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# Decomposition and succession of coleoptera on two dog corpses in Constantine, northeastern Algeria

**Fatima Zohra Guerroudj, Sélima Berchi, Amel Aouati and Selma Elbatoul Benmira**

**Abstract**
Among the different works that have been developed by entomologists concerning the decomposition of corpses, we have noticed that the gradual arrival of insects on a decomposing dead body doesn't obey the scheme of the eight squads.
In Algeria, works on forensic entomology are in their first steps, especially for Coleoptera on which no work has been done yet. That's why we have chosen to deal with this subject, by choosing two dead animals, an adult dog and a puppy.
The study was carried out in spring, in an open area localized near the Biosystematic and Ecology of Arthropods laboratory, Chaabat Erssas Constantine, Algeria. The two corpses were put in two separate cages to protect them from any possible except beetles or flies. Already a few hours after the two cadavers have been brought into their position they were visited by insects which started with egg-deposition. After the capture of the insects, the identification revealed that they belong to two major insect orders which are flies (Diptera) and beetles (Coleoptera). These insects partly constitute the necrophagous fauna.
Our daily sampling has allowed us to collect a total of 724 specimens on the corpse of the adult dog, 58% of which belong to the order Diptera and 42% belong to the order of beetles. On the cadaver of the puppy, we identified 165 specimens of which 26% belong to the order Diptera and 74% belong to the order of Coleoptera.
The results show a fine, dissimilar diversity of necrophagous beetle insects on the corpses of the adult dog compared to the puppy belonging to different families, genus and species.

**Keywords:** Forensic entomology, animals cadavers, coleoptera

## 1. Introduction
The idea of using insects in criminal investigations is not recent; it is in the 13th century that the first criminal case was treated with the help of insects. It was only later, towards the end of the 19th century that the first scientific foundations of the use of necrophagous insects were made based on the works of Megnin (1828-1905). Since then, forensic entomology has significantly evolved.
When an animal species dies, it is quickly visited and colonized by numerous organisms such as bacteria, fungi, birds or even arthropods with a clear preponderance of necrophagous insects. The role of these insects is essential in the process of corpse decomposition and helps to date the death of a corpse and assess the probability that a body has been displaced.
Several studies have been conducted on the involvement of Diptera in the decomposition process of a corpse [1-4]. Although they are neglected in forensic entomology, Coleoptera may be used in the estimation of the post mortem interval of a body. Works of [5-11], and many others can be cited in this context.
In some areas of Constantine, packs of stray dogs are found in dozens. Their presence is a real public danger and most are shot down by the city's hygiene services. From this information came the idea of using these dead dogs in this study which consists of reporting our contribution on the different stages of the substrate degradation and, by the same, analyzing the biodiversity of the involved Coleoptera. For this study, we focused our work on the degradation of an adult dog corpse and compared it with a puppy.

## 2. Materials and Methods
### Animal model
This study was carried out on two dog corpses coming from the hygiene services just after death. The first is a 1.5 kg puppy and the second corpse is a 13 kg adult dog.

**Period and place of study**

The decomposition period of these two bodies was during spring. The corpse of the puppy was deposited on March 27, 2012 in a wooden cage of 1.20m$^2$. This cage was covered with a wire mesh of small netting to protect the corpse of any predators. The adult dog corpse was deposited on 05 April 2012 in the same cage type but larger than the first (3m$^2$). The two cages were placed in an open space near the laboratory of Biosystematics and Ecology of Arthropods located at Chaabat Erssas in Constantine (36 ° 20'16.20 "N, 6 ° 37'33.32" E, altitude 571 m).

**The Tracking of the bodies decomposition stages**

The study of the dead bodies' decomposition and their colonization by necrophagous insects requires daily tracking. For this we performed two visits per day; one at 10 am and another at 2 pm, except on weekends and rainy days. The information collected at each visit is recorded on a field notebook.

**Insect collecting**

Two methods have been used for insect collecting. An active method with a fly catcher and two passive methods namely, the emergence trap and the Barber pitfall trap. The first is a 28cm$^3$ cubic cage veiled with tulle. At the base of this cage, a veiled sleeve that allows access of emerging Diptera attracted by meat bait suspended on the upper side of the cage. The second type of trap is based on the use of soapy water containers buried in the soil and their upper part flushing the surface around the corpse. This type of trap is well adapted for collecting Coleoptera moving on the ground. This method expresses quantitative sampling.

**Laboratory treatment of harvested insects**

**Conservation and identification methods**

Field samples were returned to the laboratory for sorting. After that; they were put in the freezer for 5 minutes to be killed for identification. For the recognition techniques of the families, genera and species of the Coleoptera, we have referred to the works of [6, 12-16].

**Results exploitation methods**

A quantitative and qualitative data analysis is carried out using various ecological indices. The first index uses statistical descriptors to describe quantitatively the stands. This is the species richness (S) that represents the number of species in the study area and the abundance (A) that expresses the number of individuals in a species. We also used the relative abundance or relative frequency expressed as a percentage of individuals in a species (ni) compared to the total number of individuals (N) for all species [17]. According to [18] the relative abundance (pi = ni /N, where ni is the number of species of the population i, N being the total number) of the species in a stand or in a sample characterizes the faunal diversity of a given environment.

$F(\%) = ni/N \times 100$

The second index type is Shannon Weaver (H') and equitability (E). The Shannon index allows quantifying the heterogeneity of the biodiversity of a study environment.

It is given by the following formula:

$H' = - \sum Pi \log 2 \, Pi \quad Pi = ni/N$

Ni: number of individuals of species i, ranging from 1 to S (total number of the species).

N: total number of examined individuals.

Log2: the natural logarithm based on 2.

H' is the diversity index of Shannon Weaver expressed in Bits binary units (It is the binary unit of information quantity that can represent two distinct values: 0 or 1).

The equitability index measures the distribution of individuals within species, independently of species richness. Its value varies from 0 (dominance of a species) to 1 (equitable distribution of individuals in the species)

It is given by the formula: $E = H' / H\,Max$

$H'max = \log S$ (S = total number of species)

## 3. Results

**Composition of the necrophagous fauna**

**Systematic inventory**

The study carried out on the puppy's corpse lasted 16 days, at the end of which we obtained a total of 165 individuals divided into 10 different families. These families are represented by 5 families of Diptera (Calliphoridae, Sarcophagidae, Anthomyiidae, Piophilidae and Phoridae), 4 families of Coleoptera (Dermestidae, Staphylinidae, Silphidae and Histeridae) and 1 family of Hymenoptera (Pteromalidae). The Coleoptera are represented by 5 species (Table 1).

**Table 1 :** Checklist of Coleoptera species identified on the puppy's corpse

| Family | Genus | Species |
|---|---|---|
| Silphidae | *Silpha* | *Silpha arniata* (Linnaeus, 1758) |
| Silphidae | *Silpha* | *Silpha sinuata* (Fabricius, 1775) |
| Histeridae | *Hister* | *Hister unicolor* (Linnaeus, 1758) |
| Dermestidae | *Dermestes* | *Dermestes peruvianus* (Laporte de Castelnau, 1840) |
| Staphylinidae | *Creophillus* | *Creophilus maxillosus* (Linnaeus, 1758) |

As for the study of the adult dog corpse, it lasted over 34 days during which we collected a total of 724 individuals. They were divided into 1 family of Hymenoptera (Pteromalidae), 5 families of Diptera (Calliphoridae, Sarcophagidae, Muscidae, Fanniidae and Piophilidae) and 6 families of Coleoptera (Dermestidae, Staphylinidae, Silphidae, Histeridae, Trogidae and Cleridae). 9 species belonging to the order of Coleoptera have been identified (Table 2).

**Table 2:** Checklist of Coleoptera species identified on the adult dog corpse

| Family | Genus | Species |
|---|---|---|
| Silphidae | *Silpha* | *Silpha rugosa* (Linnaeus, 1758) |
| Silphidae | *Silpha* | *Silpha obscura* (Fabricius, 1775) |
| Histeridae | *Hister* | *Hister unicolor* (Linnaeus, 1758) |
| Histeridae | *Hister* | *Hister purpurascens* (Herbst, 1791) |
| Histeridae | *Saprinus* | *Saprinus aeneus* (Fabricius, 1775) |
| Histeridae | *Saprinus* | *Saprinus semistriatus* (Scriba, 1790) |
| Dermestidae | *Dermestes* | *Dermestes peruvianus* (Laporte de Castelnau, 1840) |
| Staphylinidae | *Creophillus* | *Creophilus maxillosus* (Linnaeus, 1758) |
| Trogidae | *Trox* | *Trox hispidus* (Pontoppidan, 1763) |

**Coleoptera species according to the decomposition stage**

The cadavers decomposition of the puppy and the adult dog passes through 4 stages are indicated in Tables 3 and 4. On the same tables appear the species of Coleoptera according to the state of decomposition of the studied substrates. The fresh stage involves the active participation of the Silphidae. This participation concerns particularly the *S. rugosa* species followed by *S. sinuata* and *T. hispidus* for the adult dog cadaver (Tables 3 and 4).

On the corpus of the adult dog, all the Coleoptera species and more particularly *S. rugosa, S. sinuata* and *D. peruvianus* are very active during the swelling and putrefaction stage (Table 3). Unlike the puppy's corpse where the species are well represented when the substrate begins to dry out (Table 4). Some species, namely *S. arniata* and *D. peruvianus* for the puppy's cadaver and *S. sinuata, T. hispidus, H. unicolor, C. maxillosus* and *H. purpurascens* for the adult dog cadaver are not active at the beginning of drying phase (Tables 3 and 4)

**Table 3:** Coleoptera succession according to the decomposition stage (puppy's corpse)

| Stage / Coleoptera families | Fresh | Bloated | Advanced | Dry |
|---|---|---|---|---|
| *S. rugosa* | * | ** | **** | * |
| *S. arniata* | | | * | |
| *C. maxillosus* | | | *** | * |
| *H. unicolor* | | | *** | * |
| *D. peruvianus* | | | *** | |

**Table 4:** Coleoptera succession according to the decomposition stage (adult dog corpse)

| Stage / Coleoptera families | Fresh | Bloated | Advaced | Dry |
|---|---|---|---|---|
| *S. rugosa* | ** | ************** | **** | *** |
| *S. sinuata* | * | ************ | **** | |
| *T. hispidus* | * | **** | * | |
| *S. aeneus* | | | ****** | ** |
| *S. semistriatus* | | ***** | * | *** |
| *D. perivianus* | | ************ | ********** | ******* |
| *H. unicolor* | | ***** | ****** | |
| *C. maxillosus* | | ********* | | |
| *H. purpurascens* | | * | * | |

**Ecological Indices of Composition**

**Relative abundances of Coleoptera families identified on both corpses**

Fig. 1 shows that *Silphidae* are the most numerous on both cadavers, with a relative frequency of 66% for the corpse of the puppy and 40% at the adult dog. This family is followed by the *Histeridae* with 19% for the puppy and 20% the adult dog, while *Staphylinidae* comes after with 9% for the puppy and 6% for the adult. The abundance of *Dermestidae* is significantly higher in the adult dog with 25%, while it reaches 6% in the puppy. On the cadaver of the adult dog, two families not reported on the corpse of the puppy exist; *Cleridae* with 5% and *Trogidae* with 4%.

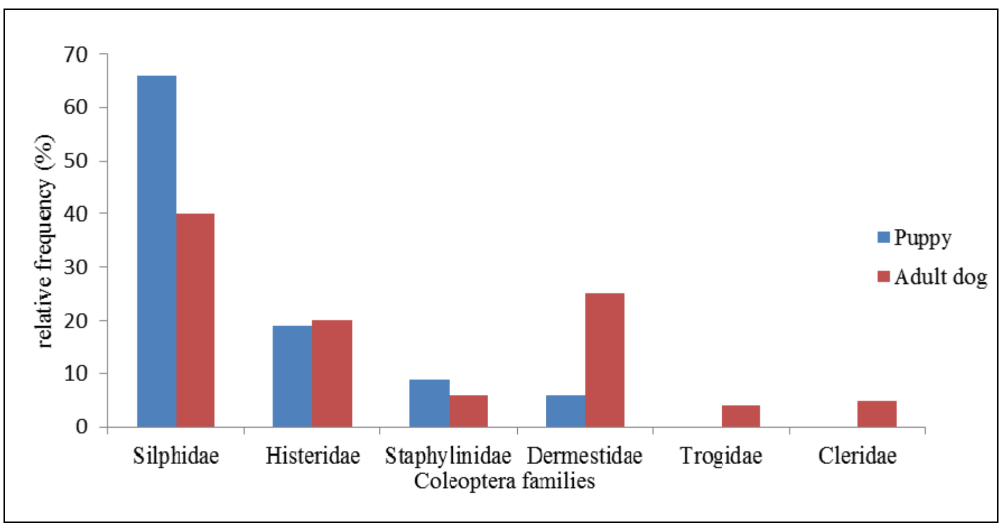


**Fig 1:** Relative frequencies of Coleoptera families identified on both corpses

**The total or species richness (S)**

Fig. 2 shows that the species richness recorded over time on the puppy's cadaver varies from 0 to 4 species. Yet, it is noteworthy that this specific richness of 4 is not considered in absolute terms. Indeed, for each sampling day, the species number varies on the one hand and the species may appear one day or disappear on another day. Hence, during the decomposition, we could identify 5 species of Coleptera, namely *S. rugosa* and *S. arniata* (Silphidae), *C. maxillosus* (Staphylinidae), *D. peruvianus* (Dermestidae), and *H. unicolor* (Histeridae).

In March, the species richness is limited to 1 species which is *S. rugosa*. Starting from April, a better representativeness of the species richness can be observed with a value of 4 species namely *S. rugosa* (Silphidae), *C. maxillosus* (Staphylinidae), *D. peruvianus* (Dermestidae), and *H. unicolor* (Histeridae). Subsequently, the number of species decreases progressively until a zero species richness is reached during decomposition period.

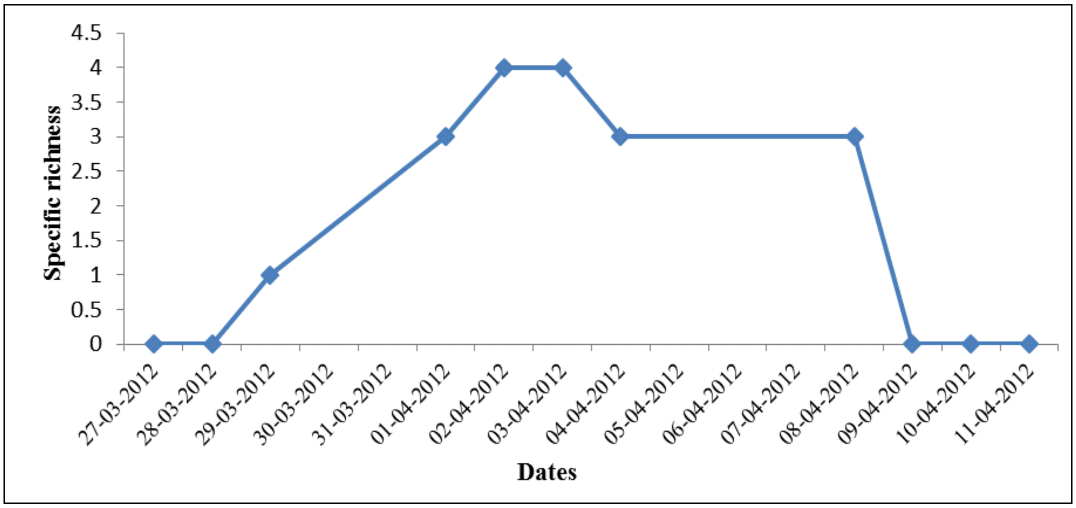


**Fig 2:** Specific Richness Recorded over Time on the Puppy's Cadaver

Fig. 3 shows that the specific richness recorded on the cadaver of the adult dog varies from 0 to 9 species. During the decomposition, we could identify 9 species of Coleoptera, namely: *S. rugosa* and *S. obscura* (Silphidae), *C. maxillosus* (Staphylinidae), *D. peruvianus* (Dermestidae), *H. unicolor, H. purpurascens*, *S. aeneus* and *S. semistriatus* (Histeridae) and *T. hispidus* (Trogidae).

From 5/04/2012 to 9/4/2012 the species richness is limited to 3 species which were: *S. obscura, S. rugosa* and *T. hispidus*. It decreases to 1 species on 17/4/2012 and starting from 19/4/2016 an increase in the number of species of Coleoptera was observed. On 21/4/2012, a better representativeness of this richness was reached to 9 species. Starting from this date, a noticeable decrease of the species richness was observed and reaches 1 species represented by *D. peruvianus* in the last sampling day.

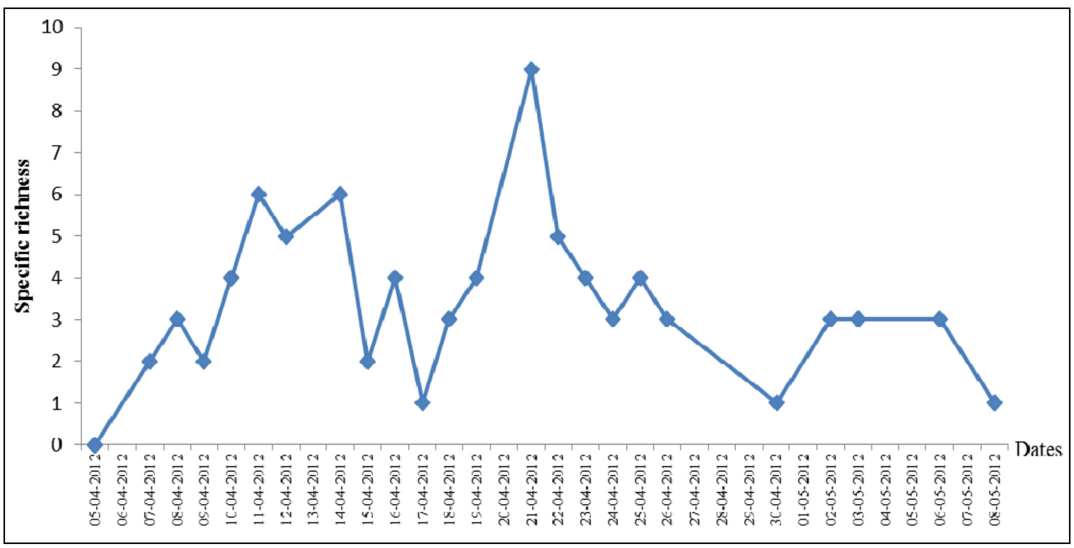


**Fig 3:** Specific richness recorded over time on the adult dog cadaver

### Ecological Indices of structure

### Shannon-Weaver Index H' and Equitability E (puppy corpse)

For a better appreciation of a stand's structure and diversity, the Shannon-Weaver index (H ') has been used. The variation curve of the diversity indices and equitability during the decomposition period of the puppy's cadaver is variable (Fig. 4). The highest value is 1.45 bits, registered on 03/4/2012, in other words, 5 days after the death of the puppy. This day is marked by a great diversity of the samples that visited the corpse. It is noteworthy that the lowest value is recorded on 04/4/2012 with 0.5 bits which indicates a low diversity within the necrophagous fauna. The stand is indeed dominated by the species *S. rugosa* only.

Another index taken into account is the equitability E. The recorded values range from 0.11 to 0.33 which can result in instability between the species throughout our experimentation. In other words, each decomposition stage has not the same number of species.

The curve relative to the variation indices of diversity and equitability (Fig. 4) shows four periods. The first one comes between 28/3/2012 and 29/3/2012 with E values tending to 0, i.e. no species of Coleoptera has been collected. The second period is between 01/4/2012 and 03/4/2012 where E values oscillate between 0.19 and 0.33 indicating a good distribution of the species within the necrophagous stand.

The third period corresponds to the lowest value estimated at 0.11 and observed on 4/4/2012. It tends to 0 which explains the dominance of a single species of Coleoptera, namely *C. maxillosus*. The fourth period starts on 08/4/2012, with a value of E tending to increase (0.18), suggesting some homogeneity between the species of Coleoptera.

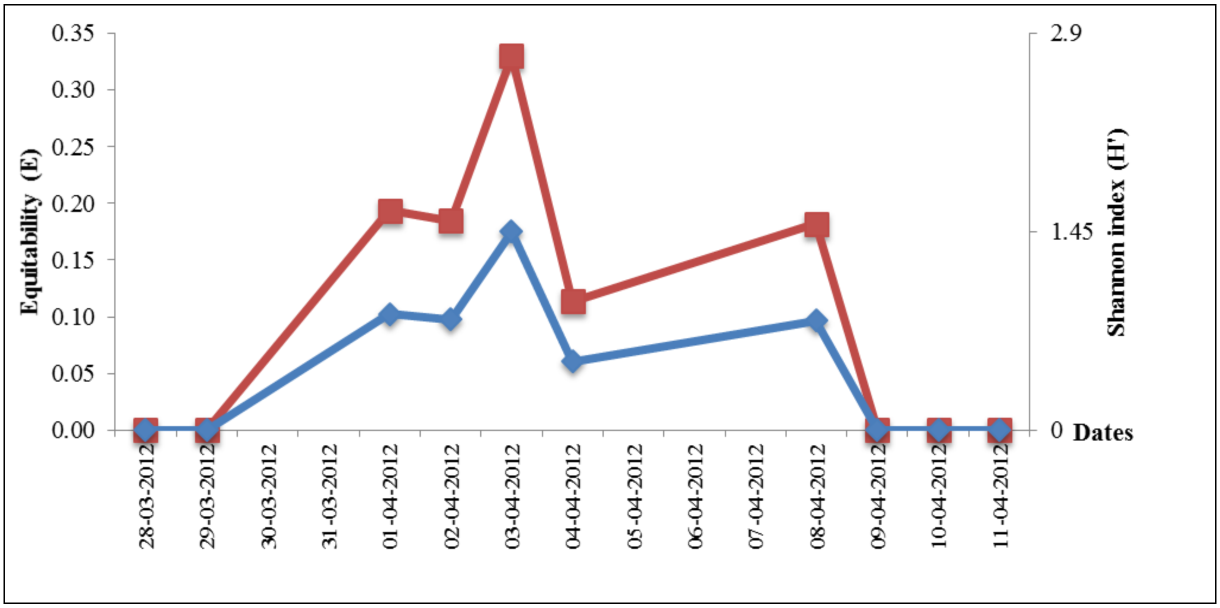


**Fig 4:** Shannon-Weaver Index H' and Equitability E recorded over time on the puppy corpse

**Shannon-Weaver Index H 'and Equitability E (Adult Dog Corpse)**

Fig. 5 shows the daily variations of the Shannon index. Thus, over a 34-day sampling period (from April 5, 2012 to May 08, 2012), the Shannon index analysis reveals that species diversity varies between 0 bit and 2.76 bits/individuals.

The peak of diversity is reached on 21/4/2012 with average information of 2.76 bits. This result indicates a visit of several species on the corpse, namely *S. rugosa and S. obscura*, *C. maxillosus*, *D. peruvianus*, *H. unicolor, H. purpurascens*, *S. aeneus*, *S. semistriatus* and finally *T. hispidus*. The lowest Shannon H' index was observed on 05/4/2012; the first day of the corpse deposition, with H' of 0 bit.

As far as equitability E is concerned, Figure 5 shows a sawtooth curve less marked than that of the Shannon index, but representing some instability between species throughout our investigation period. Regularity reached the maximum value on 21/4/2012 with an equitability of 0.63. This result indicates that each species is represented by a similar number of individuals, which means that the necrophagous population is in equilibrium.

Equitability is considered to tend toward 0 when it takes values less than 0.5. The minimum value of 0 is also recorded on 05/4/2012 i.e. the first day of depositing the corpses. This value was recorded on 17/4/2012, on 30/4/2012 and on 08/5/2012 where the dominant species of the necrofauna were *H. unicolor* and *D. peruvianus* respectively.

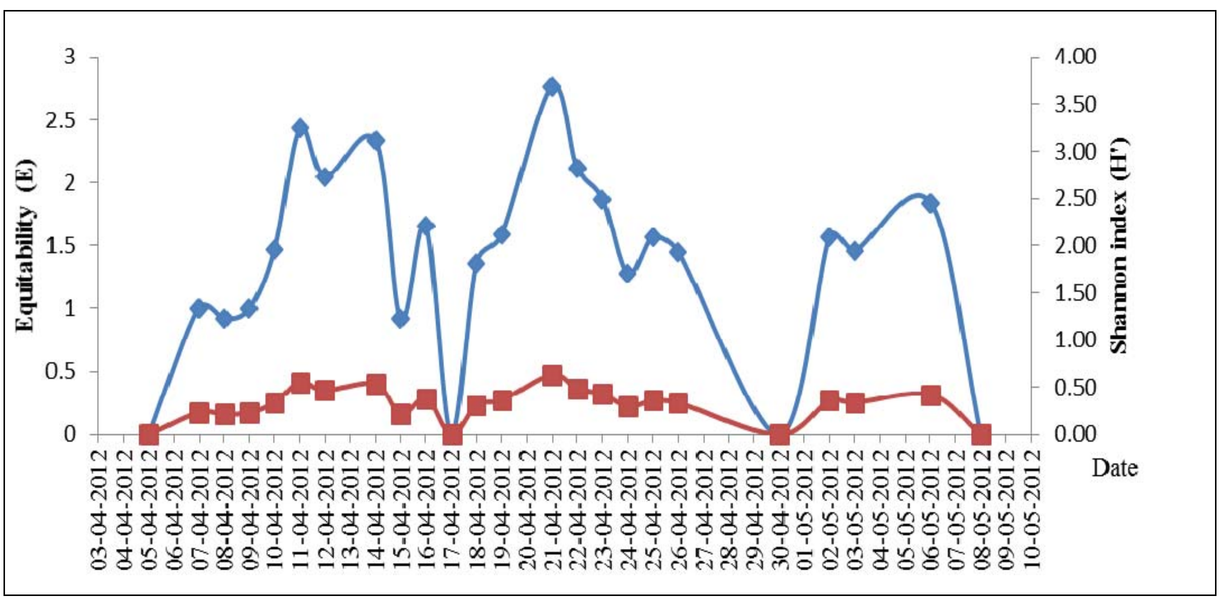


**Fig 5:** Shannon-Weaver Index H' and Equitability E recorded over time on the adult dog corpse

## 4. Discussion

The degradation of the two bodies of the puppy and the adult dog has begun just few minutes after the death, as confirmed by [19]. In our investigations, we observed and confirmed the four decomposition stages described and proposed by [20] namely the fresh stage, the swelling stage associated with Purification, the advanced stage of decomposition and finally the drying stage. We have also witnessed the timeline of these degradation stages reported by [21-24].

The first insects to colonize the cadavers are depicted as cited by [24-27] by Diptera of the Calliphoridae family. Moreover, in light of our results, the Coleoptera intervene early in the corpse decomposition. This finding is valid for both the puppy and the adult dog. These results are consistent with those of [28, 26].

Another precision reported by [9] is that Silphidae are the first Coleoptera to settle a body. Thus, during this investigation, their presence on the adult dog corpse is observed on the 3rd day of decomposition as confirmed by [29, 30]. This latter emphasizes that for a smaller animal like puppy of this study, the Silphidae arrive relatively early on the second day. It seems, as remarked by [31, 10] that this Coleoptera family is more attracted to small carcasses. The Silphidae actually have a great capacity to detect the cadaver's odors, which explains why they appear earlier [32].

The total number of samples collected on the puppy's corpse was 165 individuals; with 39 Samples of Diptera and 111 of Coleoptera. We also collected 724 necrophagous insects on the adult dog's corpse, 414 of which were Diptera, 302 Coleoptera and 8 Hymenoptera.

On the two cadavers, we note that the Silphidae are the most numerous with a relative frequency of 66% and 40% on the puppy and the adult dog, respectively. This family is followed by Histeridae with 19% in the puppy and 20% at the adult dog. Staphylinidae comes in the third position with 9% for the puppy and 6% for the adult dog. The abundance of Dermestidae is much higher in the adult dog, with 25%, and 6% in the puppy. We noted the presence of two families on the cadaver of the adult dog not found on the corpse of the puppy. These are Cleridae with 5% and Trogidae with 4%. Their absence on the small substrate could be explained by the fact that decomposition is faster in the puppy, leaving no time for the Coleoptera of the Cleridae and Trogidae family to appear [33]. Mentions a family other than that of the Trogidae, which is the Nitudilidae family.

We note that one essential characteristics of any settlement is the degree of organization [34, 35] reported that when an ecosystem has favorable living conditions, many species exist and each of which is represented by a number of individuals and the diversity index is then high. On the other hand, when conditions are unfavorable, only a small number of species are found, and the value of the index is low.

Although our experiments on the two substrates conducted under similar conditions, we noted some discrepancies, notably in the number of collected individuals, the daily species richness, and also in the species diversity. We also noticed significant differences in the number of Coleoptera sampled from the puppy corpse compared to that of the adult dog. Indeed, the one collected from the puppy's cadaver reached 111 samples of Coleoptera against 302 in the corpse of the adult dog. Regarding the Shannon and Weaver diversity index, the maximum values recorded in the cadavers of the puppy and the adult dog were 1.45 bits and 2.76 bits respectively. These results reveal that the species diversity of necrophagous fauna is greater on the large substrate. The equitability index with a value of 0.63 shows a good diversity on the adult dog cadaver. This can be explained as suggested by [26] by the difference in substrate size and decomposition time. However, the same author confirms that the variation in necrophagous species can be explained not only by the difference in the cadaver's size, but it is also linked to the nature of the substrate and its own physical characteristics (thickness of the fur, food…etc.).

## 5. Conclusion

Our investigations on two substrates; the cadavers of a puppy and an adult dog showed that the difference in their size and the duration of decomposition have a significant effect on the diversity of the necrophagous insects involved in the cadaveric decomposition.

Coleoptera have without doubt an appreciable role in the corpse decomposition process. Indeed, species of this order do not settle the corpse immediately after death, but at different periods, which makes them important in forensic entomology. Moreover, the three families of Coleoptera recorded in this study, namely the Silphidae, Dermestidae and Histeridae should be considered for prospective forensic entomology studies. It would then be interesting to identify species with a potential role in cadaveric decomposition by conducting more in-depth investigations, such as the Diptera along with the study of adult bio-ecology and immature stages. It has been observed on the ground, during our investigations, that Coleoptera and Diptera colonize a body in the same way. In other words, not only do they intervene early in the decomposition of a corpse but once the females have laid their eggs, they give larvae that participate in the cadaveric decomposition process.

Apart from these perspectives, studies on the life cycle of Coleoptera species taken from cadavers should be considered for a better understanding of their involvement in the determination of the post mortem interval (PMI) along with Diptera. It would also be interesting to determine cadaveric odorous compounds to better understand the interactions between the substrate and the relatively well represented Silphidae.

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