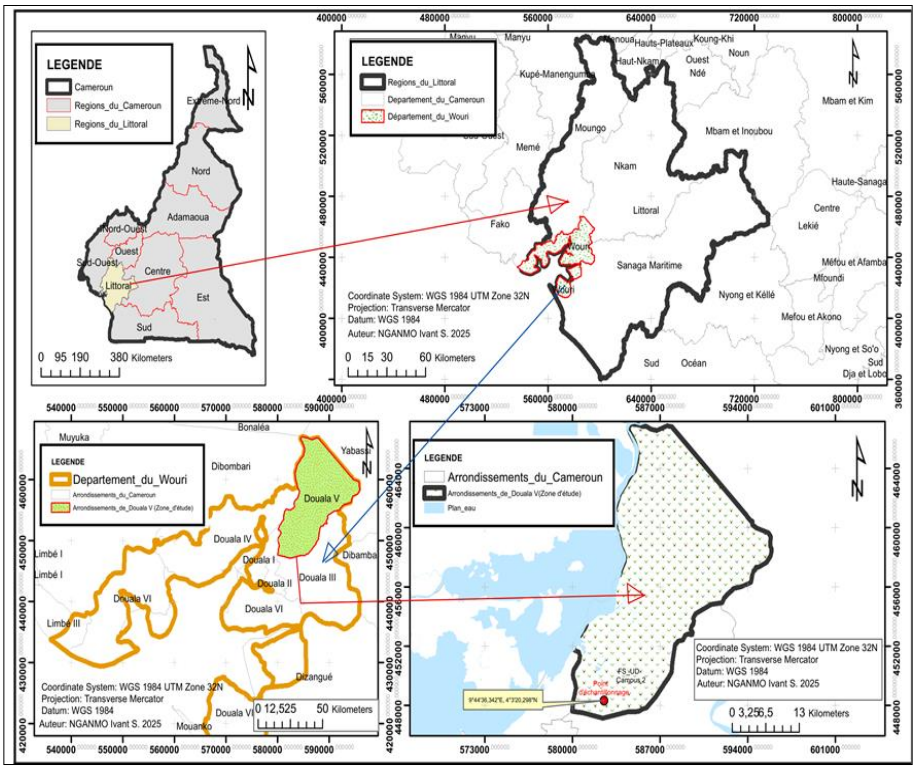

Fig 1: Map of the study site within the University campus

Fig 2: Preparation of the insects for identification

5. Data Processing and Analysis

The data were analyzed using Excel version 2016 and Past version 4.10. These softwares allowed us to enter the data, construct the curves and calculate the variables below:

Relative abundance (Ar_i) which is the ratio of the number of individuals (n_i) in a given group to the number of individuals (N) [20]:

$$\mathbf{Ar_i\ (\%)} = \frac{\mathrm{ni\ x\ 100}}{N}$$

Four classes of relative abundance were defined as follows:

- High abundant species (Ar ≥ 10 %).
- Abundant species (5 % ≤ Ar < 10 %).
- Low abundant species (1 % ≤ Ar < 5 %).
- Very low abundant species (Ar < 1 %).

Species richness, denoted S, is the simplest form of expression for stand diversity. It represents the total number of species collected in a community.

$\mathbf{S} = \frac{S-1}{Ln\ (n)}$ if S varies between 0 (zero richness) and infinity (high richness).

Species diversity were assessed using the Shannon and Weaver entropy index. It reflects the diversity of species that make up stand in an environment and the abundance of individuals per species in the stand. Shannon's entropy or diversity index, denoted H' [21], is given by the following formula:

$$H' = -\sum_{i=0}^{s} Pi\ x\ ln2Pi$$

where Pi= relative frequence of species i in the community ($= \frac{ni}{N}$), S= species richness of the stand; $n_{i=}$ number of individual of species i in the stand; N= sample size.

$0 \leq H' \leq \ln(s)$

The evenness index (E) was used to study the regularity of species distribution within each season. This index can vary from 0 to 1. It is highest when species have identical abundances in the stand and lowest when a single species dominates the entire stand. Insensitive to species richness, it is very useful for comparing potential dominance between stations or between sampling dates.

$E = \frac{H'}{ln2\,(S)}$ H': being the Shannon index, S: the total richness and E: equality.

Pielou evenness index (J') wich measures the evenness of individual within families, regardless of species richness (21):

$$J' = \frac{\mathbf{H'}}{Hmax}$$

Where H' represents Shannon's diversity index; Hmax: the maximum diversity of a stand with the same species richness. Pielou's Equitability index varies between 0 and 1. It will tend towards 0 when almost all the population is concentrated in a single species (monospecific stand) and toward 1 when all the species in the stand have the same abundance;

Simpson's diversity index measures the probability that two individuals selected random from the sample population belong to the same species. This index is calculated using the following formula**:**

$$D = \sum [\frac{ni.\,(ni-1)}{N(N-1)}]$$

For a more intuitive interpretation of the result, the D relationship was used and interpreted in this case as a dominance index. With ni = number of individuals of species i and N = sample size. For a fixed number of species, it is greater when the frequency distribution is equitable. Thus, D varies between 0 (dominance of a single species in the community) and 1 (codominance of a several species in the community).

Results

1. Stages of decomposition of the carcass of the domestic pig (*Sus scrofa domesticus*)

The decomposition lasted 83 days and based on physical/morphological changes observed on the pig carcass, we observed five different stages of its degradation: fresh, bloated,

Table 1: Duration of different stages of decomposition of the pig carcass

Decay stages	Duration (days)
Fresh	[1 to 2]
Bloated	[3 to 5]
Putrefied	[6 to 9]
Dried	[10 to 40]
Skeletonized	[41 to 83]

Fresh stage (day 1 to day 2)

This is the first stage of decomposition process of the corpse. The body appears normal since it shows no visual signs of death. The skin is still plient; no odor is perceptible with our sense of smell. A few hours after death, the first insects colonized the corpse, testifying the emission of odors although they are not inhalable by the human nostrills. Upon arrival, they first flies fly over the corpse before landing on the natural orifices (nostrils, mouth, ears, eyes and anus) and feed.

Bloated stage (day 3 to day 5)

This phase of cadaveric alteration is characterized by the beginning of the perception of odors by human and also the increasing in the number of insects on the corpse. The carcass has distended skin, thus showing its bloated, which leads to an increase in the size of the carcass. Insect's larvae are also observed in the depths of the natural orifices on the 4th day postmortem. From this day 4, the odors are very strong and perceptible from a distance of about 5 meters before the carcass.

Putrefied stage (day 6 to day 9)

This phase is characterized by the deflation of the carrion, which releases strong odors that are inhalable more than six meters from the corpse by human nostrills. Insect larvae, as well as adult insects, are also very numerous. We also observe the beginning of skin decomposition, the presence of hair on the ground, and a thick layer of cadaveric fluid on the ground.

Dried stage (day 10 to day 40 days)

This fourth stage of carcass decomposition is characterized by a progressive, gradual, and decreasing disappearance of

odors, which become imperceptible to our sense of smell on the 30th postmortem day. The skin continues to decompose with the increase of hairs on ground, in parallel with the decrease in the number of insects on the corpse.

Skeletonized stage (day 41 to day 83)

This fifth and last stage of the decomposition of the corpse is characterized by the almost complete disappearance of all the flesh, which remains only in the level of the joint tendons. The bones are exposed and completely dislocated from each other. The number of insects still active on the carcass is also very low.

2. Composition of the necroentomofauna of the corpse of the domestic pig (*Sus scrofa domesticus*) according to the decay process

A total of 5373 individuals were collected, distributed in 3 classes, 12 orders, 28 families, 22 genera and 40 species. The composition and the number of species varied from the fresh stage to the skeletonized state. Seven families of insects were identified in the fresh stage and then nine families in the bloated stage, 13 families in the putrefied stage and finally 20 families for the dried and skeletonized stages respectively (table 2). The various diversities index was calculate.

Table 2: Composition of the cadaveric entomofauna of the domestic pigs (*Sus scrofa domesticus*) corpses according to the various stages of decomposition

Classes	Orders	Families	Trophic guilds	Decay stages					Total number	Ar
				Fresh	Bloated	Putrefied	Dried	Skeletonized		
Arachnida	Acari	Ni	Omnivorous	0	0	0	14	169	183	3,41
	Araneida	Ni	Predators	0	0	0	1	2	3	0,06
Hexapoda	Coleoptera	Anthicidae		0	0	0	0	14	14	0,26
		Carabidae		0	0	1	22	18	41	0,76
		Cleridae		3	1	0	0	0	4	0,07
		Curculionidae		0	0	0	33	0	33	0,61
		Histeridae	Predators	4	0	3	0	3	10	0,19
		Mordellidae		0	0	34	5	15	54	1,01
		Scarabaeidae	Predators	0	3	7	48	1	59	1,1
		Staphylinidae	Predators	0	3	6	0	4	13	0,24
	Dictyoptera	Blattidae	Omnivorous	0	0	0	1	15	16	0,3
	Diptera	Anophelidae		1	0	0	0	6	7	0,13
		Calliphoridae	Necrophagous	253	1891	1361	1099	10	4614	85,87
		Culicidae	Hematophagous	0	0	7	1	0	8	0,15
		Diopsidae		0	0	0	0	1	1	0,02
		Drosophilidae	Necrophagous	1	1	0	5	3	10	0,19
		Muscidae	Necrophagous	3	55	33	29	44	164	3,05
		Ni		0	0	0	0	2	2	0,04
		Phoridae	Necrophagous	0	0	15	5	0	20	0,37
		Psychodidae		0	0	0	2	0	2	0,04
		Sarcophagidae	Necrophagous	0	2	1	4	1	8	0,15
		Sciaridae		0	0	54	5	3	65	1,21
		Sciomyzidae		0	0	0	1	0	1	0,02
		Scyaridae	Saprophagous	0	0	0	0	1	1	0,02
		Stratiomyidae	Saprophagous	0	0	0	1	2	3	0,06
		Trichoceridae		0	0	0	2	0	2	0,04
	Hymenoptera	Formicidae	Parasitooîds	0	0	0	6	0	6	0,11
		un		0	2	0	0	0	2	0,04
	Orthoptera	Gryllidae	Omnivorouss	0	0	0	0	1	1	0,02
	Chrysalid	un		0	0	0	0	1	1	0,02
	Heteroptera	un		0	0	0	0	8	8	0,15
	Homoptera	un		0	0	0	0	2	2	0,04
	Lepidoptera	un		0	0	0	1	0	1	0,02
		Tineidae	Opportunistics	1	1	3	0	3	8	0,15
		Trineidae	Opportunistics	0	0	0	1	5	6	0,11
Myriapod	Diplopoda	un	Omnivorous	0	2	1	0	0	3	0,06
Total				266	1961	1526	1286	334	5373	100

Legend: un = unidentified

The Shannon index shows that one family (Calliphoridae) dominates at the skeletonized ($H'_{skeletonized}$ = 0.89) and putrefied ($H'_{putrefied}$ = 1.09). The values of the equitability index confirm the data obtained ($J'_{skeletonized}$ = 0.36; $J'_{putrefied}$ = 0.39). At the bloated ($H'_{bloated}$ = 2.02) and dried (H'_{dried} = 1.95) stages, Calliphoridae still dominates, but the other families contribute more to the numbers.

The calculated values of the Berger-Parker dominance index show that family diversity is high at the bloated stage (bloated ID = 0.26) followed by the dried stage (dried ID = 0.34). The Simpson index value confirms these data (bloated ID = 0.84; dried ID = 0.81). At the fresh (fresh ID = 0.51), putrefied (putrefied ID = 0.74), and skeletonized (skeletonized ID = 0.80) stages, family diversity is significantly lower.

The Chao-1 non-parametric estimator shows that 12 out 14 “true” species were captured, and that 2 species escaped the collector at the fresh stage. At the bloated stage, 16 out of 16 “true” species were obtained. Similarly, 16 out of 22 “true” species were obtained and 6 species escaped the

collector at the putrefied stage. As for the dried stage, 22 out of 23 "true" species, 1 specie escaped the collector, and 12 out of 18 "true" species were obtained at the skeletonized stage, and 6 species escaped the collector.

The comparison using the Margalef index shows that the decomposition stages richest in species are dried, followed by putrefied, while skeletonized, the fresh stage and the bloated.

Table 3: Diversity and distribution of insects according to the stages of decomposition of the domestic pigs (*Sus scrofa domesticus*) corpses

Diversity indexe	Stages of decomposition				
	Fresh	Bloated	Putrefied	Dried	Skeletonized
Number of taxa (S)	12	16	16	22	12
Number of individuals	266	1961	1526	1286	334
Simpson (D)	0,69	0,84	0,44	0,81	0,36
Shannon (H')	1,56	2,02	1,09	1,95	0,89
Margalef	1,97	1,98	2,05	2,93	1,89
Equitability(J')	0,63	0,73	0,39	0,63	0,36
Berger-Parker	0,51	0,26	0,74	0,34	0,80
Chao-1	13,5	16,25	22	23	18,0

3. Taxonomic variation in abundance according to the stages of decomposition of the domestic pig corpse.

Ordinary scale

The order Diptera was the most abundant at all stages of decomposition with 4905 individuals (91.29%) of all the cadaveric entomofauna captured. It was followed by the order of Coleoptera with 228 individuals (4.24%) and the order of Acari with 183 individuals (3.41%). Then comes the orders of Dictyoptera and Hymenoptera, which each had 16 individuals (0.30%). Lepidoptera and Heteroptera followed with 7 individuals (0.13%) and 8 individuals (0.15%) respectively. These leaders were followed by Homoptera with 2 individuals (0.04%), Diplopoda with with 3 individuals (0.06%), Orthoptera and Chrysalids with 1 individual each (0.02%). Diptera was dominant in four stages of degradation namely fresh, bloated, putrefied and dried with respectively 4.80%, 36.27%, 27.38% et 21.48%. The skeletonized stage was dominated by Acari with 3.15% due to the absence of soft tissue such as flesh and the presence of bones since they are specialized in the consumption of hard tissues along with Coleoptera (table 4).

Table 4: Variation of the abundance of the orders of cadaveric entomofauna collected on the corpses of the domestic pigs (*Sus scrofa domesticus*)

Orders	Stages of decomposition											
	Fresh		Bloated		Putrefied		Dried		Skeletonized		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Acari	0	0,00	0	0,00	0	0,00	14	0,26	169	3,15	183	3,41
Spiders	0	0,00	0	0,00	0	0,00	1	0,02	2	0,04	3	0,06
Chrysalids	0	0,00	0	0,00	0	0,00	0	0,00	1	0,02	1	0,02
Beetles	7	0,13	7	0,13	51	0,95	108	2,01	55	1,02	228	4,24
Dictyoptera	0	0,00	0	0,00	0	0,00	1	0,02	15	0,28	16	0,30
Diplopoda	0	0,00	2	0,04	1	0,02	0	0,00	0	0,00	3	0,06
Diptera	258	4,80	1949	36,27	1471	27,38	1154	21,48	73	1,36	4905	91,29
Heteroptera	0	0,00	0	0,00	0	0,00	0	0,00	8	0,15	8	0,15
Homoptera	0	0,00	0	0,00	0	0,00	0	0,00	2	0,04	2	0,04
Hymenoptera	0	0,00	2	0,04	0	0,00	6	0,11	8	0,15	16	0,30
Lepidoptera	1	0,02	1	0,02	3	0,06	2	0,04	0	0,00	7	0,13
Orthoptera	0	0,00	0	0,00	0	0,00	0	0,00	1	0,02	1	0,02
Total	266	4,95	1961	36,50	1526	28,40	1286	23,93	334	6,22	5373	100,00

Family scale

The family of Calliphoridae was the most represented with 4614 individuals (85.87%) of the overall collected fauna, followed by the Muscidae with 170 individuals (3,82%). The least represented families were the Trichoceridae with 2 individuals (0.04%), Diopsidae with 1 individual (0.02%), the Gryllidae with 1 individual (0.02%), and the Sciomyzidae with 1 individual (0.02%).

According to the differents decay stages, the Calliphoridae family was dominant in the fresh stage with 4.71%, in the bloated stages with 35.19%, in the putrefaction stage with 25.33% and in the drying stage with 20.45%, but very weakly represented in the skeletonized stage with 0.19%. This dominance of the Calliphoridae family is a consequence of their diet, which is rich in soft tissues and fluids, like that of corpses, since they have a mouthpart that allows them to feed easily, particularly on the bodily fluids of decomposition animals (table 5).

Table 5: Variation of the abundance of the families of the cadaveric entomofauna collected on the corpses of domestic pigs (*Sus scrofa domesticus)*

Families	Stages of decomposition											
	Fresh		Bloated		Putrefied		Dried		Skeletonized		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Anophelidae	1	0,02	0	0,00	0	0,00	0	0,00	6	0,11	7	0,13
Anthicidae	0	0,00	0	0,00	0	0,00	0	0,00	14	0,26	14	0,26
Blattidae	0	0,00	0	0,00	0	0,00	1	0,02	15	0,28	16	0,30

Calliphoridae	253	4,71	1891	35,19	1361	25,33	1099	20,45	10	0,19	4614	85,87
Carabidae	0	0,00	0	0,00	1	0,02	22	0,41	18	0,34	41	0,76
Cleridae	3	0,06	1	0,02	0	0,00	0	0,00	0	0,00	4	0,07
Culicidae	0	0,00	0	0,00	1	0,02	1	0,02	0	0,00	2	0,04
Curculionidae	0	0,00	0	0,00	0	0,00	33	0,61	0	0,00	33	0,61
Diopsidae	0	0,00	0	0,00	0	0,00	0	0,00	1	0,02	1	0,02
Drosophilidae	1	0,02	1	0,02	0	0,00	5	0,09	3	0,06	10	0,19
Formicidae	0	0,00	0	0,00	0	0,00	6	0,11	0	0,00	6	0,11
Gryllidae	0	0,00	0	0,00	0	0,00	0	0,00	1	0,02	1	0,02
Histeridae	4	0,07	0	0,00	3	0,06	0	0,00	3	0,06	10	0,19
Mordellidae	0	0,00	0	0,00	34	0,63	5	0,09	15	0,28	54	1,01
Muscidae	3	0,06	55	1,02	39	0,73	29	0,54	44	0,82	170	3,16
Phoridae	0	0,00	0	0,00	15	0,28	5	0,09	0	0,00	20	0,37
Psychodidae	0	0,00	0	0,00	0	0,00	2	0,04	0	0,00	2	0,04
Sarcophagidae	0	0,00	2	0,04	1	0,02	4	0,07	1	0,02	8	0,15
Scarabaeidae	0	0,00	3	0,06	7	0,13	48	0,89	1	0,02	59	1,10
Sciaridae	0	0,00	0	0,00	54	1,01	3	0,06	1	0,02	58	1,08
Sciomyzidae	0	0,00	0	0,00	0	0,00	1	0,02	0	0,00	1	0,02
Staphylinidae	0	0,00	3	0,06	6	0,11	0	0,00	4	0,07	13	0,24
Stratiomyidae	0	0,00	0	0,00	0	0,00	1	0,02	2	0,04	3	0,06
Syrphidae	0	0,00	0	0,00	0	0,00	2	0,04	3	0,06	5	0,09
Tineïdae	1	0,00	1	0,02	3	0,06	1	0,02	8	0,15	14	0,26
Trichoceridae	0	0,00	0	0,00	0	0,00	2	0,04	0	0,00	2	0,04
Unidentified	0	0,00	4	0,07	1	0,02	16	0,30	184	3,42	205	3,82
Total	266	4,95	1961	36,50	1526	28,40	1286	23,93	334	6,22	5373	100,00

Genera scale

At the genera scale, it appears that the genera *Chrysomya* was dominant with 2644 individuals (49.21%) of the total fauna sampled throughout the entire period of the experiment. This was followed respectively by the genera *Hemipyrellia* with 862 individuals (16.04%) with the exception of the skeletonized stage, where they were completely absent. The genera Lucia with 669 individuals (12.45%) although absent at the first stage, was present at the other four stages. The least abundants were the genera *Pheidole* and *Aethyopomyia* with 3 individuals (0.06%), *Culex* and *Coelalysia* with 2 individuals (0.02%). Depending on the stages of decomposition, the genera *Chrysomya*

was dominant at the fresh and dried stages, with 147 individuals (2.74%) and 691 individuals (12.86%). They were followed by the genera *Hemipyrellia* in the fresh and dried stages with 1.97% and 9.12%. The bloated and putrefied stages were dominated by the genera *Lucia* with 9,70% while the skeletonized stage was dominated by the genera *Chysomya* with 0.17% of the captured fauna (tableau 6).

Table 6: Variation of the abundance of the genera of the cadaveric entomofauna collected on the corpses of domestic pigs (*Sus scrofa domesticus)*

Genera	Stages of decomposition											
	Fresh		Bloated		Putrefied		Dried		Skeletonized		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Aethyopomyia	0	0,00	0	0,00	1	0,02	2	0,04	0	0,00	3	0,06
Anopheles	1	0,02	0	0,00	4	0,07	0	0,00	0	0,00	5	0,09
Atherigona	2	0,04	13	0,24	0	0,00	6	0,11	0	0,00	21	0,39
Bengalia	0	0,00	168	3,13	0	0,00	0	0,00	0	0,00	168	3,13
Blatta	0	0,00	0	0,00	0	0,00	0	0,00	11	0,20	11	0,20
Chrysomya	147	2,74	691	12,86	1297	24,14	500	9,31	9	0,17	2644	49,21
Coelalysia	0	0,00	2	0,04	0	0,00	0	0,00	0	0,00	2	0,04
Culex	0	0,00	0	0,00	1	0,02	1	0,02	0	0,00	2	0,04
Drosophila	1	0,02	1	0,02	0	0,00	5	0,09	3	0,06	10	0,19
Hebecnema	0	0,00	0	0,00	0	0,00	9	0,17	1	0,02	10	0,19
Helina	0	0,00	0	0,00	22	0,41	0	0,00	0	0,00	22	0,41
Hemipyrellia	106	1,97	240	4,47	26	0,48	490	9,12	0	0,00	862	16,04
Hister	4	0,07	0	0,00	3	0,06	0	0,00	3	0,06	10	0,19
Hydrotaea	0	0,00	14	0,26	0	0,00	4	0,07	0	0,00	18	0,34
Isomyia	0	0,00	271	5,04	0	0,00	0	0,00	0	0,00	271	5,04
Lucilia	0	0,00	521	9,70	38	0,71	109	2,03	1	0,02	669	12,45
Musca	1	0,02	28	0,52	1	0,02	6	0,11	10	0,19	46	0,86
Ophyra	0	0,00	0	0,00	0	0,00	0	0,00	29	0,54	29	0,54
Sarcophaga	0	0,00	2	0,04	1	0,02	4	0,07	1	0,02	8	0,15
Spilogona	0	0,00	0	0,00	11	0,20	0	0,00	0	0,00	11	0,20
Pheidole	0	0,00	0	0,00	0	0,00	3	0,06	0	0,00	3	0,06
Unindentified	4	0,07	10	0,19	121	2,25	147	2,74	266	4,95	548	10,20
Total	266	4,95	1961	36,50	1526	28,40	1286	23,93	334	6,22	5373	100,00

Species level

This level is characterized by the high abundances of *Chrysomya polymita* with 1428 (26.58%) and *Hemipyrellia pulchra* with 680 (12.66%) of the whole species census. According to the different decay stage, *Chrysomya chloropyga* has fairly the same abundance at the fresh with 135 (2.51%) and dried with 154 (2.84%) (table 7).

Table 7: Variation of the abundance of the species of cadaveric entomofauna collected on the corpse of domestic pig (*Sus scrofa domesticus*)

Species	Stages of decomposition											
	Fresh		Bloated		Putrefied		Dried		Skeletonized		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Anopheles sp.	1	0,02	0	0	0	0	0	0	0	0	1	0,02
Aethyopomyia sp.	0	0	0	0	1	0,02	2	0,04	0	0	3	0,06
Atherigona sp.	2	0,04	13	0,24	4	0,07	4	0,07	0	0	23	0,43
B. orientialis	0	0	0	0	0	0	0	0	1	0,02	1	0,02
Bengalia sp.	0	0	168	3,13	0	0	0	0	0	0	168	3,13
Blatta sp.	0	0	0	0	0	0	0	0	10	0,19	10	0,19
C. albiceps	0	0	0	0	0	0	1	0,02	0	0	1	0,02
C. chloropyga	135	2,51	0	0	0	0	154	2,87	0	0	289	5,38
C. laxifrons	0	0	356	6,63	0	0	4	0,07	0	0	360	6,7
C. marginalis	0	0	0	0	24	0,45	9	0,17	0	0	33	0,61
C. oumeensis	0	0	0	0	75	1,4	0	0	3	0,06	78	1,45
C. polymita	0	0	39	0,73	1131	21,05	258	4,8	0	0	1428	26,58
C. putoria	0	0	40	0,74	0	0	74	1,38	0	0	114	2,12
C. vanemdeni	12	0,22	256	4,76	67	1,25	0	0	0	0	335	6,23
Chrysomya sp.	0	0	0	0	0	0	0	0	6	0,11	6	0,11
Coelalysia sp.	0	0	2	0,04	0	0	0	0	0	0	2	0,04
Culex sp.	0	0	0	0	1	0,02	1	0,02	0	0	2	0,04
Drosophila sp.	1	0,02	1	0,02	0	0	5	0,09	3	0,06	10	0,19
H. fernandica	10	0,19	0	0	0	0	59	1,1	0	0	69	1,28
H. pulchra	9	0,17	240	4,47	0	0	431	8,02	0	0	680	12,66
H. zumpti	45	0,84	0	0	0	0	0	0	0	0	45	0,84
Hebecnema sp.	0	0	0	0	0	0	4	0,07	1	0,02	5	0,09
Helina sp.	0	0	0	0	22	0,41	0	0	0	0	22	0,41
Hemipyrellia sp.	42	0,78	0	0	26	0,48	0	0	0	0	68	1,27
Hister sp.	4	0,07	0	0	3	0,06	0	0	3	0,06	10	0,19
Hydrotaea sp.	0	0	14	0,26	0	0	4	0,06	0	0	18	0,33
Isomyia sp.	0	0	271	5,04	0	0	0	0	0	0	271	5,04
L. cuprina	0	0	0	0	38	0,7	103	1,92	1	0,02	142	2,63
L. pulchra	0	0	0	0	0	0	2	0,04	0	0	2	0,04
L. sericata	0	0	514	9,57	0	0	4	0,07	0	0	518	9,64
Lucilia sp.	0	0	7	0,12	0	0	0	0	0	0	7	0,12
Musca sp.	1	0,02	28	0,52	1	0,02	6	0,11	10	0,19	46	0,86
Ophyra sp.	0	0	0	0	0	0	0	0	29	0,54	29	0,54
P. megacephala	0	0	0	0	0	0	3	0,06	0	0	3	0,06
Spilogona sp.	0	0	0	0	6	0,11	0	0	0	0	6	0,11
S. africa	0	0	0	0	1	0,02	3	0,06	0	0	4	0,07
S. fulvipollinosa	0	0	0	0	5	0,09	0	0	0	0	5	0,09
S. zumpti	0	0	0	0	0	0	1	0,02	0	0	1	0,02
Sarcophaga sp.	0	0	2	0,04	0	0	0	0	1	0,02	3	0,06
Unidentified	4	0,07	10	0,19	121	2,25	154	2,87	266	4,95	555	10,33
Total	266	4,95	1961	36,5	1526	28,4	1286	23,93	334	6,24	5373	100

Discussion

1. Ethology of the cadaveric entomofauna and duration of the different stages of pig carcass decay process

The present study, whose objective was to inventory and determine the dynamics of the cadaveric entomofauna of pig corpses in Ndogbong in order to contribute to better understanding of the crime scenes, allowed us to delimitated five stages of decay process namely: fresh, bloated, putrefied, dried and skeletonized which is similar to the results obtained by Carvalho *et al.* [22], Martinez *et al.* [23], Shattuck [24] and Sukchit *et al*. [25] who also recognized this same number of stages of the degradation of corpse during their research conducted on domestic pig (*Sus scrofa domesticus*) carcass. This result is also similar to the results of the research work of Rumiza *et al*. [26], Feugang Youmessi [4], Keshavarzi *et al.* [27], Iancu and Pârvu [28] which demonstrates a certain homogeneity in the evolution of the physical changes observed during the cadaveric alteration process, conversely the studies conducted by Bharti and Singh [29] that showed four stages of decomposition (fresh, bloated, putrefied and dried). This slight difference may be the consequence of the differential variation of environmental conditions between the different research environment as well as the size of the biological material; it being understood that these spatial conditions of the littoral area (mangrove) coupled with the size of the substrate are determining factors that influence the evolution of the carcass alteration process.

Similarly, the durations of the different stages of degradation are almost superimposable to those obtained by Feugang Youmessi *et al*. [12] and Martinez *et al*. [23] although different from those obtained by Carvalho *et al*. [22] and Keshavarzi *et al*. [27]. This difference seems to be due to the size of the substrate as well as the biogeographic conditions specific to each region. Indeed, according to Villet [30], Anderson [9, 31], Amendt *et al*. [32], Koffi [33] and Kpama-Yapo *et al*. [34], the evolution of the decomposition of corpses is a continuous process whose speed depends on environmental parameters. Our study took place at a littoral zone with specific characteristics such as temperature, hygrometry, relative humidity, mud soil, wind speed which as surly affect the decay process as well as the biotic variables (substrate size, conditioning, etc.).

In line with the results of Barros-Souza *et al.* [35], Iancu and Pârvu [28], Keshavarzi *et al*. [27], the cadaveric entomofauna was dominated by Calliphoridae family, which was the first to colonize the corpse. This observation contradicts that of the same authors on other research setting probably because of the ground parameters which characterize the mangrove where our study was carried out. Thus, respectively works of Serbino and Godoy [36] demonstrated that the first colonizers consisted of Muscidae, although poorly represented in the cadaveric entomofauna that these authors recorded. This variance in the composition of this cadaveric entomofauna would be the consequence of the variation in environmental parameters during their experiment on the rat carcass; knowing that our research was carried out at a littoral zone and on a big biological corpse.

2. Taxonomic composition of the cadaveric fauna according to the stages of pig cadaver alteration.

The composition of the corpse fauna has been related to the different phases of the decay process of the pig corpse. In line with authors such as Keshavarzi *et al.* [27], Rumiza *et al.* [26] and Carvalho *et al*. [22] at the fresh stage, we also inventoried several families, namely Calliphoridae (genera: *Chrysomya* and *Hemipyrellia*), Cleridae, Histeridae (genera: *Hister*) and Muscidae (genera: *Atherigona*), with a slight systematic difference for the second authors, who also listed the Phoridae. This result differs from those gleaned by Koffi [33] and Lutz *et al*. [37]. This difference is justified by the specificity of the entomological entomofauna of our study area which is a particular ecosystem with its specific abiotics parameters as emphasized by Campobasso *et al*. [38].

At the bloated stage, carcass was colonized by the Calliphoridae (genera: *Chrysomya*, *Lucilia*, *Hemipyrellia*) and Muscidae (genera: *Musca* et *Atherigona*) different from the result gathered by Hobischak *et al.* [39], Grassberger and Franck [40] who sampled Scarabidae (genera: *Onthophalus*), Silphidae (genera: *Nicroporcus*), and Calliphoridae (genera: *Protophormia*) at this bloated stage, while Kelly *et al* [41] only collected Calliphoridae (genera: *Campsomyiops*) during their experiment conduct also on pig carcasses.

During the putrefied stage, we sampled four insect families. These are the Calliphoridae (genera: *Chrysomya*), Sciaridae, Muscidae (genera: *Helina* and *Spilogona*) and the Mordellidae which are identical to those obtained by Bharti and Singh [29] and Carvalho *et al.* [22].

In parallel with the results of the work carried out by Feugang Youmessi and Djonga [5], Calliphoridae was also recorded in the putrefaction state of the carcass of pig, all in the young state, thus proving that they emerged from the larvae buried under the soil contained in the container.

At the dried stage, the necrophagous fauna consisted of Calliphoridae (*Chrysomya, Hemipyrellia*), Scarabaeïdae, Curculionidae, and Muscidae (genera: *Hebecnema, Musca* and *Atherigona*). These results are consistent with those of Hobischak *et al* [39] and thus show that representatives of these families arrive late on the corpse to find food suitable for their mouthparts and diet.

The skeletonized stage was marked by the presence of the Carabidae and Mordellidae families, all of which are Coleoptera. These organisms are adapted to this stage of degradation not only because they are chewing insects that feed on hardened tissues, but also because they are predators and feed on other insects present on and around the corpse Ouiza *et al*. [42].

3. Adults emerged from larvae rearing at the laboratory

Similar to Charabidze [43] and Severin *et al*. [44], we noted that the emergence of adult insects in the laboratory showed daily time differences up to several weeks. This phenomenon reflects the fact that some larvae from the same egg cluster complete their development life cycle faster than others. This variability can be justified either by the existence within the same clutch of intrinsic factors designated by the term individual performance, i.e. specific to each larva, which influence its speed of development, or also because the egg cluster were not laid on the same day or even by inter/intra specific competitions for food which slowed/accelerated the entry into pupation of the larvae or by the differential sensitivity of the larvae to abiotic variables in the laboratory (31,37,38). Indeed, Matuszewski *et al.* [45] and Ouiza *et al*. [42], face with similar speed of development of larvae since the speed of development also depends on the biotic parameters (intrinsic, interspecific competition…) specific to each larva.

The adult specimens emerged in the laboratory were mostly Diptera of the family Calliphoridae of the genera *Chrysomya* and a few individuals of the genera *Lucilia,* Stratyiomyidae of the genera *Hermetia*, and Sarcophagidae of the genera *Sarcophaga.* This result is consistent with those obtained by Feugang Youmessi and Djonga [4]. Muscidae were not identified among the adults emerged in the laboratory. As emphasized by Faria *et al*. [46], Fredrickx *et al.* [47, 48] and Anderson [49], this absence may be the consequence of the harsh laboratory conditions, which would have stressed the larvae of this taxon and consequently make them to death since the development rate of insect larvae is a function of abiotic and biotic variables.

Conclusion

At the end of our 83-day study on the inventory and dynamics of the cadaveric entomofauna of the corpse of the domestic pig (*Sus scrofa domesticus,* Linnaeus*,* 1758) at Ndogbong-Douala, Littoral zone of Cameroon, we can say that this animal decomposed within five stages namely: fresh, bloated, putrefied, dried and skeletonized. The cadaveric entomofauna sample was 5.373 individuals, shared into 3 classes, 12 orders, 28 families, 22 genera et 40 species. The composition and number of families varied from the fresh state to the skeletonized stage. We identified 7 families in the fresh stage, 9 families in the bloated stage, 13 families in the putrefied stage, and then 20 families for the dried and skeletonized stages respectively. Just a few

minutes after death, the first insects to colonize the carcass were Diptera of the Calliphoridae family, which became more abundant over time alongside the Muscidae. The Blattidae and Histeridae families were the last to arrive on the corpse. The mean insects that we census during our experiment are Calliphoridae (*Hemipyrellia fernandica, Chrysomya putoria, Chrysomya polymita, Chrysomya laxifons,* C. *albiceps* and *Lucilia* sp.), Muscidae (*Musca* sp., *Atherigona* sp. and *Hydrotaea* sp.), which were also obtained from emergences in the laboratory, thus proving that they are necrophagous taxa. These species of judicial importance can also be infested by parasitoïds of the order of Hymenoptera (*Coelalysia* sp.) whom were captured during our experiment.

We observed that the indices show that diversity peaks at bloated stage (Shannon and Simpson) and a better distribution of individuals among species (equitability). It drops significantly during skeletonized, with a drastic drop in the number of individuals, the number of taxa, and equitability, reflecting a reduction in resources or a change in the ecosystem at this stage of decomposition.

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