Rare Invertebrates Colonizing Green Roofs in London

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Abstract

The biodiversity potential of green roofs in London and their potential role in invertebrate conservation and habitat mitigation were studied. In summer and autumn 2004, I investigated three different habitat types: green (*Sedum*) roofs, brown/biodiverse roofs, and brownfields. The study focused on three diverse invertebrate groups: Araneae (spiders), Coleoptera (beetles), and aculeate Hymenoptera (wasps, ants, bees). A high abundance of invertebrates were found on the roofs. At least 10% of species collected at the study sites were designated nationally rare or scarce, in accordance with criteria established by the intergovernmental agency Natural England. The data indicates that green and brown/biodiverse roofs can be important tools for invertebrate conservation.

Key words: biodiversity; brown/biodiverse roofs; brownfield sites; green roofs; invertebrates; nationally rare and scarce species; spiders

Introduction

Even our most industrial, built-up cities need not be completely devoid of green space and wildlife. While parks and gardens come to mind as obvious refuges for nature, plants and animals are often more adventurous with regard to the places they colonize and use. Not many people associate rooftops with wildlife habitats, but if suitable niches are available or provided, plants and animals will rapidly move in and establish communities. In some cases, green roofs offer the only valuable wildlife sanctuaries in our cities and towns. Of particular importance is the fact that these rooftops already exist, so no additional space has to be sacrificed. The potential to provide habitat for wildlife on green roofs is tremendous. In London, for instance, 26,000 hectares of available roof space could be greened with little effort, and this would create 28 times the green space of Great Richmond Park (Grant, Engleback & Nicholson, 2003).

The term "green roof" describes both intensive, ornamental roof gardens and extensive roofs with more naturalistic plantings or self-established vegetation. Intensive green roofs are like parks and gardens at roof level and require deep soil and regular maintenance. Extensive roofs have more naturalistic plantings and shallower natural substrates and are either sown with (local) wildflower mixes or *Sedum* matting or left to colonize naturally. Extensive green roofs require little or no maintenance and are relatively inexpensive to establish.

The environmental benefits provided by green roofs are well documented (Grant, Engleback & Nicholson, 2003; Getter & Rowe, 2006). What green roofs can achieve in terms of biodiversity, however, is less well known. They may provide new habitats in areas that currently lack suitable wildlife space, act as green corridors linking existing habitats, facilitate wildlife movement and dispersal, and serve as refuges for declining and rare species. One of the most pressing issues in the U.K. is the role that green roofs might play in terms of habitat mitigation for the lost biodiversity of redeveloped brownfield sites. (In the U.K., "brownfield" land is land that has had a previous industrial use but can be built on; it is not necessarily contaminated.)

Brownfield sites include some of the most species-diverse habitats left in the U.K. They are sometimes referred to as "English rainforests" ("A Bleak Corner of Essex," 2003), because some of them harbor the same number of rare invertebrates that can be found in ancient woodlands (Gibson, 1998). The best sites may contain up to half of an entire county's invertebrate fauna (Gibson, 1998; www.buglife.org.uk). With the intensification of modern farming methods in rural areas, these sites, which have largely escaped improvement, have become wildlife refugia—habitat "islands" in a "sea" of industrial agriculture (Angold et al., 2006; www.buglife.org.uk).

So what is the problem? There is increasing pressure to redevelop the brownfield sites. In London, for example, according to the latest estimates, 24,000 new homes are expected to be built each year (DETR, 2000). The general government strategy is to build 60% of these homes on brownfield sites (DEFRA, 2003). Huge swathes of industrial brownfield along the Thames estuary are slated for redevelopment, and this will have an immense impact on wildlife.

To offer suitable habitat replacement for the community of invertebrates associated with brownfield sites, we need to understand the ecology behind these habitats, along with the ecology of green roofs. This will help us design green roofs to maximize their biodiversity potential. The aim of this paper is to document some of the invertebrate diversity associated with green roofs in London, as a first step to understanding their ecology.

Methods

Study Sites

In summer and autumn 2004, I sampled and quantified the fauna and flora of nine sites, including three *Sedum* green roofs ("FC4," "Retail," and "Waitrose," located in Canary Wharf; Figure 1), two recently constructed brown/biodiverse roofs ("Laban Dance Centre" and "Creekside Education Centre"; Figure 2), and four brownfield habitats ("Wood Wharf" in Canary Wharf; "Sentinal" and "BR," near the Laban Dance Centre; and "Creek Ground," adjacent to the Creekside Education Centre; Figure 3) in the London area. Our study sites were chosen to encompass a good representation of green roof, brown roof, and brownfield habitat. The roofs were covered with different substrate types such as aggregate, *Sedum* matting, and other vegetation, so that the influence of substrate on community development could be investigated. Table 1 lists the ages and areas of the roof and brownfield sites. As previously mentioned, green roofs are not common in the U.K., so it is difficult to find suitable study sites. Moreover, as the general construction practice to date has incorporated green roofing based on *Sedum* matting, the availability of green or brown roofs based on aggregate is limited.

Sampling Techniques

The research focused on sampling the invertebrate population of the study sites. It targeted certain groups of importance to the U.K. Biodiversity Action Plan and English Nature's Species Recovery Programme (www.english-nature.org.uk) notably, Araneae (spiders), Coleoptera (beetles), and aculeate Hymenoptera (wasps, ants, and bees, excluding sawflies and parasitic wasps). These groups were identified to species level: Spiders were identified by the author and checked by Peter Harvey; hymenopterans were identified by Peter Harvey; and beetles were identified by Richard Jones. The presence and abundance of other incidental invertebrates were also recorded.

Pitfall trapping was the primary sampling technique. At each sampling site, 10 pitfall traps (125 ml, 85 × 60 mm polystyrene cups) were buried in the substrate, with their rims flush with the surface. The traps were filled with a solution of 33% antifreeze and 67% water. Every three weeks from May through October, the traps were emptied and refilled. The contents of each pitfall trap were collected in a single separated container.

Results

Results indicated a high abundance of invertebrates on the roofs. In some cases, the total number of individuals was higher on roofs than at our brownfield sites (Figure 4). This was surprising, considering that the brownfield sites are very species rich. It should be noted that the brown roofs surveyed in this research were created just one year prior to sampling. Consequently, these sites were in the early stages of succession but are expected to increase in invertebrate abundance over time. On the *Sedum* green roofs, the total number of invertebrates collected was in fact higher than on the brownfield sites. However, the data was somewhat distorted by the high numbers of snails: At least half the invertebrates collected on the *Sedum* roofs were snails. The presence of snails in such high numbers was somewhat puzzling but may be best explained by the lack of mammalian predation. Moreover, snails are commonplace at green roof farms, so they were most likely brought in on the original *Sedum* matting and persisted over the years. I decided to include snails in the analysis since they do provide a valuable food source for birds.

Figure 5 shows the mean number of invertebrates collected in each trap at one collection. This table mimics the results of

Figure 4; however, it presents a more accurate picture because individual traps can be lost or taken by birds.

The species diversity index was calculated for all sites (see Figure 6). The data indicated that the brownfield sites were more species rich than the *Sedum* green roofs and the sampled brown roofs. As mentioned earlier, however, the brown roofs were only a year old, and this probably explains the somewhat low species diversity. (Indeed, my results for 2005 and 2006 do indicate that biodiverse roofs become more species rich over time [Kadas, 2002]).

The high abundance of invertebrates is, in and of itself, of great interest. Furthermore, at least 10% of our collected species from the target groups are in fact considered nationally rare and scarce, as defined by the intergovernmental agency Natural England (Figure 7; Table 2). The data shows that all of the sampled *Sedum* green roofs and even the newly created brown roofs house spider species listed as nationally rare and scarce (Figure 8). Most of our green roofs—but most importantly, both of the new brown roofs—accommodate beetle species of national importance (Figure 9). This data implies that if suitable habitat is created on green or brown roofs, it could provide an essential tool for species conservation.

Discussion

(i) Biodiversity Potential of Green Roofs

The main aim behind this project was to determine the biodiversity potential of green roofs. What can they offer? How can they be used for habitat creation in the "urban jungle"? The results are most surprising. Even the relatively few *Sedum* green roofs present in London provide effective habitat for a large number and diversity of invertebrates. Furthermore, the newly created substrate-based brown/biodiverse roofs at Laban and Creekside are highly species rich. It will take some time before these roofs are fully colonized by flora and fauna, but the early results indicate that their potential is enormous.

This research compares green roofs with well-established urban brownfield sites. It would be interesting to compare green roofs with greenfield sites (semirural agricultural land). Research shows that most brownfield sites are more species diverse than greenfield sites (Gibson, 1998; www.buglife.org.uk). The planting of monocultures and the use of intensive management systems in greenfields tend to lower their species diversity. It is possible, therefore, that green roofs could support more species on the whole and have higher species diversity than these semirural sites.

(ii) Species of Interest

In addition to providing valuable habitat for wildlife in general, green roofs can host a number of species of interest that are rare or scarce in other habitats. Many of the species collected in this study are in fact highly localized and have a low or limited range of distribution. Consequently, the establishment of green roofs may provide additional resources for these species—and in some cases, the only habitat in which they can survive.

My project focuses on spiders, beetles, and aculeate Hymenoptera. The results show that at least 10% of all species recorded are in fact faunistically interesting. All are either RDB (Red Data Book) species, nationally rare or scarce, or have limited range of distribution (Figure 7). Consequently any additional habitat provided for these species—such as green roofs—is vital for their long-term survival. My results suggest that meaningful habitats can be created and managed in urban areas.

(iii) Araneae

Spiders were chosen as one of the main focus groups in this project not only because several spider species are threatened in the East Thames Gateway but also because spiders occupy the mid-trophic level of the food chain, and thus they give a good indicator of the abundance of species in the lower and higher trophic levels. Spiders display a wide variety of foraging strategies, which dictate requirements for vegetation and soil structure (Gibson, Hambler & Brown, 1992). This invertebrate group is so diverse in terms of foraging and habitat requirements that spider abundance and species richness may be considered a good measure of the overall biodiversity potential of the sampled habitats.

Seventy-two different species were collected from the study sites in 2004. This represents almost 12% of the total U.K. (Harvey, Nellist & Telfer, 2002) and 30% of the Greater London spider fauna (Milner, 1999). It is remarkable that such a high percentage of London's spider fauna has been found on these roofs—which represent a relatively small space—in a single year. Furthermore, five new species were recorded for Greater London: *Pardosa agresits* and *P. arctosa* (Lycosidea); *Steatoda phalerata* (Salticidae); and *Silometopus reussi* and *Erigone aletris* (Lyniphidae). The last of these species (*E. aletris*) has never been collected in southern England before.

As noted already, the roof habitats are not only being colonized by ubiquitous invertebrate species but also by local, rare, and highly specialized species (Figure 8). In fact, we collected wetland spiders of national importance such as *Arctosa leopardus* and *Pirata latitans* (both from the Lycosidae). These species take advantage of the diverse surfaces of the roofs, such as the shadier sections—even those created by architectural features such as solar panels—and areas where rainwater is allowed to accumulate. This is further evidence of the tremendous potential these roofs have for biodiversity conservation.

(iv) Coleoptera

The majority of beetle species feed on vegetation or decaying organic matter, hence the number and identity of different beetle species gives an indication of the amount of resources that the habitat can provide. The results for beetles in my survey were very similar to those for spiders. Over 10% of the collected species found on the green and brown/biodiverse roofs had national or local conservation status (Figure 9). Some of the species found were very rare, such as *Microlestes minutus*, which has only been recorded six times in the U.K. Two of these records came from the newly created biodiverse roof in Canary Wharf. This finding suggests that if a suitable habitat is created, wildlife will soon colonize.

The *Sedum* green roofs had extremely high populations of the ladybird *Coccinella* 7-*punctata*. Indeed, it might be said that roofs were almost infested with ladybirds and their larvae. The precise reason for this is not yet known. I can only speculate that aphids are very numerous on these roofs, which are insecticide free, and that the ladybirds are taking advantage of the profusion of aphids. Another ladybird, *Hippodamia variegata*, was also found in relatively high numbers on the brown/biodiverse roofs, and this is noteworthy because of the species' status as nationally scarce.

(v) Aculeate Hymenoptera

While this study attempted to focus on aculeate Hymenoptera, the sampling technique used was not the most ideal to target this group. Pan trapping was used, but in many cases, the traps went missing. To sufficiently analyze the presence of this group, it would have been necessary to include visual surveys of the roofs. My results, however, do indicate that aculeate Hymenoptera species are present, and furthermore, that green and brown/biodiverse roofs give vital resources to many of our nationally rare and scarce species. Most of these species are highly localized and can only be found on brownfield sites. Therefore the presence of these species on the roofs is especially important. Since many brownfield sites are earmarked for redevelopment, green and brown roofs could provide the essential habitat needed for the survival of these species. It has to be added, however, that for successful conservation of target species, the roofs must be designed for their specific habitat requirements. While *Sedum* plants can provide vital pollen and nectar resources for hymenopterans, roofs composed entirely of *Sedum* matting only offer these resources for a limited time, namely the relatively short flowering period of the plants. It is essential to provide a wide range of native wildflowers in our roof habitats to prolong the resource availability for these species.

It is also essential to provide nesting material for these species. I have recorded significantly higher numbers of Hymenoptera on biodiverse roofs when material such as old wood and sandbanks are provided.

Conclusion

Green, biodiverse roofs could play an important role not only in creating additional wildlife spaces in urban areas but also in the conservation of rare or endangered species. This research shows that green roofs house a large swathe of invertebrates, at least 10% of which are nationally rare or scarce. Consequently, the potential for these artificial habitats is vast.

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Glossary

Brown/biodiverse roofs: These are substrate-based (rather than sedum-based) extensive roofs created specifically for biodiversity. The substrate in many cases is recycled aggregate, and it is generally left to colonize naturally or is seeded with an annual wildflower mix or local seed source.

Pan trapping: A sampling technique similar to pitfall trapping that uses a yellow pan trap (dimensions: 250 × 350 × 40mm).

Succession: The sequential change in vegetation and the animals associated with it, either in response to an environmental change or induced by the intrinsic properties of the organisms themselves.

Figure 1: Retail *Sedum* roof, Canary Wharf, London.

Figure 2: Laban Dance Centre (brown/biodiverse) roof.

Figure 3: Sentinal, flood defence wall (brownfield site), Deptford, London.

Figure 4: Total number of invertebrates collected at each study site in 2004.

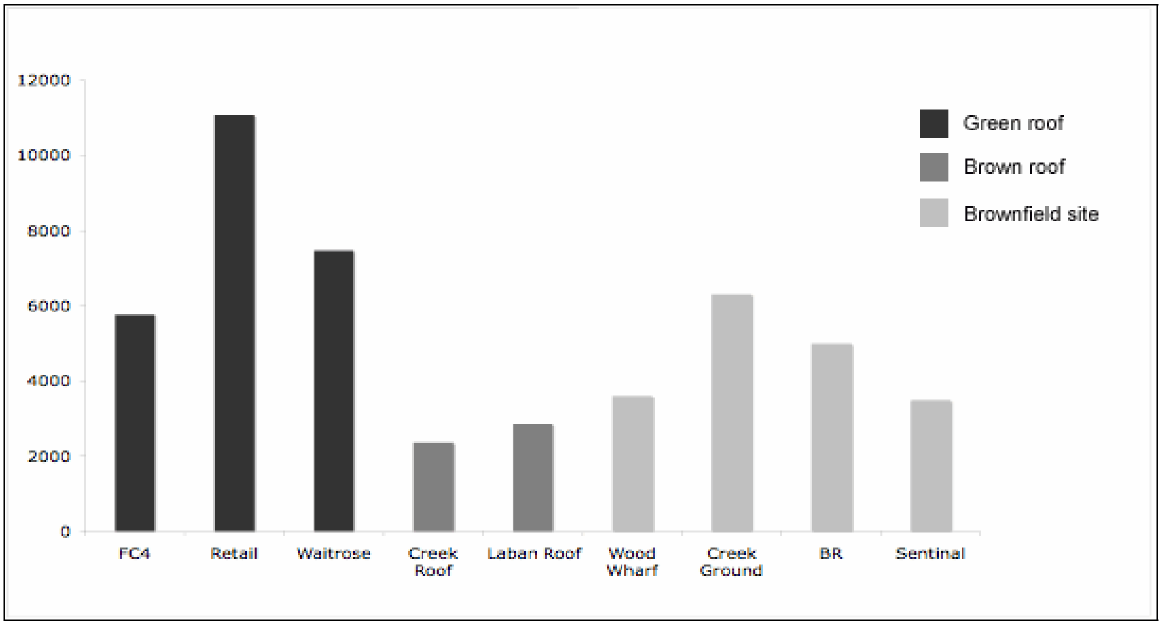

Figure 5: The mean number of invertebrates collected in each trap (2004).

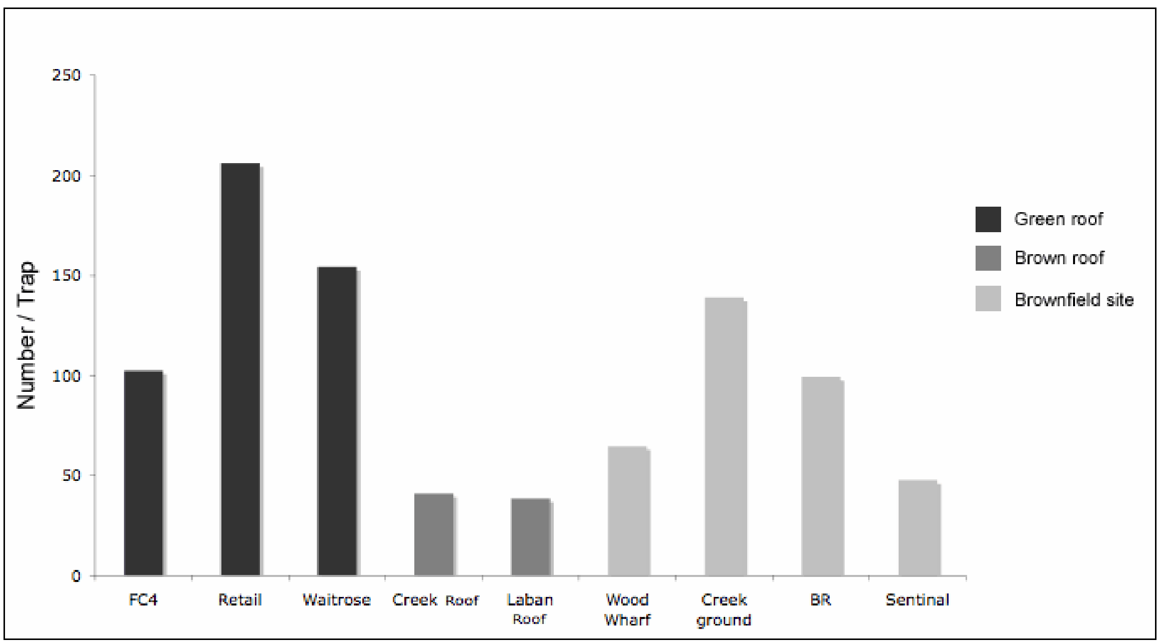

Figure 6: Shannon-Weiner species diversity index of invertebrates in 2004.

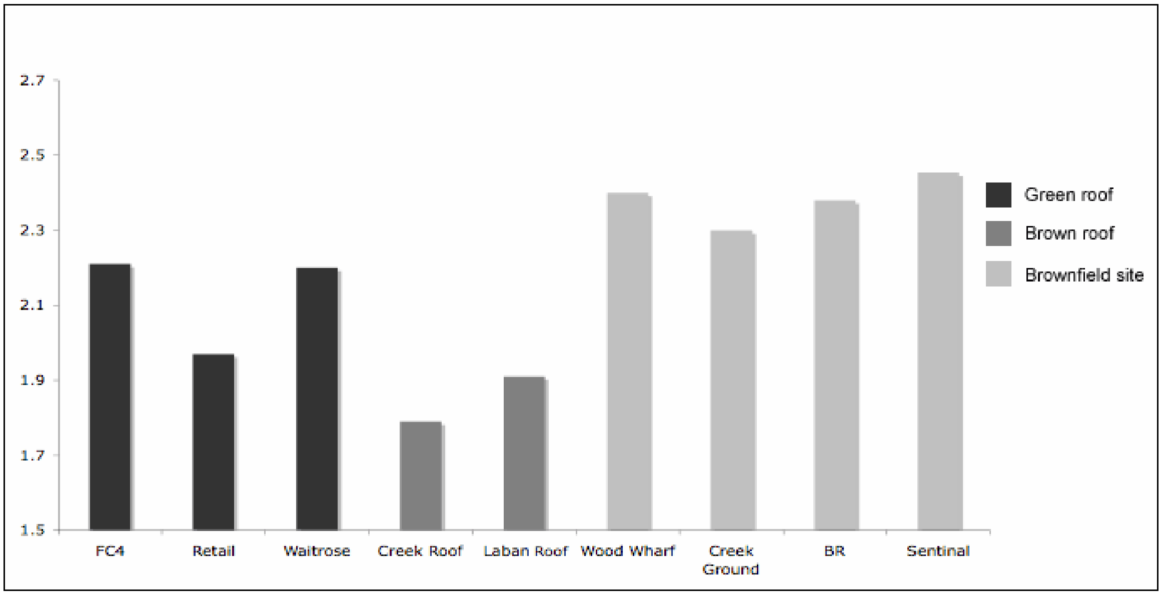

Figure 7: Total number of taxonomic arachnid (Araneae), aculeate Hymenoptera, Coleoptera, and notable species in the sample (2004).

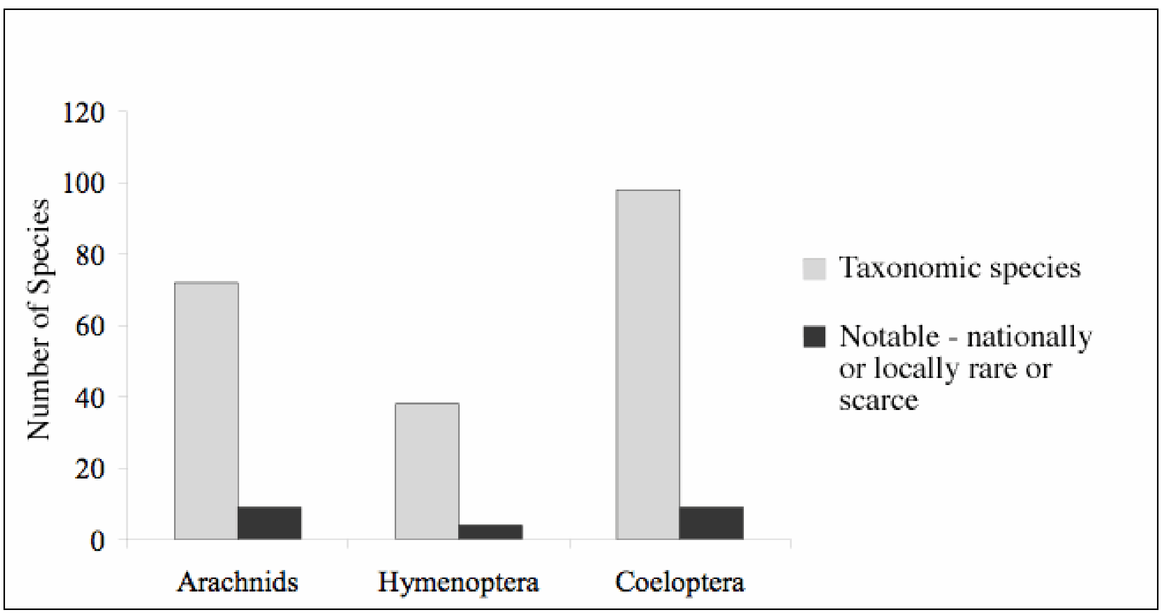

Figure 8: The proportion of species of importance in the 2004 sample for spiders.

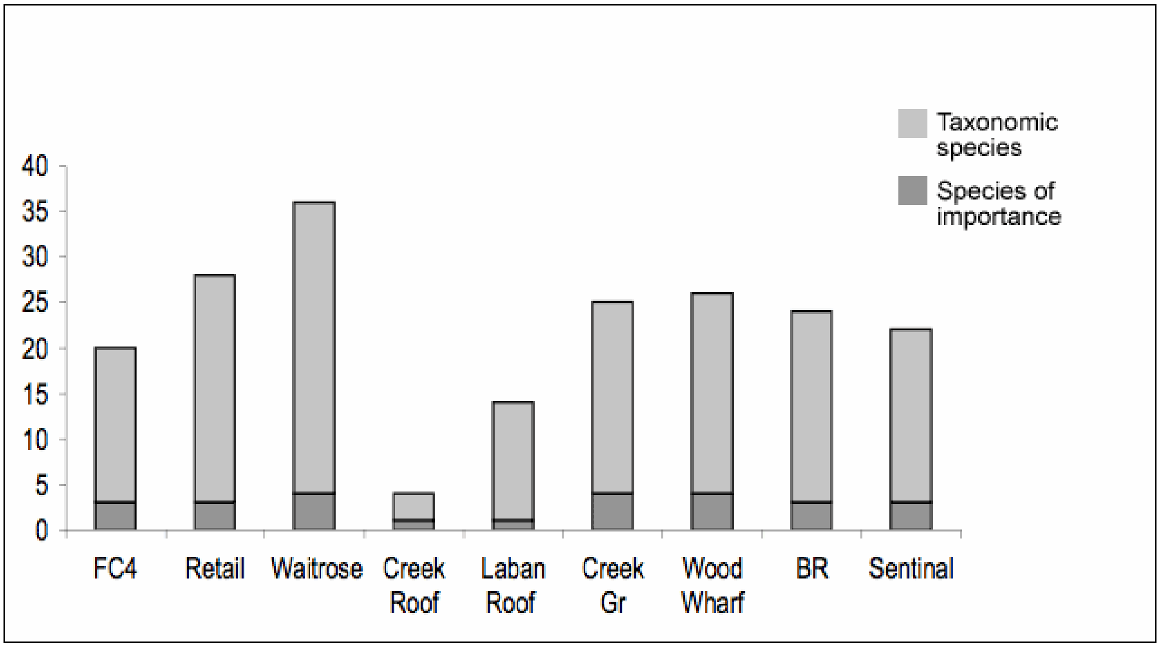

Figure 9: The proportion of species of importance in the 2004 sample for beetles.

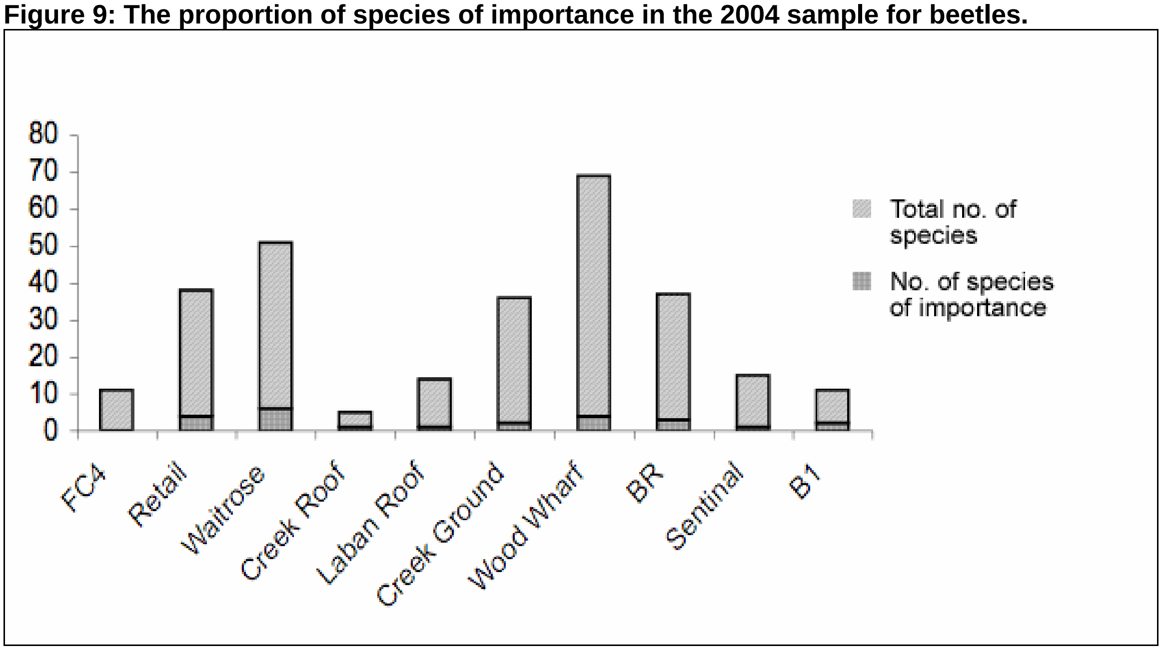

Table 1. Age, elevation, and area of the green and brown/biodiverse roofs in the study, and the age and area of the sample brownfield sites.

Green/Brown Roofs	Age (yrs)	Height (m)	Area of Roof (m2)
Fc4, Canary Wharf: TQ375803	9	66.7	800
Retail, Canary Wharf: TQ376804	6	18	300
Waitrose, Canary Wharf: TQ377803	5	20	600
Creek Roof, TQ376773	3	5	80
Laban Roof, TQ376775	3	25	200
Brownfield Sites			**Area of Sampled Site (m2)**
Creek Ground: TQ375773	3		Approx: 2000
Wood Wharf: TQ381803	Not known		Approx: 5000
Sentinal: TQ377773	4		150
BR (Black Redstart): TQ377777	5		100

Table 2. Invertebrate species list for all samples (2004).

ARACHNIDS—Spiders		
Family	**Species**	**Status (Where status is not indicated, the species is known to be common.)**
Agelenidae	Agelenidae immature	
Lycosidae	Alopecosa puverulenta	
Amaurobiidae	Amaurobious similis	
Araneidae	Araneid immature	
Araneidae	Araneus qudratus	
Linyphiidae	Bathyphantes gracilis	
Salticidae	Bianor aurocintus	**Nationally scarce, notable A**
Clubionidae	Clubiona reclusa	
Dictynidae	Dictyna unicata	
Linyphiidae	DipLocephalus cristatus	
Linyphiidae	Diplostyla concolor	
Gnaphosidae	Drassodes cupreus	Local (only found in a specific [local] region)
Gnaphosidae	Drassodes immature	
Gnaphosidae	Drassodes lapidosus	
Theridiidae	Enoplognatha immature	
Theridiidae	Enoplognatha ovata	
Theridiidae	Enoplognatha thoracica	Local
Linyphiidae	Erigone aletris	**1st record for south England in Canary Wharf**
Linyphiidae	Erigone arctica	**Local 1st record since 1957**
Linyphiidae	Erigone atra	
Linyphiidae	Erigone dentipalpis	
Linyphiidae	Erigone immature	
Salticidae	Euophrys immature	
Salticidae	Euophrys lanigera	Local
Salticidae	Heliophantus flavipes	

Linyphiidae	Lephyphantes imm.	
Linyphiidae	Lepthyphantes leprosus	
Linyphiidae	Lepthyphantes minutus	
Linyphiidae	Lepthyphantes tenuis	
Linyphiidae	Linyphiid immature	
Lycosidae	Lycosidae immature	
Linyphiidae	Meioneta rurestris	
Tetragnathiedae	Meta mengei	
Gnaphosidae	Micaria pulicaria	
Linyphiidae	Micrargus herbigradus	
Linyphiidae	Microlinyphia pusilla	
Linyphiidae	Milleriana inerrans	Local
Theridiidae	Neottiura bimaculata	**Local 1st record for London**
Linyphiidae	Oedothorax apicatus	Local
Linyphiidae	Oedothorax fuscus	
Linyphiidae	Oedothorax immature	
Linyphiidae	Oedothorax retusus	
Linyphiidae	Ostearius melanopygius	**Nationally scarce, notable A**
Tetragnathiedae	Pachygnatha clercki	
Tetragnathiedae	Pachygnatha degeeri	
Lycosidae	Pardosa agrestis	**Nationally scarce, notable B, 1st London record**
Lycosidae	Pardosa agricola	**Local 1st record for London**
Lycosidae	Pardosa amenta	
Lycosidae	Pardosa immature	
Lycosidae	Pardosa monticola	**1st record since 1957**
Lycosidae	Pardosa nigriceps	
Lycosidae	Pardosa palustris	
Lycosidae	Pardosa prativaga	
Lycosidae	Pardosa pullata	
Liocranidae	Phrurolithus festicus	
Linyphiidae	Prinerigone vagans	Unknown
Salticidae	Salticidae	
Salticidae	Salticidea immature	
Salticidae	Salticus scenicus	
Linyphiidae	Silometopus reussi	Local
Agelenidae	Tegenaria domestica	
Agelenidae	Tegenaria duellica	
Agelenidae	Tegenaria gigantea	
Agelenidae	Tegenaria immature	
Agelenidae	Tegenaria sp	
Theridiidae	Theridion melanurum	Synanthropic
Lycosidae	Trochosa ruricola	
Linyphiidae	Troxochrus scabriculus	Local
Thomisidae	Xysticus cristicus	
Thomisidae	Xysticus immature	
Thomisidae	Xysticus kochi	Local
Araneidae	Zilla diodia	**Nationally scarce, notable B**

Zodariidae	Zodarion italicum	**Nationally scarce**
Araneidae	Zygiella x-notata	**1st record for London**
	Harvestman	
COLEOPTERA—Beetles		
Family	**Species**	**Status**
Anobiidae, woodworm beetles	Stegobium paniceum (Lin.)	Local
Anthicidae, "ant" beetles	Anthicus antherinus L.	Local
	Anthicus floralis	Local
Apionidae, Minute weevils	Pseudapion rufirostre (Fab.)	
Byrrhidae, pill beetles	Simplocaria semistriata (Fab.)	
Cantharidae, Soldier beetles	Cantharis lateralis (Lin.)	Local
Carabidae, Ground beetles	Amara aenea DeGeer	
	Amara aulica (Panz.)	
	Amara curta Dej.	**Nationally scarce, notable B**
	Amara eurynota Panz.	**Very local**
	Amara familiaris	Local
	Unidentified Amara species	
	Bembidion guttula Fab.	
	Bembidion quadrimaculatum L.	
	Bembidion tetracolum Say	
	Bradycellus verbasci Duft.	
	Calathus fuscipes Goeze	
	Harpalus affinis Schr.	
	Harpalus rubripes	
	Harpalus tardus Panz.	**Very local**
	Microlestes minutulus	**Very rare**
	Notiophilus biguttatus Fab.	
	Notiophilus rufipes Curt.	
	Notiophilus substriatus Wat.	
	Pterostichus strenuus Panz.	
	Trechus obtusus Erich.	
Cerambycidae, longhorn beetles	Grammoptera ruficornis	
Chrysomelidae, Leaf and flea beetles	Chaetocnema concinna Marsh.	
	Chaetocnema hortensis (Fourc.)	
	Haltica lythri	
	Longitarsus unidentified species 1	
	Longitarsus unidentified species 2	
	Phyllotreta cruciferae	
	Phyllotreta undulata Kuts.	
	Psylliodes chrysocephaha (Lin.)	
	Sphaeroderma testaceum Fab.	
Coccinellidae, Ladybirds	Adalia bipunctata (Lin.)	
	Coccinella 7-punctata Lin.	
	Exochomus 4-pustulatus (Lin.)	

	Hippodamia variegata (Goeze)	**Nationally scarce, notable B**
	Micraspis 16-punctata (Lin.)	
	Propylea 14-punctata (Lin.)	
	Psyllobora 22-punctata (Lin.)	
	Rhyzobius litura (Fab.)	
	Scymnus species	
	Unidentified ladybird larvae	
Curculionidae, Weevils	Anthonomus rubi (Herbst)	
	Barypeithes pellucidus (Boh.)	
	Ceutorhynchus floralis (Payk.)	
	Ceutorhynchus quadridens (Pz.)	
	Gymnetron pascuorum Gyll.	
	Hypera postica (Gyll.)	
	Phyllobius maculicornis	
	Phytobius quadrituberculatus	Local
	Sitona hispidulus (Fab.)	
	Sitona lineatus	
	Sitona puncticollis (Steph.)	
	Trichosirocalus troglodytes (Fab.)	
Dermestidae, Hide & larder beetles	Anthrenus verbasci (Lin.)	
Elateridae, Click beetles	Athous campyloides Newm.	**Nationally scarce, notable B**
	Agriotes sputator (Lin.)	
Hydrophilidae, water beetles	Cercyon species	
	Megasternum obscurum Marsh.	
	Lagriidae Lagria hirta (Lin.)	
Lathridiidae Corticaria species	Enicmus transversus (Ol.)	
Leiodidae, fungus beetles	Lyocyrtusa vittata	**Very local**
Mordellidae, Flower beetles	Mordellistena pumila (Gyll.)	
Nitidulidae, Pollen beetles	Epuraea species	
	Meligethes species	
	Meligethes aeneus (Fab.)	
Oedemeridae, Flower beetles	Nacerdes melanura (Lin.)	**Very local**
	Oedemera lurida (Marsh.)	
	Oedemera nobilis	Local
Phalacridae, smut beetles	Olibrus species	
	Olibrus flavicornis (Sturm)	**RDB-K**
Scrabaeidae, dung beetles	Aphodius equestris (Panz.)	**Very local**
Staphylinidae, Rove beetles	Aleochara species	
	Aleocharinae unidentified species	
	Unidentified rove beetle	
	Ocypus olens	
	Othius laeviusculus Steph.	Local
	Oxytelus innustus	Local
	Oxytelus rugosus	
	Quedius boops Grav.	

	Quedius molochinus (Grav.)	
	Stenus aceris Steph.	Local
	Stenus pallipes	Local
	Stilicus orbiculatus	Local
	Tachinus marginellus	Local
	Tachyporus chrysomelinus (Lin.)	
	Tachyporus hypnorum (Fab.)	
	Tachyporus nitidulus (Fab.)	
	Xantholinus linearis Ol.	
Throscidae, small click beetles	Trixagus carinifrons (de Bonv.)	Local
	Trixagus dermestoides (Lin.)	
Forficulidae, Earwigs	Forficula auricularia L.	
Anthocoridae, flower bugs	Orius minutus (L.)	
	Unidentified species	
Cercopidae, froghoppers	Philaenus spumarius	
Cicadellidae, leafhoppers	Aphrodes bicinctus (Schr.)	
Coreidae, Leaf bugs	Bathysolen nubilis	**Nationally scarce, notable B**
	Coreus marginatus (Lin.)	
	Coriomeris denticulatus (Scop.)	Local
Cydnidae, shieldbugs	Legnotus limbatus (Geoff.)	Local
Lygaeidae, ground bugs	Kleidocerys resedae (Panz.)	
	Scolopostethus species	
	Unidentified lygaeid	
	Unidentified lygaeid species 2	
	Unidentified lygaeid species 3	
	Unidentified lygaeid species 4	
Miridae, leaf bugs	Chlamydatus evanescens Boh.	**RDB3**
	Chlamydatus pullus (Reut.)	
	Chlamydatus saltitans (Fall.)	Local
	Nysius species	
	Unidentified mirid	
Nabidae, damsel bugs	Nabis nymph	
Pentatomidae, Shield bugs	Dolycoris baccarum (Lin.)	Local
	Eurydema oleracaea (Lin.)	
	Podops inuncta (Fab.)	Local
Armadillidiidae, pill woodlice	Armadillidium vulgare (Latr.)	
Unidentified	Unidentified species	
Unidentified	Unidentified lacewing larva	
Unidentified	Unidentified microlepidopteron	
Unidentified	Unidentified species	
ACULEATE HYMENOPTERA—Bees, wasps, and ants: insects with marked "waist" (defined region between the thorax (chest-plate) and the abdomen (belly)).		
Family	**Species**	**Status**
Apoidea	Andrea bicolour	**Locally scarce**
Apoidea	Andrea flavipes	
Apoidea	Andrea fulva	

Apoidea	Andrea minutula	
Apoidea	Andrena nigroaena	
Apoidea	Andrea scotica	**Introduced species**
Apoidea	Andrea trimmerana	
Apoidea	Apis mellifera	**Nationally scarce, notable B**
Pompilidae	Auplopus carbonarius	
Apoidea	Bombus lapidarius	**Nationally scarce, notable B**
Apoidea	Bombus lucorum	
Apoidea	Bombus (Psithyrus) sylvestris	
Apoidea	Bombus terrestris	
Pompilidae	Caliadurgus fasciatellus	
Sphecidae	Ectemnius secinctus	
Formicoidea	Lasius flavus	**Nationally scarce, notable B**
Formicoidea	Lasius mixtus	
Formicoidea	Lasius niger	
Formicoidea	Lasius umbratus	
Apoidea	Lasioglossum calceatum	
Apoidea	Lasioglossum lativentre	
Apoidea	Lasioglossum leucopus	**Locally rare**
Apoidea	Lasioglossum leucozonium	
Apoidea	Lasioglossum minutissimum	
Apoidea	Lasioglossum morio	
Apoidea	Lasioglossum smeathmanellum	
Apoidea	Lasioglossum villosulum	
Apoidea	Megachile centuncularis	
Formicoidea	Myrmica scabrinodis	
Formicoidea	Myrmica rubra	
Apoidea	Nomada fabriciana	
	Parasitica indet	
Cimbicidae	Sawfly indet	
Sphecoidea	Psen dahlboni	
Vespoidea	Trypoxylon attenuatum	
Vespoidea	Vespula gernanica	
Vespoidea	Vespula vulgaris	
HEMIPTERA—Land bugs: These insects have a beak or rostrum for sucking plant or animal juices. Their forewings, when present, are horny with a membranous tip.		
HETEROPTERA (Sub-order)		
Family	**Species**	**Status**
Miridae	Chlamydatus evanescens	**Nationally rare**
Miridae	Chalamydatus saltitan	
Miridae	Chalamydatus pullus	
Lygaeidae	Cymus glandicolor	
Pentatomidae	Eysarcoris fabricii	
Lygaeidae	Nysius senecionis	**Very local**
Lygaeidae	Nysius sp	
Lygaeidae	Scolopostethus sp	
Pentatomidae	Syromastus rhombeus	**Very local**

Lygaeidae	Lygaeid nymphs	
Miridae	Unidentified	
HOMOPTERA (Sub-order)		
Homoptera	Unident leafhopper	
	unident springtail	
DIPTERA—True flies: insects with only one pair of wings, the hind pair of wings reduced to pin-shaped halters.		
Family	**Species**	**Status**
Diptera	Sphaerophoria rueppllellii	
Diptera	Syritta pipiens	
Syrphidae	Hoverfly larva	
ORTHOPTERA—Crickets and grasshoppers: stout-bodied insects with an enlarged saddle-shaped pronotum (first chest-segment). Their hind leg is usually long, modified for jumping.		
Family	**Species**	**Status**
Tettigoniidae	Pholidoptera griesoaptera	
Acrididae	Chorthippus parallelus	