SERBD-International Journal of Multidisciplinary Sciences
ISSN (Online): xxxx-xxxx
Volume 01 Issue 01, Apr- June, 2018

GREEN ROOFS SUPPORT A WIDE DIVERSITY OF COLLEMBOLA IN URBAN GRASSLAND AREA OF FIROZABAD

Dr. Madhu Mehra*
Entomological Research Laboratory, Department of Zoology,
M.G. Balika (P.G.) College, Firozabad, U.P., India
drmadhu.mehra@gmail.com

Abstract: This work was conducted to detect changes in feeding habits of spring tails, related to their ecological niche in the ecosystem. *Green roofs stone crop (Sedum pachyphyllum)* rooftops of buildings. *Loss in urban areas by supporting plant and animal communities. To determine whether green roofs can support collembolan biodiversity, we collected pitfall samples from March – May-2014 on two extensive and two intensive green roofs in urban area (grassland), Firozabad. Most dominant (Twenty mororphospecies) were found across the roofs, indicating that green roofs support a diversity of collembolan taxa. The intensive roofs (which are so named as they require more intensive care), per Getter Rowe (2006) though roofs type may not be the most significant factor affecting collembolan biodiversity. Each of the four green roofs possessed a different set of top three abundant collembolan taxa. Green roofs support moderate collembola diversity, preserving natural habitat is important to maintain species richness.*

Keywords: ***Collembola diversity, Green roofs, Habitat loss***

INTRODUCTION

Collembola represent one of the most abundant groups in soils, where they play an important ecological role. One of their main contributions to the soils is the regulation of fungal populations [Warnock et al, 1982], affecting their dispersion, and also that of bacteria, to colonize new substrata. Due to the remarkable affinity of springtails with edaphic habitats, they can be found in a great variety of ecological habitats and can be associated with several organisms such as fungi and epiphytic plants [Palacios-Vargas and Gomez-Anaya 1994]. In natural environments, collembola feed on a great variety of resources, such as fungi, bacteria, mosses, pollen grains, spores, decaying plants and debris [Mc Millan and Healey 1971]. Some authors have studied the food preferences, finding that they can vary depending on the season and on the vertical distribution of the springtail species. Green roofs are intentional, artificial constructions on the roofs of buildings. Green roofs consist of a waterproof membrane, drainage layer, a filter membrane, growing medium, and vegetation successively layered on top of a typical building rooftop. They are usually vegetated, having originated from roof gardens. There are two main roof types, which are divided by depth of the substrate and thus the identity of the vegetation. Extensive roofs typically have a shallow substrate layer and feature succulent plants of the genus *Sedum pachyphyllum [*and so may be called *Sedum* roofs].

Intensive roofs [which are so named as they require more intensive care], typically have more herbaceous vegetation [and so many be called herbaceous roofs], potentially including shrubs and trees, and thus require a substrate deeper than 20 cm. While there are many reasons for constructing green roofs, they are typically economic in nature.

Collembola are primarily soil- dwelling arthropods that are considered to be a sister group to insects, but are not part of class insect. They are morphologically distinguished from other arthropods by the presence of a collophore [a tube like structure that protrudes from their first abdominal segment and is likely used for gas- exchange purpose]. Often, they also possess a furcula which they can use as springing mechanism, and this gives rise to their common name springtails. Like most soil dwelling arthropods, they are more often found in moist environments as opposed to dry ones, as most collembola easily desiccate, though some collembola species have adapted to dry environments.

As collembola are typically detritivores, they consume decaying vegetation but also fungi, and can contribute to soil-formation processes. They can also be found in grassy areas, in trees, or even in intertidal zones. They are often preyed upon by carnivorous arthropods organisms such as spiders, mites, centipedes, and ground beetles.

This study was conducted to determine overall collembola biodiversity on four representative green roofs [two herbaceous, two sedum] in the urban core of the Firozabad, Bandipur area. The study was framed as an inquiry in to three major points; 1- what is the biodiversity of collembola on the green roofs; 2- do both herbaceous and *Sedum* green roofs provide habitat for collembola; 3- if so, do they promote similar or different species. To test these principles, we analyzed total numbers and abundance of morphospecies on the roofs over a three month time period.

. Figure 1: ***Morphospecies of Collembola***

MATERIALS AND METHODS

Sampling and Collection Pitfall traps were placed on four urban green roofs in the area and sampled every two weeks between 9 March 2014 and 26 May 2014, for area's names, locations, and sample dates. Nine traps were placed on each roof in a permanent position in an equidistant rectangular pattern.

Traps were filled to two thirds capacity with 10% acetic acid [vinegar] to preserve the caught specimens. Vinegar was used because of its relatively low volatility, non – toxic effects for vertebrates such as birds that visit the green roofs [personal observation], and for cost considerations as well.

The contents from all ten pitfall traps on a roof were aggregated in to one sample from the roof per date. We observed that the vinegar discolored some specimens [collembola and spiders] and may have deteriorated their physical structure as well, so in the lab contents of the sample were transferred from 10% acetic acid to 80% ethanol for longer term preservation. This was accomplished by straining the samples over a coffee filter until the acetic acid dripped away; then, the coffee filter and its contents were immersed in 80% ethanol.

Para taxonomy and identification Samples were first broadly sorted in to groups of beetles, spiders, and a group of all other specimens with the use of a dissecting microscope at magnifications between 6.3 x- 12.0 x magnifications. After wards, collembola were extracted from the 'other' specimen category primarily by pipette, or, in the case of the more robust individuals, carefully picked out by forceps, again under a dissecting microscope, with magnification up to 30.0 x. Care was taken to ensure this separation of collembola was comprehensive, and that all visible collembola were separated out.

Collembola were grouped in to distinct morphospecies, an acceptable substitute for when identifying to species is not feasible [Oliver & Beattie, 1996]. We were able to classify some collembola as belonging to order Symphypleona. Morphospecies counts of greater than 20 individuals were estimated.

Statistical Analysis Species richness were calculated to quantitatively compare collembola diversity between different roof sites. The similarity was used to determine which roofs hosted the most similar community compositions.

RESULTS AND DISCUSSION

In total, 1820 individuals in 20 morphospecies of collembola were observed between March 9 and June 26. Some morphospecies were observed at each collection date, while others varied in how frequently they were observed. **The most species rich roof. AKH, supported 18 morphospecies, only 9** of them were observed on three or more collection dates.

We do not have data from April- 13 on roof BDP due to bird disturbances of the pit fall traps, Additionally, the March 9 data on roof ALK is an outlier – only three individuals total were observed significantly fewer than any other sample. Because we cannot accurately predict the morphospecies totals and abundances for the two dates, we have not attempted to interpolate these values.

Morphospecies Results Number morphospecies had a variable trend based on whether the roofs were herbaceous] AKH and ALK] or Sedum [BRM and BDP]. Herbaceous morphospecies richness decreased over the course of the season, while the Sedum roofs increased in diversity until mid April, then decreased. On both sets of roofs, morphospecies number declined by the end of May.

AKH had the greatest number of morphospecies observed across the six collection dates [18 morphospecies] and ALK had the fewest (11). See Table- 1 for complete classification.

Table 1: ***Total morphospecies richness observed over the season on each roof***

Roof	**AKH**	**ALK**	**BRM**	**BDP**	**Herbaceous**	**Sedum**
MSR	18	11	13	14	18	19

Note: MSR = Morphospecies richness; AKH =Akilabad Hasanpur; ALK= Alampur Kotla; BRM = Baramai; BDP= Bandipur

The two herbaceous roofs (AKH and ALK) hosted a combined 18 morphospecies [missing morphospecies 8 and 14], while the two sedum roofs [BRM and BDP] hosted a combined 19 [missing morphospecies 7]. Notably, one morphospecies, morphospecies 14, was only observed on BDP, where it was observed on three different collection dates. All other morphospecies were observed at least once on two or more roofs.

Each roofs was dominated by a different morphospecies that accounted for between 36% [morphospecies 21, AKH] and 67% [morphospecies 12, BDP] of the total individuals counted. For both Sedum roofs, one morphospecies accounted for over half of the total individuals [morphospecies 12, BDP; morphospecies 9, BRM], while this was not observed in herbaceous roofs. In all cases, individuals of one or two morphospecies constituted over half the observed total.

Table 2: Detailed information on each green roofs data of water and soil analysis

Green roof name	**Abbreviation**	**Collection date-1**	**Collection date-2**	**Collection date-3**	**Collection date-4**	**Collection date-5**	**Collection date-6**
Akilabad Hanspur	AKH	9 March 2014	23 March 2014	09 April 2014	21 May 2014	04 May 2014	18 May 2014
Alampur Kotla	ALK	16 March 2014	30 March 2014	15 April 2014	29 April 2014	11 May 2014	25 May 2014
Baramai	BRM	10 March 2014	24 March 2014	08 April 2014	22 April 2014	04 May 2014	19 May 2014
Bandipur	BDP	16 March 2014	30 March 2014	No sample collected	28 April 2014	12 May 2014	26 May 2014

An interesting result emerged, however, when collembola morphospecies of order Symphypleona were grouped. Table 2- demonstrates that collembola of the order Symphypleona were present in a significantly larger proportion on the Sedum roof BDP than the other three green roofs. Watering data available from the roofs as an explanatory variable is listed well.

Table 3: ***Proportion of individuals belonging to the order Symphypleona across the season:-***

Roofs	**% Symphypleona**	**Is the roof watered?**
AKH	6.57	No
ALK	12.9	Yes
BRM	1.23	Yes
BDP	90.9	Occasionally by hand.

Abundance Results The roofs with herbaceous vegetation supported a higher number of collembola than the Sedum, both individually and when pooled [Table 3].

Table 4: Total number of collembola over the season on each roof

Roof	***AKH***	***ALK***	***BRM***	***BDP***	***Herbaceous***	***Sedum***
Count	568	301	220	928	870	950

SERBD-International Journal of Multidisciplinary Sciences
ISSN (Online): xxxx-xxxx
Volume 01 Issue 01, Apr- June, 2018

Collembola abundance oven the season showed an interesting trend when comparing the two herbaceous roofs to each other, as well as the two Sedum roofs. Patterns over time mirrored each other separately on herbaceous and Sedum roofs.

Table 5: Twenty Morphospecies of Collembola Observed With Biotopes-

S.No.	Species	Biotopes
1	*Hypogastrura essa*	AS
2	*Ceratophysella gibbosa*	BA
3	*Xenylla grisea*	AS
4	*Xenylla christianseni*	BA
5	*Xenylla welchi*	BA
6	*Microgastrura minutisima*	BP
7	*Superodontella cornifer*	BB, BP
8	*Superodontella shasta*	BA
9	*Brachystomella arida*	BP
10	*Mesaphorura yosii*	AS
11	*Proisotoma minuta*	AS
12	*Ballistura laticauda*	AS
13	*Cryptopygus thermophilus*	AS
14	*Cryptopygus benhami*	AS
15	*Isotomurus bimus*	AS
16	*Entomobrya ligata*	AS
17	*Entomobrya triangularis*	AS
18	*Pseudosinella octopunctata*	E
19	*Seira purpurea*	E
20	*Ptenothrix marmorata*	E

Where Noted:_AS= Agricultural soil; BA= Basiodiocarps of Amanita sp; BB= Basidiocarps of Boletus sp; BP= Basidiocarps of Polyporus sp; E = Epiphytic plants.

Among the studied species, in which we were able to identify the gut contents, in 52% of them there was recognizable plant organic matter; in 39% there were fungal conidia and spores, and only in 9% animal remains were found, mainly mites and springtails.

Figure2 : Samples collection sites images

Our study is the first to examine collembola biodiversity on both intensive and extensive green roofs in the same grassland area. The total morphospecies diversity on the intensive and extensive roofs, and then to compare the two in order to determine whether one roof type provided a better habitat than the other. All four roofs support collembola biodiversity, but not equally so. The herbaceous roof AKH supported both most morphospecies and number of individuals. Interestingly, roofs type does not seem to play the hypothesied critical role in grouping which morphospecies are observed: the two Sedum roofs have the least similar species composition, and the most similar compositions belong to an herbaceous and Sedum roofs than it was to the other herbaceous roofs ALK. This suggests that the binary system of characterizing green roofs by vegetation may be two simplistic when explaining roof biodiversity.

Three of our roofs were were nominally watered, while this was found a logarithmic trend of collembolan abundance on extensive green roofs compared to substrate water content, with a threshold level of 5% below which abundance quickly decreased, and roof watering likely contributes to keeping moisture above the threshold value allowing higher collembolan diversity.

Species specific differences in substrate water content are likely to manifest themselves with a closer analysis of substrate moisture found that, in urban fields, Sminthurinus species were successful in emerging after they re-watered soils that had undergone an experimental four month drought.

More broadly, they found various Symphypleona but no individuals from either Entomobryomorpha or Poduromorpha.

Symphypleona on every roof but BDP, were they comprised 91% of the population. Roof watering is not likely to be the sole explanatory variable for our observed dramatic difference in Symphypleona proportion, but substrate moisture may be.

The total collembolan abundances follow an interesting seasonal pattern. The herbaceous roofs share a similar pattern increasing and decreasing abundances. Why the roofs follow such a similar trend is still unexplained, though it likely relates to soil moisture and perhaps temperature as well. While we did not have temperature or substrate moisture data, Sedum roofs may warm faster than herbaceous roofs do, ending dormancy in the over-wintered egg population and thus starting the collembolan life cycle, resulting in more observed individuals sooner in the season.

Our results suggest that when green roofs are constructed with sterilized soil so no collembolan or other micro arthropods are present, they may prove suitable as small scale, easily monitor able models, for grassland areas, where small initial population sizes and limited dispersal area means that random fluctuations are important drivers for selection of which species can become dominant. As artificial, locally homogenous and accessible habitats, they may prove to be ecologically relevant model systems.

CONCLUSION

Different green roofs support different collembolan assemblages. Each roof had a unique most dominant set of morphospecies, and while herbaceous roofs support a higher biodiversity of collembolan, Sedum roofs host more morphospecies. Thus, the binary system of classifying roofs as Sedum or herbaceous may be inadequate for accurate determining the biodiversity of animals on these roofs. Further, our data suggests that green roofs collembolan do not follow a succession pattern, and that instead, early conditions and random chance provide the makeup of what species are observed.

If roofs are established with sterilized soil and vegetation, they may prove useful as models for mainland grassland colonization processes.

ACKNOWLEDGEMENT

It gives we are very much gratitudes to " Mr. D.N. Sharma" Mandal Sachiv, of Distrist, Firozabad, and I would like to thank "Mr. Anil Upadhyay" chief secratory of M.G. Balika [P.G.] College ,Firozabad; for providing facilities to conduct water & soil analysis and for consulting library. And I would like to thank my parents [Shr. Dhan Singh Mehra & Smt. Govindi Devi Mehra] their support in my during research period and help in execution of study the field work.

REFERENCES

[1] Alvarez, T., Frampton, G.K. & Goulson, D. (1999). The effects of drought upon epigeal collembola from arable soils. Agricultural and Forest Entomology, 1,243-248.

[2] Angold, P.G., Sadler, J.P., Hill, M.O., Pullin, A., Rushton, s., AUSTIN, K., Thompson, K.(2005.) Biodiversity in urban habitat patches. Science of the Total Environment, 360(1-3), 196-204.

[3] Braaker, S., Ghazoul, Obrist, M.K., & Moretti, M. (2014). Habitat connectivity shapes urban arthropod communities: the key role of green roofs. Ecology, 95(4), 1010-1021

[4] Kadas, G. (2006). Rare Invertebrates Colonizing Green Roofs in London. Urban Habitats, 4(1), 66-86.

[5] Elnitsky, M.A., Benoit, J.B., Denlinger, D.L.,& Lee, R. E. (2008). Desication tolerance and drought acclimation in the Antarctic collembolan Cryptopygus antarcticus. Journal of Insect Physiology, 54(10-11), 1432-1439.

[6] Francis, R. A., & Lorimer, J. (2011). Urban reconciliation ecology: The potential of living roofs and walls. Journal of Environmental Management.

[7] Greenslade, P.J.A. Simpson & CH. A. Grgurinovic.(2002). Collembola associated with fungal fruit bodies in Australia. Pedobiologia 46: 345-352.

[8] Gedge, D., & Kadas, G. (2005). Green roofs and biodiversity. Biologist, 52(3), 161-169.

[9] Getter, K. L., & Rowe, D. B. (2006). The role of extensive green roofs in sustainable development. Hort. Science, 41(5), 1276-1285.

[10] Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. Science (New York,), 319 (February), 756-760.

[11] Liu., K. (2004). Engineering Performance of Rooftop Gardens through Field Evaluation. Journal of Roof Consultants Institute, 2, 4-12.

[12] Lundholm, J. T., & Richardson, P. J.(2010). Habitat analogues for reconciliation ecology in urban and industrial environments. Journal of Applied Ecology. 1365-2664.

[13] Maclvor, J. S., & Lundholm, J. (2011). Insect species composition and diversity on intensive green roofs and adjacent level ground habitats. Urban Ecosystems, 14(2), 225-241.

[14] Mc Millen, J.H. & I.N. Healey,1971. A Quantitative technique for the analysis of gut content of collembola. Revue d' Ecologie et de biologie du sol 8: 295-300.

[15] Madre, F., Vergnes, A., Machon, N., & Clergeau, P. (2013). A comparison of 3 types of green roofs as habitat for arthropods. Ecological Engineering, 57, 109-117.

[16] McKinney. M. L. (2002). Urbanization, Biodiversity, and Conservation. Bioscience.1641/0006-3568 (2002).

[17] McKinney, M. L. (2008). Effects of urbanization on species richness: A review of plants and animals, Urban Ecosystems, 11(2), 161-176.

[18] Madhu Mehra & P.P.Grover (2017). The study of population diversity of collembola in Firozabad regions ..Deptt of zoology (ENT. Res. Lab.), M.G.Balika (P.G.) College, Firozabad (U.P.), Proc. Zool. Soc. India 16(1): 77-79.

[19] Oberndorfer , E., Lundholm, J., Bass, B., Coffman, R.R., Doshi, H., Dunnett, N., Rowe, B.(2007). Green Roofs as Urban Ecosystems: Structures, Functions, and Services.Bioscience. 1641/B571005.

[20] Oliver, I., & Beattie, A. J. (1996). Invertebrate morphospecies as surrogates for species: a case study. Conservation Biology, 10(1), 99-109.

[21] Palacios Vargas, J.G. & J.A.Gomez Anaya- 1994. Lista actualizada de colembolos miceto filos de Mexico [Hexapoda: Entognatha]. Folia Entomologica Mexicana. 92: 21-30.

[22] Rosenzweig, M. L. (2003). Win-Win Ecology: How the Earth's Species can survive in the Midst of Human Enterprise. Oxford University Press, USA.

[23] R.K. Verma, Madhu Mehra (2010). Collembolan community influenced by Abiotic factors in Nacot village area of Uttrakhand state (District- Pithoragarh), Ent. Research Lab. Deptt. Of Zoology, R.B.S. College Agra, 282003. Ind. Res. Comm. Vol.(2): 169-170.

[24] Rumble, H., & Gange, A. C. (2013). Soil micro arthropod community dynamics in extensive green roofs, Ecological Engineering, 57, 197-204.

[25] Schindler, B. Y., Griffith, A. B., & Jones, K. N. (2011). Factors Influencing Arthropod Diversity on Green Roofs Factors Influencing Arthropod Diversity on Green Roofs, 4(1).

[26] Schrader, S., & Boning, M. (2006). Soil formation on green roofs and its contribution to urban biodiversity with emphasis on Collembolans. Pedobiologia, 50(4), 347-356.

[27] Verhoef, H. A., & Van Selm, A. J. (1983). Distribution and population dynamics of Collembola in relation to soil moisture. Holarctic Ecology, 6,387-394.

[28] Warnock, A.J., A.H. Fitter & M.B. Usher. 1982. The influence of a springtail, Folsomia candida [Insecta, Collembola], on the mycorrhizal association of leek, Allium porum, and the vesicular- Arbuscular mycorrhizal endophyte, Glomus fasciculatus. New phytologist 90: 285-292.

[29] Ward, D. F., New, T. R., & Yen, A.L. (2001). Effects of pitfall trap spacing on the abundance, richness and composition of invertebrate catches. Journal of Insect Conservation, 5(1999), 47-53.

[30] Williams, N.S.G.,Lundholm, J., & Scott Maclvor, J. (2014). Do green roofs help urban biodiversity conservation? Journal of Applied Ecology, 51(6), 1643-1649.