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Original article (Orijinal araştırma)

Differences in succession of Coleoptera species attracted to pig carcasses in rural and urban habitats in Eskişehir Province, Turkey[1]

Eskişehir ilinde kırsal ve kentsel habitatlardaki domuz leşlerine çekilen Coleoptera türlerinin süksesyon farklılıkları

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Summary

The aim of this study was to determine Coleoptera succession in pig carcasses in Eskişehir Province, Turkey, and to evaluate differences in successional patterns between rural and urban habitats. A total of 24 pig carcasses were placed in rural and urban areas in Eskişehir Province for one-year period between June 2012 and May 2013. A total of 80 species belonging to the families Staphylinidae, Histeridae, Dermestidae, Silphidae and Cleridae (Coleoptera) were collected either directly from carcasses or sifted for the specimens hiding in the soil. The months and duration of all species on the different stages of carcass decomposition were recorded. In addition, new records were added to the Coleoptera fauna of carcass for Turkey. The study revealed that, both species number and activity periods were different even in areas very close to each other. It is suggested that this type of long-term succession study should be performed across all provinces of Turkey. Acquired data could potentially be used for estimating the minimum post-mortem interval in forensic cases in Turkey.

Keywords: Coleoptera succession, forensic entomology, pig, rural, Turkey, urban

Özet

Bu çalışmanın amacı, Eskişehir ilinde domuz leşi üzerindeki Coleoptera süksesyonunun belirlenmesi ve kırsal ve kentsel habitatlardaki süksesyonal düzen farklılıklarının değerlendirilmesidir. Eskişehir ilinde bulunan bir kırsal bir de kentsel alana toplam 24 domuz leşi, Haziran 2012 ve Mayıs 2013 arasında bir yıllık süre boyunca yerleştirilmiştir. Coleoptera takımı içerisinde Staphylinidae, Histeridae, Dermestidae, Silphidae ve Cleridae familyalarına ait toplam 80 tür, ya direkt olarak leş üzerinden ya da toprakta bulunan türler için elemeyle toplanmıştır. Tüm türlerin ayları ve farklı çürüme evrelerinde bulundukları süreler belirlenmiştir. Buna ek olarak Türkiye'nin leş Coleoptera faunasına yeni kayıtlar eklenmiştir. Yapılan çalışmada, çok yakın alanlarda bile hem tür sayısının hem de aktivite periyodlarının belirgin şekilde farklılık gösterdiği açığa çıkmaktadır. Bu şekildeki uzun-süreli süksesyon çalışmalarının Türkiye'nin tüm illerinde yapılması gerekliliği ortaya konulmuştur. Elde edilen veriler Türkiye'de adli olaylarda minimum ölüm zaman aralığı tahmininde potansiyel olarak kullanılabilecektir.

Anahtar sözcükler: Coleoptera süksesyonu, adli entomoloji, domuz, kırsal, Türkiye, kentsel

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Introduction

Decomposition is a natural and necessary process responsible for the cycling organic material, such as dead plant or animal matter, through the ecosystem. Carrion represents a temporary and changing food source for a varied and distinct community of organisms (Putman, 1983). Insects are generally the first organisms which come to carcasses and they colonize in a predictable sequence. This sequence depends on nutritional changes in the carcass and variables like geographical region, habitat, season, and climatological and microclimatic conditions, but this sequence is predictable within these parameters (Anderson, 2001). In forensic entomology, Coleoptera seems to be neglected because Diptera locate corpses faster, thus they are more useful in minimum post-mortem interval (PMI_{min}) estimation (Midgley et al., 2010). However, some Coleoptera species can locate a carcass within 24 h of death which could potentially be employed in PMI_{min} estimation (Midgley & Villet, 2009). Moreover, because they cover most of the succession period, Coleoptera could be used in making more accurate PMI_{min} estimations as they colonize in a predictable sequence. In addition, since they exist longer on corpses, their larvae could be used in toxicological analysis for certain drugs (Midgley et al., 2010).

There are many studies regarding carcass fauna in the world. For example, Reed (1958) studied dog carcasses, Payne (1965), Anderson & Van Laerhoven (1996), Wolff et al. (2001), Grassberger & Frank (2004), Carvalho et al. (2004), Matuszewski et al. (2008, 2010a, b, 2011), Bonacci et al. (2010), Anton et al. (2011) and Prado e Castro et al. (2013) studied pig carcasses, Tantawi et al. (1996) studied rabbit carrion and Kočárek (2003) studied rat carrion. In Turkey, succession is rather a new field of study. There are only a few studies which cover the concept in a broad way. Özdemir & Sert (2009) published their study concerning the determination of Coleoptera species attracted to pig carcasses and their succession in Ankara and they detected 40 species. This was the first study which observed the succession of 12 pig carcasses over a one-year period. After this, Sert et al. (2012) published a study of dog carcass also conducted in Ankara. They detected 14 Coleoptera species. In the same year in Edirne, Bana & Beyarslan (2012) studied three pig carcasses and two placements of bovine offal and they also found 14 Coleoptera species.

The aim of the study was to determine the Coleoptera attracted to pig carcass in Eskişehir Province, Turkey, to evaluate successional differences between rural and urban habitats, and to compare the results with previous studies.

Material and Methods

This study was conducted between 21 June 2012 and 31 May 2013 in two different areas of Eskişehir Province. Temperature and precipitation data was recorded daily with Oregon Weather Station WMR89A data logger. The first part of the study was conducted in the Japanese Garden (39°46'10.39" N, 30°28'25.06" E, 796 m.), Yunus Emre Campus, Anadolu University, Eskişehir located 3 km from the city center and represents an urban area because of the constant human activity within 20 m. The flora of Yunus Emre Campus consists of 363 species belonging to 241 genera and 74 families. While most of them are angiosperms, there are 29 gymnosperm species. There are five major angiosperm families especially in the Japanese Garden; Asteraceae (Compositae) 36 taxa (%9,9), Fabaceae (Leguminosae) 29 taxa (%7,9), Poaceae (Graminae) 17 taxa (%4,6), Brassicaceae (Curiciferae) 18 taxa (%4,9) and Lamiaceae (Labiatae 22 taxa (%6). Gymnosperms in the Japanese Garden are mainly *Abies, Cedrus, Pinus* and *Picea* (Pinaceae)*; Taxus baccata L.* (Taxaceae)*; Biota, Chamaecyparis, Cupressocyparis, Cupressus, Juniperus* and *Thuja* (*Cupressaceae)*. The second location (39°56'07.12" N, 30°29'34.11" E, 1143 m) was in a highland rural area surrounded by *Quercus* forests with almost no human activity nearby. It was located within the Central District of Eskişehir Province with the nearest village, Tekeciler, located approximately 12 km from the study area.

Field studies

The 24 pigs (*Sus scrofa* L., 1758) that were left in the field weighed between 60 and 200 kg each. After obtaining permission to study with pig carcasses from the Experimental Animals Ethics Committee of Anadolu University (permit no. 2012/0001), pigs were supplied from the Production and Research Center of Gazi University, Ankara, the Education-Research and Application Farm of Ankara University and Ankara and Antalya Tropical Animal Farms. They were euthanized at the Experimental Animals Research Center of Anadolu University by means of sodium pentobarbital injection. Each month, two pigs were killed and a carcass placed as soon as possible after death at each of the sites, about. 50 m from the nearest carcass. They were placed in iron cages (1 x 1.5 x 1 m), so that they could not be eaten by vertebrate scavengers. The carcasses were checked daily over the one-year period. Adult specimens were collected using tweezers and aspirators directly from carcasses. The carcasses were rolled over to sample from their underside then put back in the original position. The soil around and under the carcasses was sifted to collect specimens which were hiding or had crawled into the soil when disturbed. The collected specimens were preserved in ethyl alcohol (70%) and acetic acid solution (10%) in the field.

Climatic data for Eskişehir are given in Figure 1.

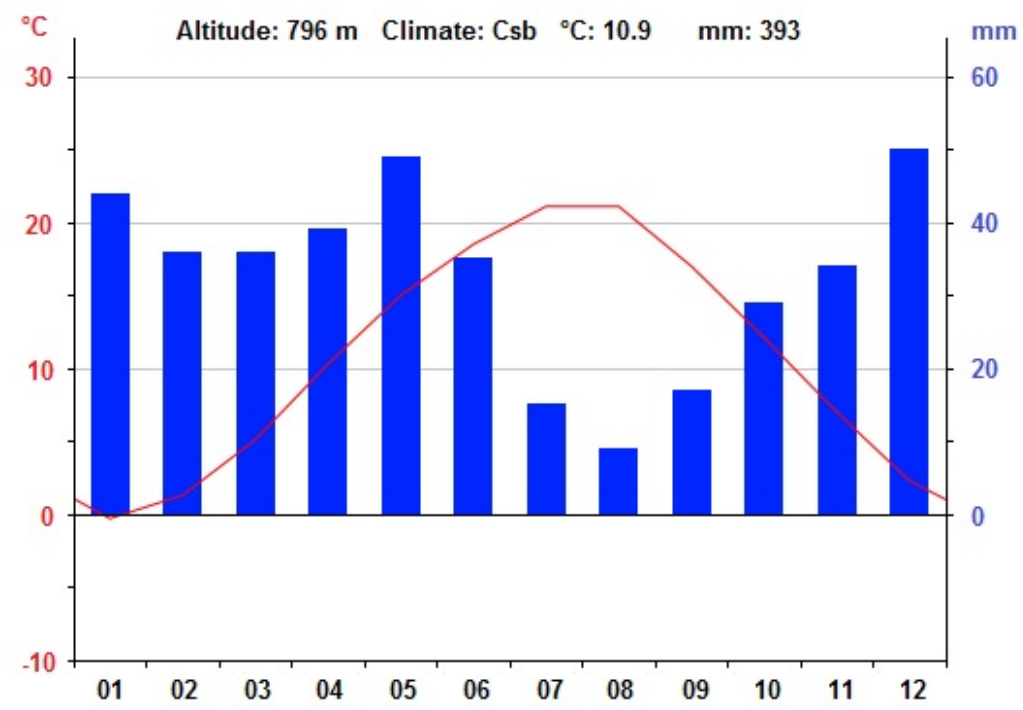

Figure 1. Mean temperature and precipitation in Eskişehir Province, Turkey from 21 June 2012 to 31 May 2013 (recorded with Oregon Weather Station WMR89A data logger).

Laboratory studies

The specimens collected from field were deposited in the collection in the Anadolu University Zoology Museum (AZUM), and then identified using Leica MZ 7.5 and Leica ZOOM 2000 stereomicroscopes. The identification of the specimens was done by authors and in the process identification keys of various researchers were used (Andres, 1925; Pfeffer, 1927; Lesne, 1930; Kalík, 1951; Halstead, 1963; Strand & Vik, 1964, 1968; Osuji, 1975; Kryzhanovskii & Reikhardt, 1976; Miller & Peck, 1979; Zanetti, 1987; Welch, 1997; Eversham, 1999; Ferreira de Almeida & Pires do Prado, 1999; Sikes & Peck, 2000; Secchi, 2002; Assing, 2006a, 2006b, 2007a, b; Lott, 2008; Özdemir & Sert, 2008; Tronquet, 2009; Dekeirsschieter et al., 2011).

Results and Discussion

In this study, 80 species belonging to five coleopteran families (Staphylinidae, Histeridae, Dermestidae, Silphidae, Cleridae) were detected. The highest number of species attracted to carcasses in the study belonged to the family Staphylinidae (39 species). This is followed by the Histeridae (23 species), Silphidae (9 species), Dermestidae (6 species) and Cleridae (3 species). Species distribution in rural and urban habitats over the study period is shown in Figures 2 to 6.

Figure 2. Distribution of Staphylinidae species in both rural and urban habitats in Eskişehir Province, Turkey over a one-year period; the same species are the same colored with solid bars representing the rural habitat, and open bars and the code UH representing the urban habitat.

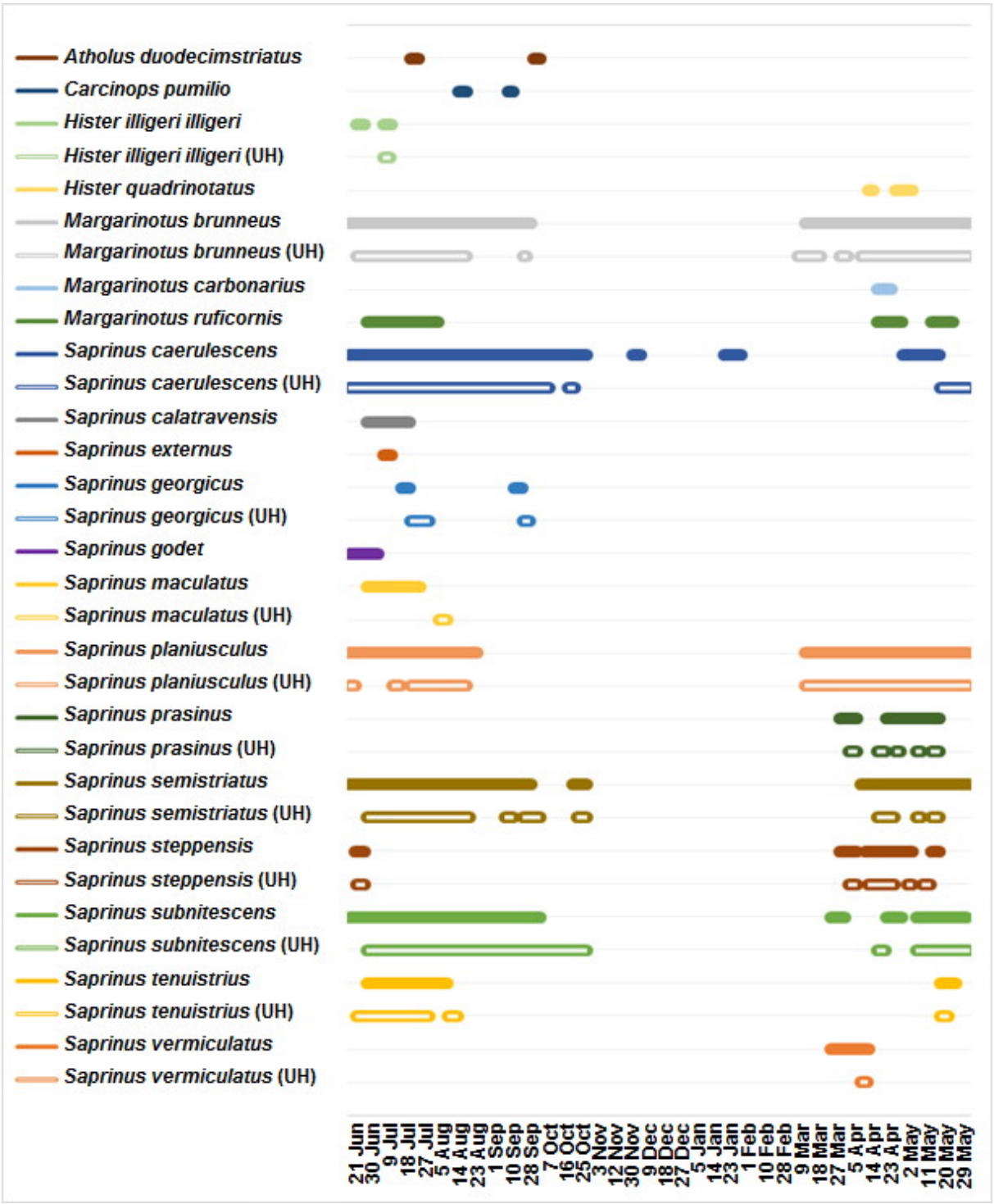

Figure 3. Distribution of Histeridae species in both rural and urban habitats in Eskişehir Province, Turkey over a one-year period; the same species are the same colored with solid bars representing the rural habitat, and open bars and the code UH representing the urban habitat.

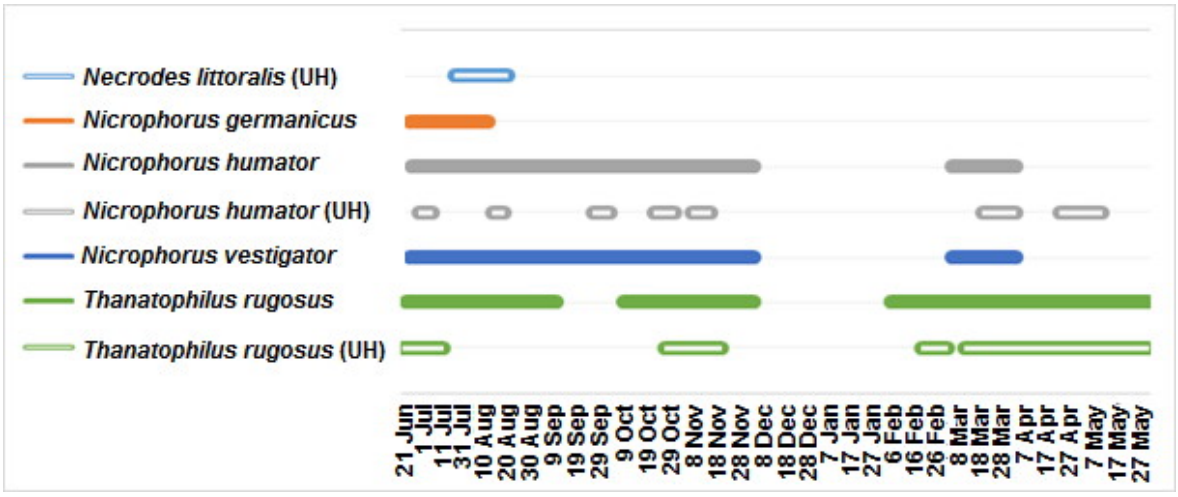

Figure 4. Distribution of Silphidae species in both rural and urban habitats in Eskişehir Province, Turkey over a one-year period; the same species are the same colored with solid bars representing the rural habitat, and open bars and the code UH representing the urban habitat.

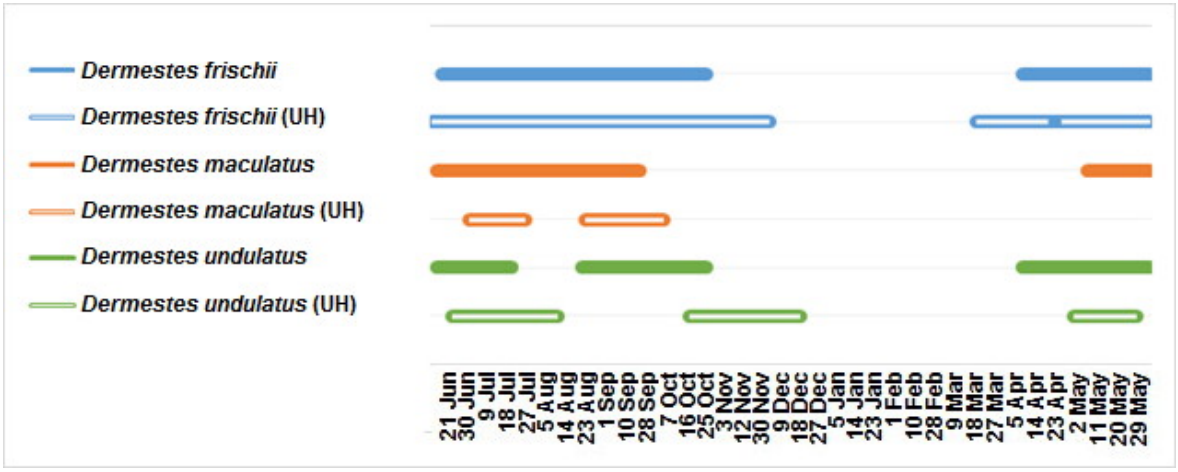

Figure 5. Distribution of Dermestidae species in both rural and urban habitats in Eskişehir Province, Turkey over a one-year period; the same species are the same colored with solid bars representing the rural habitat, and open bars and the code UH representing the urban habitat.

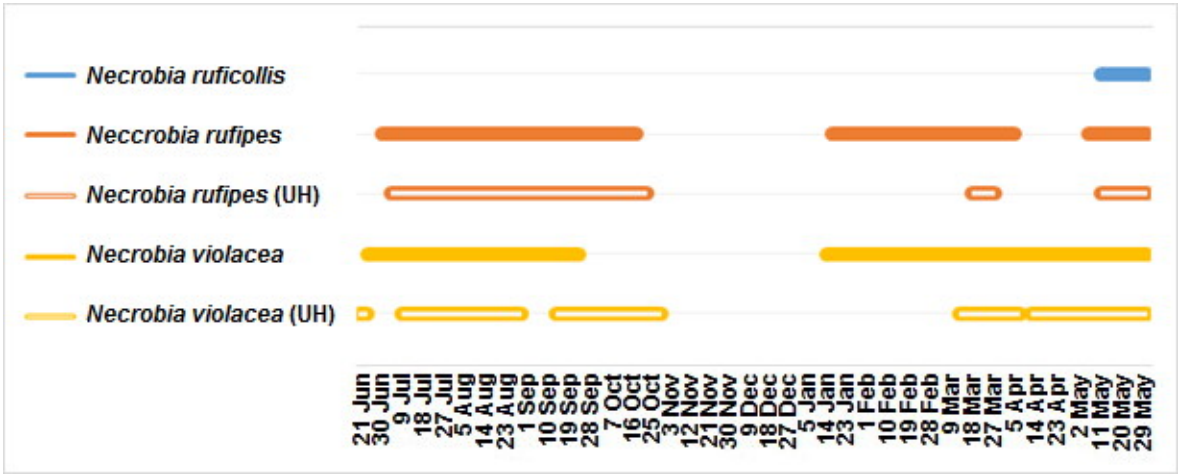

Figure 6. Distribution of Cleridae species in both rural and urban habitats in Eskişehir Province, Turkey over a one-year period; the same species are the same colored with solid bars representing the rural habitat, and open bars and the code UH representing the urban habitat.

Species according to family and their presence in rural and urban habitats are given in Table 1. Eighteen species which were detected only once (only one specimen on one occasion), were not regarded as important to succession. These species are indicated in the table. A total of 51 species were collected from pig carcasses for the first time in Turkey and these are also indicated in Table 1. Regarding habitat differences, except for *Emus hirtus* (L., 1758) and *Necrodes littoralis* (L., 1758), which were collected only from urban habitat, all other species were collected from rural habitat. Except for *Ocypus sericeicollis* (Ménétriés, 1832) and *Margarinotus merdarius* (Hoffmann, 1803) which were collected once during the study, 10 staphylinids, 12 histerids, 2 silphids, 3 dermestids and 2 clerids species were collected in both habitats.

Table 1. Species collected from pig carcasses according to family and their presence in rural and urban habitats in Eskişehir Province (The asterisk indicates species collected as a single specimen and only so are regarded as unimportant. Species which were collected from pig carcasses for the first time in Turkey are underlined)

Family	Species	Rural	Urban	Species	Rural	Urban
Staphylinidae	*Aleochara bipustulata* (L., 1761)	+	-	**Ocypus sericeicollis* (Ménétriés, 1832)	+	+
	Aleochara brevipennis Gravenhorst, 1806	+	-	*Omalium rivulare* (Paykull, 1789)	+	-
	Aleochara curtula (Goeze, 1777)	+	-	*Ontholestes murinus* (L., 1758)	+	+
	Aleochara haematoptera Kraatz, 1856	+	-	*Oxypoda collaris* Saulcy, 1865	+	-
	Aleochara intricata Mannerheim, 1830	+	+	**Oxypoda cristata* Assing, 2006	+	-
	Aleochara laevigata Gyllenhal, 1810	+	-	*Oxypoda longipes* Mulsant & Rey, 1861	+	-
	Aleochara lata Gravenhorst, 1802	+	+	*Oxypoda opaca* (Gravenhorst, 1802)	+	-
	**Aleochara maculata* Brisout de Barneville, 1863	+	-	*Philonthus concinnus* (Gravenhorst, 1802)	+	-
	**Aleochara spadicea* (Erichson, 1837)	+	-	*Philonthus corruscus* (Gravenhorst, 1802)	+	+
	Atheta harwoodi D.S. Williams, 1930	+	-	*Philonthus ebeninus* (Gravenhorst, 1802)	+	-
	Atheta incognita (Sharp, 1869)	+	-	*Philonthus laminatus* (Creutzer, 1799)	+	+
	Atheta marcida (Erichson, 1837)	+	-	*Philonthus politus* (L., 1758)	+	+
	Atheta occulta (Erichson, 1837)	+	-	*Philonthus speciosus* Cameron, 1926	+	-
	Creophilus maxillosus (L,, 1758)	+	+	*Philonthus spinipes* Sharp, 1874	+	-
	Dinothenarus flavocephalus (Goeze, 1777)	+	-	**Philonthus varians* (Paykull, 1789)	+	-
Staphylinidae	**Emus hirtus* (L., 1758)	-	+	*Platydracus flavopunctatus* (Latreille 1804)	+	+
	**Heterothops dissimilis* (Gravenhorst, 1802)	+	-	*Platydracus hypocrita* (Müller,1925)	+	-
	**Hypnogyra angularis* (Ganglbauer, 1895)	+	-	*Platystethus nitens* (C.R. Sahlberg, 1932)	+	-
	Liogluta alpestris (Heer, 1839)	+	-	*Quedius cinctus* (Paykull, 1790)	+	-
	Ocypus mus (Brullé, 1832)	+	+			

Table 1. (Continued)

Family	Species	Rural	Urban	Species	Rural	Urban
Histeridae	*Atholus duodecimstriatus* (Schrank, 1781)	+	-	*Saprinus externus* (Fischer de Waldheim, 1823)	+	-
	Carcinops pumilio (Erichson, 1834)	+	-	*Saprinus georgicus* Marseul, 1862	+	+
	**Gnathoncus nannetensis* (Marseul, 1862)	+	-	*Saprinus godet* Brullé, 1832	+	-
	**Gnathoncus rotundatus* (Kugelann, 1792)	+	-	*Saprinus maculatus* (Rossi, 1792)	+	+
	Hister illigeri illigeri Duftschmid, 1805	+	+	*Saprinus planiusculus* Motschulsky, 1849	+	+
	Hister quadrinotatus Scriba, 1790	+	-	*Saprinus prasinus* Erichson, 1834	+	+
	Margarinotus carbonarius (Hoffmann, 1803)	+	-	*Saprinus semistriatus* (Scriba, 1790)	+	+
	Margarinotus brunneus (Fabricius, 1775)	+	+	*Saprinus steppensis* Marseul, 1862	+	+
	**Margarinotus merdarius* (Hoffmann, 1803)	+	+	*Saprinus subnitescens* Bickhardt, 1909	+	+
	Margarinotus ruficornis (Grimm, 1852)	+	-	*Saprinus tenuistrius* Solsky, 1876	+	+
	Saprinus caerulescens (Hoffmann, 1803)	+	+	*Saprinus vermiculatus* Reichardt, 1923	+	+
	Saprinus calatravensis Fuente, 1899	+	-			
Silphidae	*Necrodes littoralis* (L., 1758)	-	+	*Nicrophorus vestigator* Herschel, 1807	+	-
	**Nicrophorus antennatus* Reitter, 1885	+	-	**Thanatophilus ferrugatus* (Solsky, 1874)	+	-
	Nicrophorus germanicus (L., 1758)	+	-	*Thanatophilus rugosus* (L., 1758)	+	+
	Nicrophorus humator (Gleditsch, 1767)	+	+	**Thanatophilus sinuatus* Fabricius, 1775	+	-
	**Nicrophorus investigator* Zetterstedt, 1824	+	-			
Dermestidae	**Dermestes dimidiatus* Boeber, 1802	+	-	**Dermestes leopardinus* Mulsant & Godart, 1855	+	-
	Dermestes frischi Kugelann, 1792	+	+	*Dermestes maculatus* DeGeer, 1774	+	+
	**Dermestes lardarius* L., 1758	+	-	*Dermestes undulatus* Brahm, 1790	+	+
Cleridae	*Necrobia ruficollis* (Fabricius, 1775)	+	-	*Necrobia violacea* (L., 1758)	+	+
	Necrobia rufipes (De Geer, 1775)	+	+			

The coleopteran species collected are compared with previous studies in Table 2. In the present study 78 species were collected in rural habitat. Among the researchers who performed their studies in rural, forest and/or semi-rural habitats, Anderson & Van Laerhoven (1996) collected 13 species, Kočárek (2003) collected 60 species, Watson & Carlton (2005) collected 34 species, Matuszewski et al. (2008) collected 72 species, Özdemir & Sert (2009) collected 37 species, Matuszewski et al. (2010b) collected 19 species, Bonacci et al. (2010) collected 12 species, Anton et al. (2011) collected 35 species, and Prado e Castro et al. (2013) collected 55 species belonging to coleopteran families collected in the present study. In contrast, while 32 species were collected in urban habitat in this study, Tantawi et al.

(1996) collected 18 species, Wolff et al. (2001) collected 11 species and Grassberger & Frank (2004) collected 10 species from urban habitat. Therefore, greater number of species have been collected from rural, forest and/or semi-rural habitats than from urban habitats when previous research is included (Table 2), and species are found for longer periods on and around carcass in rural habitats (Figures 2-6).

Table 2. Comparison of the number of identified species and total number of Coleoptera collected in the present study and previous studies

References	Location	Carcass Type	Habitat	Staphylinidae	Histeridae	Silphidae	Dermestidae	Cleridae	Other Coleoptera	TOTAL
Anderson & Van Laerhoven (1996)	British Columbia, Canada	Pig	Rural	6	1	2	1	3	9	22
Tantawi et al. (1996)	Alexandria, Egypt	Rabbit	Urban	9	5	-	2	2	8	26
Wolff et al. (2001)	Medellin, Colombia	Pig	Urban	7	1	1	1	1	4	15
Kočárek (2003)	Opava, Czech Republic	Rat	Rural (Forest)	44	4	9	2	1	85	145
Grassberger & Frank (2004)	Vienna, Austria	Pig	Urban	2	1	3	2	2	-	10
Watson & Carlton (2005)	Baton Rouge, Lousiana, USA	Bear, deer, alligator, pig	Rural (Forest)	21	6	4	1	2	26	60
Matuszewski et al. (2008)	Western Poland	Pig	Rural (Forest)	50	10	7	2	3	20	92
Özdemir & Sert (2009)	Ankara, Turkey	Pig	Rural	16	11	4	4	2	3	40
Matuszewski et al. (2010b)	Western Poland	Pig	Rural (Forest)	1	7	7	2	2	9	28
Bonacci et al. (2010)	Rende, Italy	Pig	Semi-Rural	5	1	4	1	1	3	15
Anton et al. (2011)	Thrungia, Jena, Germany	Pig	Rural	18	2	8	4	3	16	51
Prado e Castro et al. (2013)	Coimbra, Portugal	Pig	Rural (Forest)	35	10	3	4	3	25	80
Present Study	Eskişehir, Turkey	Pig	Rural/ Urban	39	23	9	6	3	-	80

Özdemir & Sert (2009) conducted their study in Ankara Province, which is adjacent to Eskişehir Province. Despite these provinces being close to each other, both species number and activity periods were substantially different. To explain, Beytepe Campus, Ankara (Özdemir & Sert, 2009) can be considered as an urban habitat similar to Yunus Emre Campus, Eskişehir. Nevertheless, 10 different species collected in Ankara were not collected in Eskişehir, and 11 species collected in Eskişehir were not collected in Ankara.

In the present study, *Aleochara maculata* Brisout de Barneville, 1863*, Aleochara spadicea* (Erichson, 1837)*, E. hirtus, Heterothops dissimilis* (Gravenhorst, 1802)*, Hypnogyra angularis* (Ganglbauer, 1895)*, Ocypus sericeicollis, Oxypoda cristata* Assing, 2006 and *Philonthus varians* (Paykull, 1789) from Staphylinidae*, Gnathoncus nannetensis* (Marseul, 1862)*, Gnathoncus rotundatus* (Kugelann,

1792) and *Margarinotus merdarius* (Hoffmann, 1803) from Histeridae*, Thanatophilus ferrugatus* (Solsky, 1874)*, Thanatophilus sinuatus* Fabricius, 1775*, Nicrophorus antennatus* Reitter, 1885 and *N. investigator* Zetterstedt, 1824 from Silphidae, and *Dermestes dimidiatus* Boeber, 1802*, Dermestes lardarius* L., 1758 and *Dermestes leopardinus* Mulsant & Godart, 1855 from Dermestidae were collected only once during the study period (Table 1). *Philonthus varians* and genera such as *Thanatophilus, Nicrophorus* and *Dermestes* are known to be associated with particular stages of decomposition (Reed, 1958; Anderson & Van Laerhoven, 1996; Kočárek, 2003; Grassberger & Frank, 2004; Matuszewski et al., 2008, 2010b), but it is possible that because of the dominance of their congenerics they were found only once. Other staphylinids are commonly found in dung, decaying organic material, and mammalian and ant nests. From the Histeridae, while *G. nannetensis* and *G. rotundatus* are known to be associated with carcasses, *M. merdarius* is normally found in forest litter, or in the moist substrate of hollow trunks, and it is less likely to be collected from carrion (Lackner & Mazur, 2015), as is in present study.

Aleochara brevipennis Gravenhorst, 1806*, Liogluta alpestris* (Heer, 1839) and *Oxypoda collaris* Saulcy, 1865 from the subfamily Aleocharinae (Staphylinidae) are often observed in forest habitats (Kočárek, 2003) and they were observed in the present study for only a relatively short period and only in the rural habitat. In the current study *Platystethus nitens* (C. R. Sahlberg, 1932) was observed on a carcass for a short time period only; it was reported by Lü & Zhou (2015) that *Platystethus* (Oxytelinae) species are most commonly found in dung and other decaying plant materials. *Philonthus spinipes* Sharp, 1874*, Platydracus hypocrita* (Müller, 1925) and *Quedius cinctus* (Paykull, 1790) from the subfamily Staphylininae can be found on decaying organic material and dung in rural habitats because they are predators on other insects, especially fly larvae. *Platydracus hypocrita* and *Quedius cinctus* were also collected from carcasses in previous studies (Özdemir & Sert, 2009; Fernández et al., 2010; Dekeirsschieter et al., 2013; Mądra et al., 2014). The fact that these species were collected only once in the present study suggests that they are relatively uncommon or carrion is not their primary habitat. *Hister quadrinotatus* Scriba, 1790*, Margarinotus carbonarius* (Hoffmann, 1803)*, Saprinus calatravensis* Fuente, 1899*, Saprinus externus* (Fischer de Waldheim, 1823)*, Saprinus godet* Brullé, 1832, *Nicrophorus germanicus* (L., 1758) and *Necrobia ruficollis* (Fabricius, 1775) are also known to be associated with carrion at various stages, but they were probably collected in low numbers because congenerics were common. *Necrodes littoralis* from the family Silphidae were observed only in the urban area, which was different from the other species detected for a short period also and in the studies of Watson & Carlton (2005) and Dekeirsschieter et al. (2011). It is possible that this species could be found in urban areas if the vegetation is suitable and food is available.

The remaining species, those not mentioned above, were collected from carcass at different times of the year. While some of them were found only in the rural habitat, others were collected from both rural and urban habitats. For example, *Philonthus laminatus* (Creutzer, 1799)*, Margarinotus brunneus* (Fabricius, 1775)*, Thanatophilus rugosus* (L., 1758) and *Necrobia rufipes* (De Geer, 1775) were observed almost throughout the whole year and could be found in any season without habitat preference. Although, the number of insect species decreased with the reduction of insect activity in winter.

Despite the fact that they were not observed in winter, *Aleochara lata* Gravenhorst, 1802*, Saprinus planiusculus* Motschulsky, 1849*, Saprinus semistriatus* (Scriba, 1790)*, Saprinus subnitescens* Bickhardt, 1909*, Nicrophorus humator* (Gleditsch, 1767) and *Dermestes frischi* Kugelann, 1792 were the most commonly observed species on carcass without habitat preference. In addition, *Creophilus maxillosus* (L., 1758)*, Saprinus caerulescens* (Hoffmann, 1803)*, Necrobia violacea* (L., 1758) and *Dermestes undulatus* Brahm, 1790 were also determined as common species, but while first three were not observed in winter in the urban habitat, *D. undulatus* was not observed in winter in the rural habitat. In contrast, as a

common species, *Philonthus politus* (L., 1758) was observed in winter in both habitats but not observed partly in summer and autumn. *Ocypus mus* (Brullé, 1832) was mostly found in winter and spring in both habitats and for a short period in summer only in the urban habitat. *Aleochara intricata* Mannerheim, 1830 was observed in every season in the rural habitat and only in spring in the urban habitat. *Dermestes maculatus* DeGeer, 1774 was not observed in winter and only in the urban habitat in spring. Among the species which were collected in both habitats, *Ontholestes murinus* (L., 1758)*, Philonthus corruscus* (Gravenhorst, 1802)*, Saprinus steppensis* Marseul, 1862 *and S. tenuistrius* Solsky, 1876 were observed through spring and summer. Another species, *Platydracus flavopunctatus* (Latreille 1804) was not found in spring in the urban habitat. While *Saprinus georgicus* Marseul, 1862 was collected in summer and autumn, *Saprinus prasinus* Erichson, 1834 and *Saprinus vermiculatus* Reichardt, 1923 were observed only in spring, and *Saprinus maculatus* (Rossi, 1792) and *Hister illigeri illigeri* Duftschmid, 1805 were collected only in summer.

Although the most of the species were distributed in both habitats, species such as *Dinothenarus flavocephalus* (Goeze, 1777)*, Philonthus concinnus* (Gravenhorst, 1802)*, P. ebeninus* (Gravenhorst, 1802)*, P. speciosus* Cameron, 1926*, Aleochara bipustulata* (L., 1761)*, A. curtula* (Goeze, 1777)*, A. haematoptera* Kraatz, 1856*, A. laevigata* Gyllenhal, 1810*, Atheta harwoodi* D.S. Williams, 1930*, A. incognita* (Sharp, 1869)*, A. marcida* (Erichson, 1837)*, A. occulta* (Erichson, 1837)*, Oxypoda longipes* Mulsant & Rey, 1861*, O. opaca* (Gravenhorst, 1802) and *Omalium rivulare* (Paykull, 1789) from Staphylinidae, *Atholus duodecimstriatus* (Schrank, 1781)*, Carcinops pumilio* (Erichson, 1834) and *Margarinotus ruficornis* (Grimm, 1852) from Histeridae, and *Nicrophorus vestigator* Herschel, 1807 from Silphidae were only collected from carcass in the rural habitat. *Dinothenarus flavocephalus, O. longipes, P. concinnus* and *P. ebeninus* where observed through the whole year, whereas the other species were collected in various combinations of seasons.

In this study, the decomposition process was classified in five stages, namely fresh, bloated, active, advanced and dry, after the classification system of Carvalho et al. (2004). Seasonal changes in the decomposition stages of pig carrion in rural and urban habitats and the Coleoptera species collected are given in Figures 7 to 12. Also, the time of arrival and the period of presence of species are shown in these figures. No Coleoptera species were collected in fresh stage. The decomposition process advanced rapidly in the spring and summer months, with increased temperature and insect activity, thus carcasses in both habitats reached the dry stage (Figures 7a, b; 8a, b) and generally the succession proceeded quickly (Figures 7a, b, 8a, b and 12a, b). The number of species collected decreased with the progress of the seasons through to winter (Figures 9a, b). No Coleoptera were collected from the sixth carcasses in both habitats, even though the decomposition process had continued in winter. Limited insect activity could be detected on the carcasses placed in winter, and activity was mostly delayed until the end of winter (Figures 10a, b; 11a, b). Only one species (*Thanatophilus rugosus*) was attracted to the seventh carcass at dry stage in May after being placed in December in the urban habitat. The remaining carcasses did not reach the dry stage before the end of the experiment.

In conclusion, the Coleoptera fauna of animal carcasses placed outside in Eskişehir Province, Turkey and their successional and seasonal distributions over a one-year period was determined with this study. Overall, 80 species were detected, 51 of those were collected from carcasses for the first time in Turkey. These data could potentially be used for estimating the PMI_{min} in forensic cases in Turkey. The succession of these species should be taken into consideration in forensic cases. In addition, different environmental variables, such as elevation, soil type and vegetation, should also be investigated in further studies. As a result, it is suggested that this type of study should be conducted in rural and urban areas across Turkey.

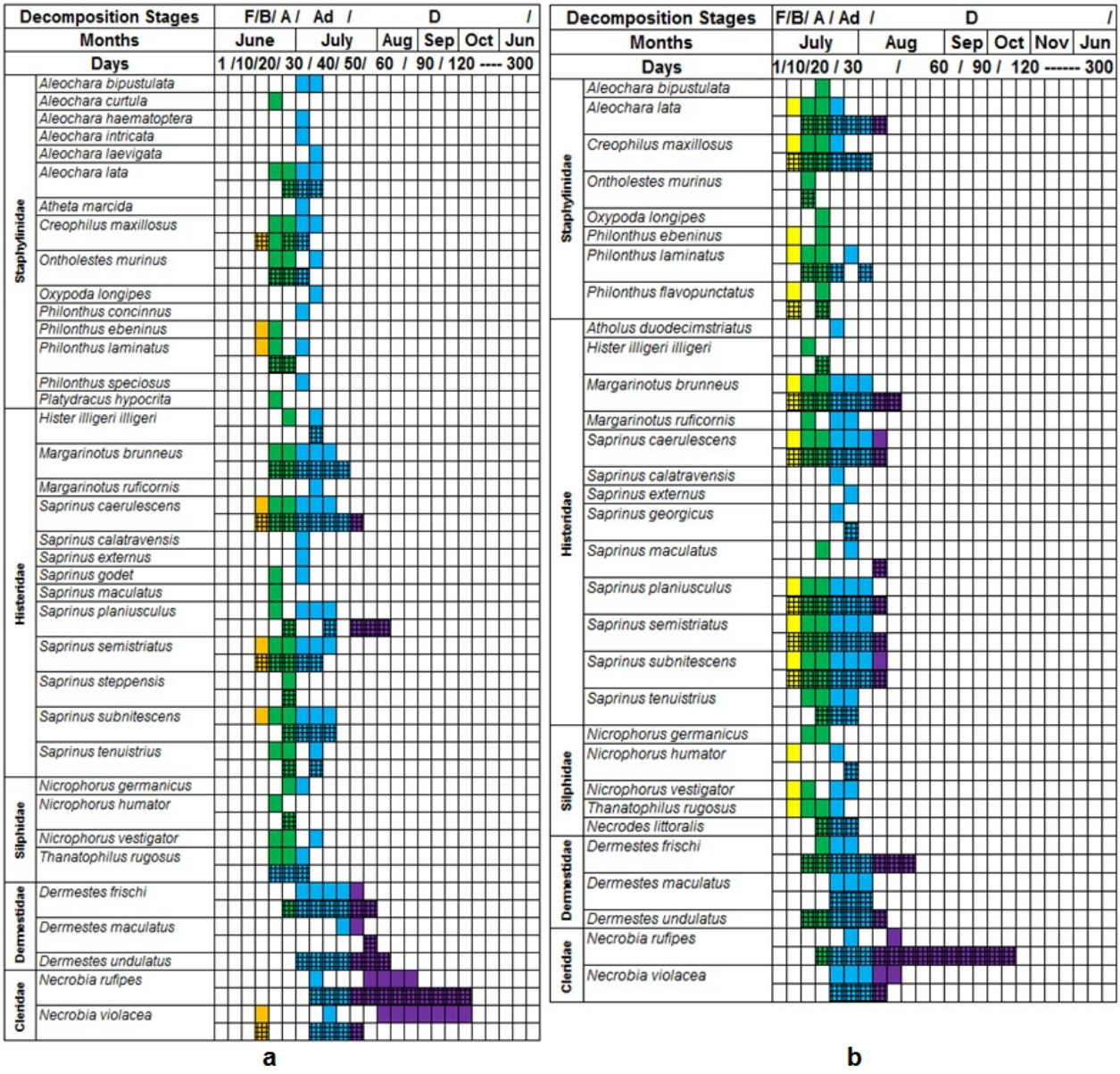

Figure 7. Succession through decomposition stages of carcasses in rural and urban habitats: a) first carcass; b) second carcass (solid, rural; crosshatched, urban). Decomposition stages: F, fresh (not shown in color because none of the insects were attracted); B, bloated (yellow); A, active decay (green); Ad, advanced decay (blue); and D, dry (purple).

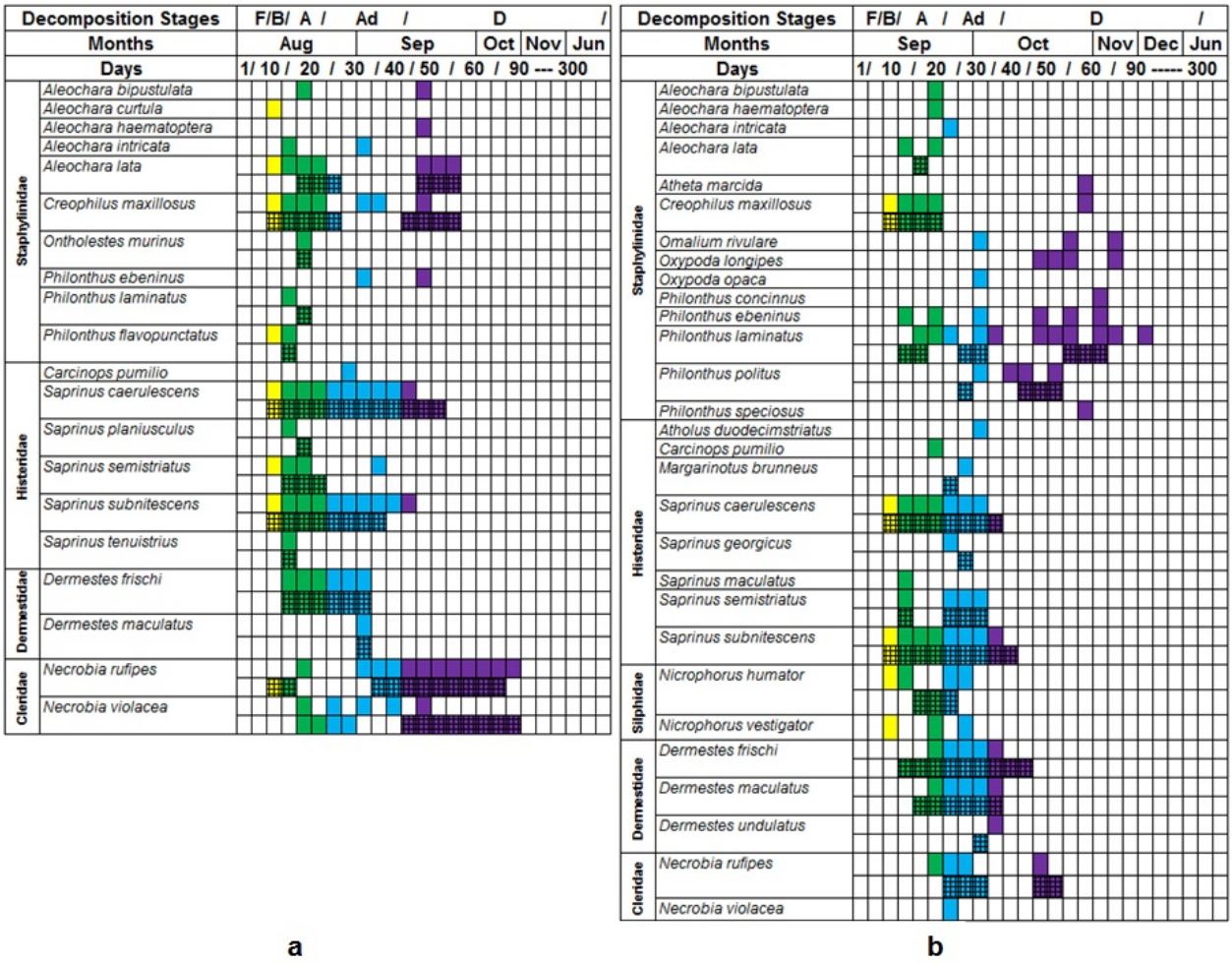

Figure 8. Succession through decomposition stages of carcasses in rural and urban habitats: a) third carcass; b) fourth carcass (solid, rural; crosshatched, urban). Decomposition stages: F, fresh (not shown in color because none of the insects were attracted); B, bloated (yellow); A, active decay (green); Ad, advanced decay (blue); and D, dry (purple).

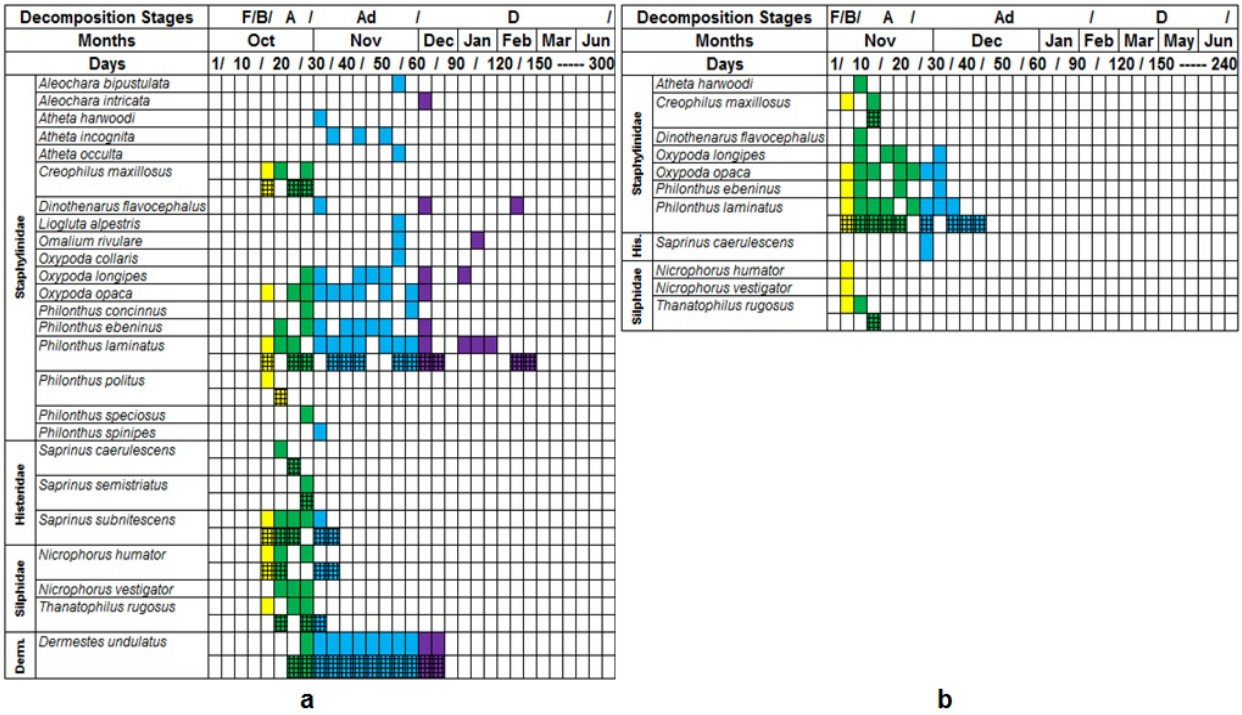

Figure 9. Succession through decomposition stages of carcasses in rural and urban habitats: a) fifth carcass; b) sixth carcass (solid, rural; crosshatched, urban). Decomposition stages: F, fresh (not shown in color because none of the insects were attracted); B, bloated (yellow); A, active decay (green); Ad, advanced decay (blue); and D, dry (purple).

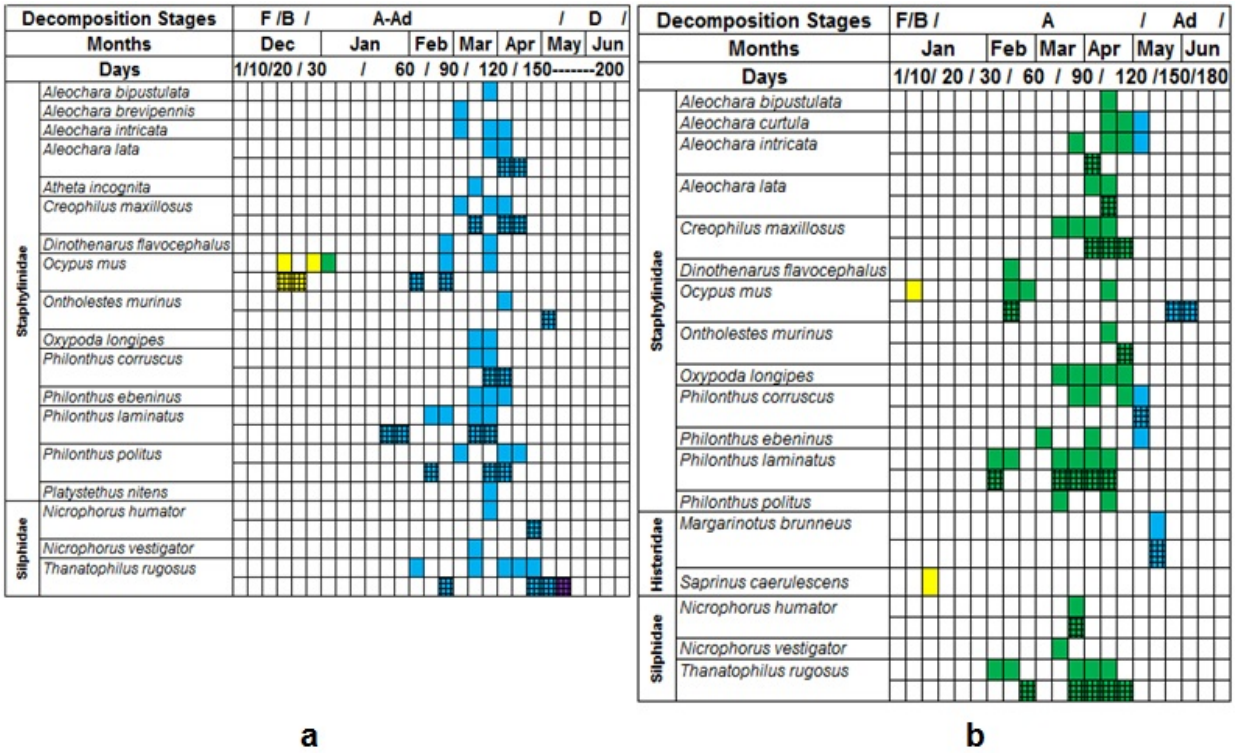

Figure 10. Succession through decomposition stages of carcasses in rural and urban habitats: a) seventh carcass; b) eighth carcass (solid, rural; crosshatched, urban). Decomposition stages: F, fresh (not shown in color because none of the insects were attracted); B, bloated (yellow); A, active decay (green); Ad, advanced decay (blue); and D, dry (purple).

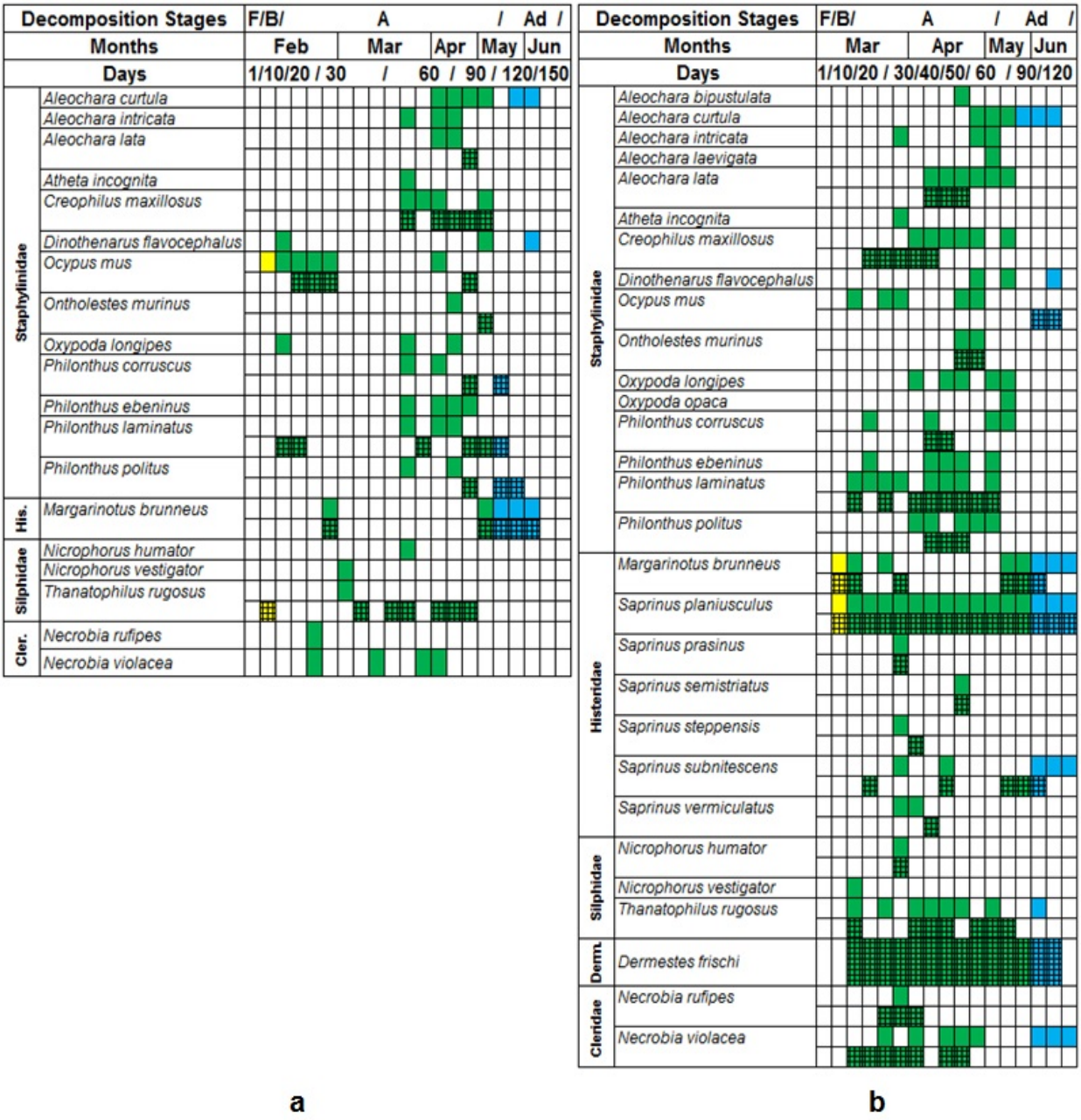

Figure 11. Succession through decomposition stages of carcasses in rural and urban habitats: a) ninth carcass; b) tenth carcass (solid, rural; crosshatched, urban). Decomposition stages: F, fresh (not shown in color because none of the insects were attracted); B, bloated (yellow); A, active decay (green); Ad, advanced decay (blue); and D, dry (purple).

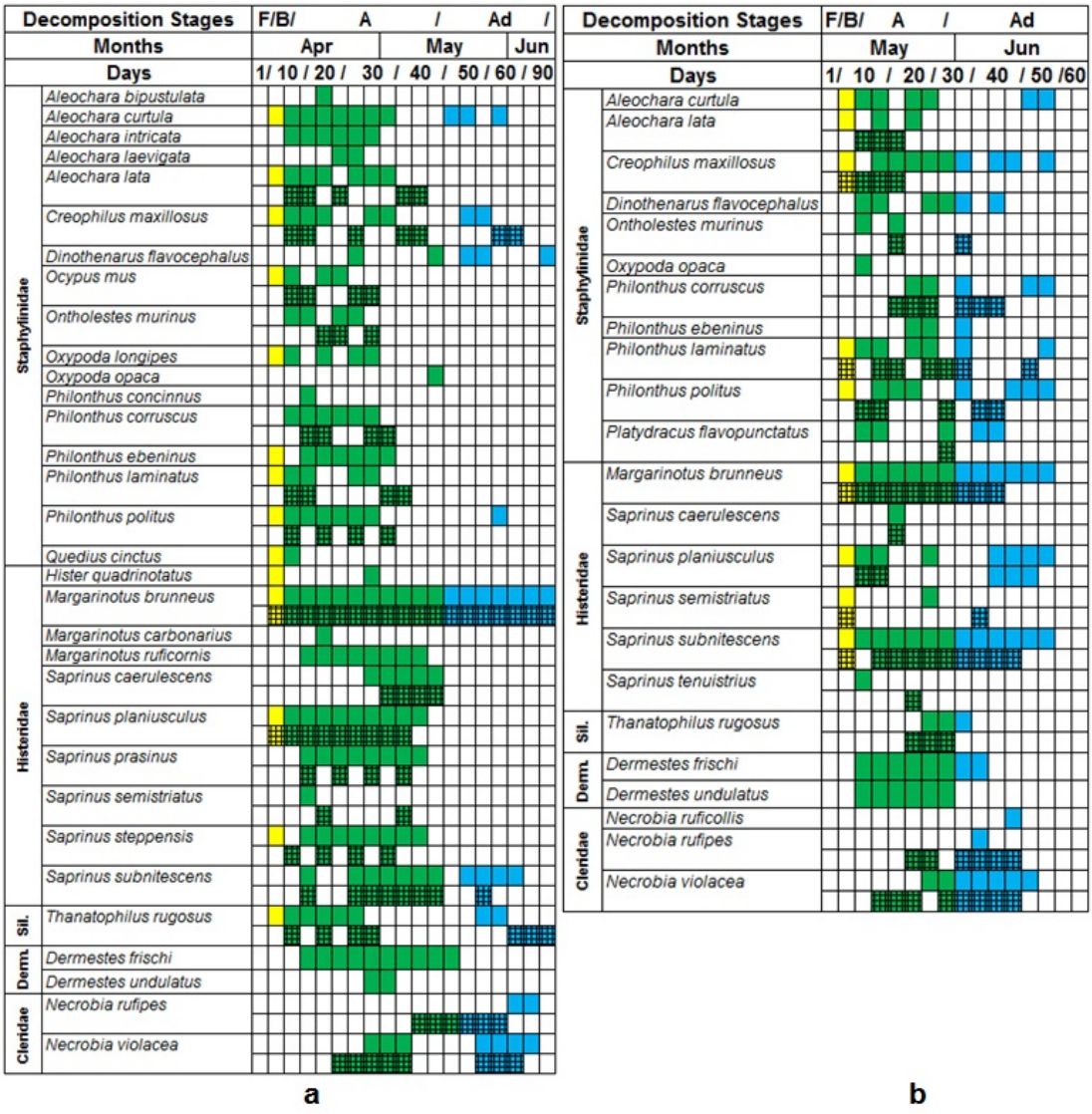

Figure 12. Succession through decomposition stages of carcasses in rural and urban habitats: a) eleventh carcass; b) twelfth carcass (solid, rural; crosshatched, urban). Decomposition stages: F, fresh (not shown in color because none of the insects were attracted); B, bloated (yellow); A, active decay (green); Ad, advanced decay (blue); and D, dry (purple).

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