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Arthropod Communities in Different Agroforesty Landscapes

Muhammad Naeem*, Stephen G. Compton and Hamidullah Shah
Department of Entomology, PMAS–Arid Agriculture University, Murree Road, Rawalpindi, Pakistan (MN),
Department of Biology, University of Leeds, Leeds, United Kingdom (SGC), and
Department of Agricultural Chemistry, NWFP Agricultural University, Peshawar (HS)

Abstract. The responses of arthropod communities to an agroforestry landscape was studied at the Leeds University Field Station (Bramham), in northern England. The experimental design consisted of tree rows (containing four species of furniture timber trees, hazel bushes and grass alleys between the tree rows), forestry plots (comprising three species of timber trees and hazel bushes) and natural woodlots (consisting of mostly pine and beech trees). Forty tree sparrow nest-boxes with guards were constructed to study the structure of this model community. The material used for nest construction was determined based on a used tree sparrow nest obtained from a hedge at the field station. Numbers of arthropods found in tree rows were significantly higher compared to both the forest plots and woodlots. Similarly, the number of green lacewings, flies and beetles were all significantly higher in the tree rows than the forestry plots and woodlots. However, no significant difference between the varying resources of artificial nesting materials was found in total fauna. The common earwigs, *Forficula auricularia* were attacked by a tachinid fly, *Triarthria. setipennis.* The rate of parasitism was 43%. This tachinid fly was further parasitised by two hymenopteran, the pteromalids, *Dibrachys. cavus and D. boarmiae*. There were no significant differences observed between the brood sizes of the tachinid hyperparasitoids.

Keywords: Tree-sparrow, parasitism, artificial bird nest materials, silvoarable agroforestry system.

INTRODUCTION

Arthropods constitute a significant portion of Earth's biodiversity and play a number of important ecological functions (Wilson, 1987). They live in widely and diversified micro-habitat and niches, and are ecologically more important than any other group of animals. The arthropod communities associated with bird nests have not been studies previously in the past, but they have the advantage of being distinct, simple structures which are easily manipulated (Kitching, 2001). The natural microcosms are often embedded in a hierarchical spatial structure, which ideally enables to test the meta-community theory (Diane *et al*., 2004). They have major advantages into support further complex, species-rich faunas at UK latitudes (comprising tens of species of phytophages, detritivores, predators, parasitoids and sheltering species), and contain a wide range of resources for arthropods (including vegetation, feathers, fur/hair, wool, faeces, dead chicks and so on) that can be readily presented in the form of simple nest mimics (Robinson, 1988). Nesting material provides habitat for many invertebrates including some domestic pests and arthropods of medical importance, so far some may crawl or fly directly to reach them (Phillips, 1977). Arthropods such as fleas, lice and mites are to be considered the most frequently investigated avian symbiotes (Figuerola, 2000; Rendell and Verbeek, 1996). Feathers are considered to be important material for the insulation of nests of many small birds, particularly in temperate latitudes (Collias and Collias, 1984; Moller, 1984).

Lacewings are observed in a wide variety of different habitats, woodland, modern pine plantation, farmland, gardens, vegetated mountain slopes and overwintering in natural sites (such as leaf litter, barns, or unheated parts of buildings (Canard and Principi, 1984). Species abundance, richness and composition of spider assemblages are greatly influenced by vegetation density (Hatley and MacMahon, 1980; Gunnarsson, 1990). Spiders have been considered as a potential priority group for the assessment of ecological disturbance because they are more abundance, diverse and sensitive to relatively small changes in habitat structure (Turnbull, 1973; Uetz, 1991; Wise, 1993). The European earwig, *Forficula auricularia* L. is native

* Corresponding author: naeem18ap@yahoo.co.uk
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to Europe, and it reaches to high population densities, it can become a major pest in gardens and a perpetual nuisance in households. Earwigs are omnivorous which feed all types of plant material as well as arthropod prey (Solomon *et al.,* 2000). They are capable of suppressing outbreak of pest species, such as pear psyllids and apple aphids (Moerkens *et al.,* 2009). Two species of the Diptera belong to family Tachinidae are the most important parasitoids of the earwig in central Europe: the dominant earwig parasitoids, *Triarthria setipennis* (Fallen), and the less abundant *Ocytata pallipes* (Fallen) (Kuhlmann, 1995). *T. setipennis* is an oviparous species, which lay relatively few eggs from which maggots hatch immediately after oviposition (Herting, 1960).

The objectives of this study were to determine the impact of resource composition and quantity on the structure of this model community. Particularly the factors involved in the arthropod trophic group that are least understood are discussed. Firstly, an experiment was performed to test the influence of different habitat on arthropods and secondly, to quantify the arthropod fauna from the different nesting materials, and a link to specific resources describing who eats what? and who needs whom?

MATERIALS AND METHODS

The field work for this study was carried out at the Leeds University Farm at Bramham, which is situated on the Leeds-York Road (A64) about 12 miles east of Leeds. The study site is an area including natural woodlots (mostly pine and beech trees), and a silvoarable agroforestry system. In 1987, a intercropping with agroforestry system was established at the site consisting of agroforestry and a forestry plots. Each agroforestry consists of tree rows (production hedges), which are separated by arable alleys (Fig. 1). The tree rows evenly spaced at 14m apart, each contain four species of high quality timber trees, ash (*Fraxinus excelsior* L.), cherry (*Prunus* sp.), sycamore (*Acer pseudoplatanus* L.) and walnut (*Juglans regia* L.). Each tree row further consists of five trees of each species planted at 4m spacing resulting a total of 20 trees per hedge. Kentish Cob hazel bushes are planted between each of the timber trees resulting in a total of 19 bushes per hedge.

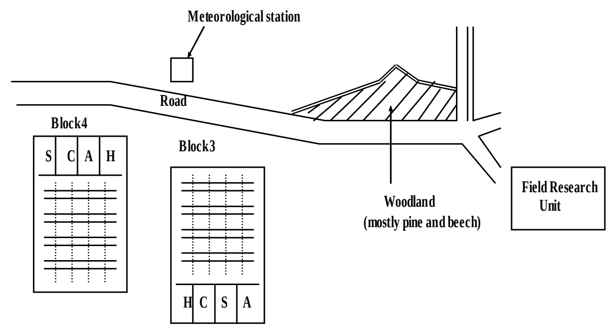

Fig. 1. Layout of the experimental site at the Leeds University Farm, England.

Forestry plots are located near to the agroforestry, containing three timber tree species planted at 2m intervals, giving a total of 120 trees per section of forestry plot. There are total of 30 hazel bushes per section of forestry plot. The agroforestry/ forestry plots of each block are surrounded by a windbreak hedge of poplar and willow trees.

Table I.- Composition of nest contents.

No.	Nesting contents	Weight (g)/box
1	Feathers	133
2	Grasses + leaves	126.8+6.18
3	Moss	133
4	Horse hair + wools	133
5	All above mix respectively	64.02+50.48+2.46+12.30+3.68
6	Feathers + grasses + leaves	72.79+57.38+2.79
7	Feathers + horse hair, wool	125.68+7.24
8	Feathers + moss	111.54+21.43

Nest contents

The basic material used for the nest construction was determined by studying a used nest of tree sparrow obtained from a hedge row as described in Table I. The feathers, wool and horse hair were sprayed with a solution made from the tablets containing, vitamin B complex (Robinson, 1988). The typical composition of each tablet is Thiamin (Vit. B1) 2.1 mg, Riboflavin (Vit. B2) 2.4

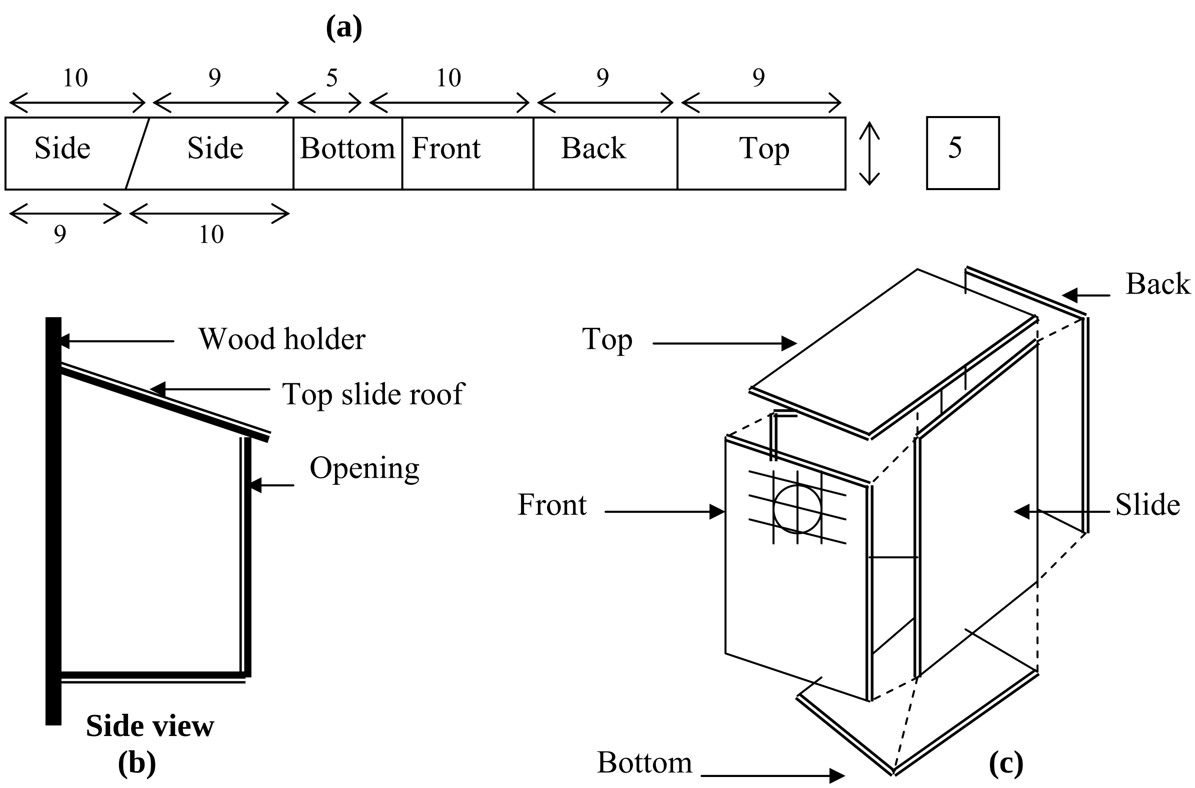

Fig. 2. (a) Construction of tree sparrow house (measurement in inches); (b) Side view of the bird box; (c) a tree sparrow bird nest-box.

mg, Niacin 27mg, vit. B6, 3mg, Folic acid, 300µg, Vit. B12, 1.5µg, Pantothenic acid, 9mg and Biotin 0.225mg. Two tablets of Vit. B were dissolved in 1 litre of distilled water, and 200ml of this solution was sprayed on animal materials. A total of 5368.45 g weight of nest material was used, of which feathers weight was around 47% of the total.

Forty guarded boxes were filled with similar nest contents as found in used nest, and assembled on trees around 9 ft above ground level, facing randomly to different directions East, North, South and West of the experimental site. The main opening hole of these boxes was closed by a 1/2 inch grill, which allowed arthropods to pass but not the only instead of birds (Fig. 2). The individual weight of the nesting materials of the each guarded bird boxes as shown in Table I. The distribution of the nest boxes among sites was as follows;

Woodland	8 guarded boxes
Agroforestry plot 3	Alley 1 (× 4 boxes)
	Alley 3 (× 4 boxes)
Agroforestry Plot 4	as above
Forestry plot 3-4	16boxes

Tree sparrow nest box information

Forty tree sparrow nest-boxes were made to study the structure of this model community. The dimensions of each nest box are as shown in Figure 2. After construction, all boxes were treated with the wood preservative cuprinol to prolong their life and help to repel water. These boxes were allowed to dry thoroughly before being erected. After four months, the nest materials were collected in A4 sealable polythene bags collected from these boxes. The arthropods were collected from these polythene bags and preserved in 70% alcohol for later identification. The pupae were removed randomly from the 18 nest-boxes and kept in Petri dishes at room temperature until the adults emerged. Emergent insects were frozen for further identification.

Sample sorting and identification of specimens

The number of arthropods was counted from the nesting materials. The specimens are identified upto species level using the following keys: Roberts (1985, 1995), Jones (1983), Chinery (1986), Wheater and Read (1996), Jones-Walters (1989) and Hopkin (1991).

Statistical analysis

Chi-square tests and Anova model were calculated by the SPSS and Minitab packages.

RESULTS

Arthropod numbers

The used tree sparrow nest was studied consisting of mixture of animal material (feathers, horse hair and excrements), vegetable fibres (leaves, straw and dry grass), Mosses, organic matter, including a proportion of insect faecal pellets, egg shells, and the fine dust. The weight of bird feathers was found higher as compared to other nesting materials.

From the guarded experiment tree sparrow nest-boxes, a total of 2316 arthropods were consisting of 1323, 890 and 97 in the tree rows, forest plots and natural woodlot, respectively (Figs. 3, 4). The green lace wing, *Crysoperla carnea* agg., was a dominant predator in both tree rows and forestry plots. The arthropods consisted of *C. carnea* (Stephens), *F. auricularia* L., spiders, beetles, 2-spotted ladybird beetle, *Adalia bipunctata* (L.), *Phratora* species, *Aphodius* species, *Dromius* species, *D. quadrimaculata* (L.), bugs, moth, psocids, social wasps, centipedes, millipedes, snail shells, dipterous pupae and larvae. Only hymenopterous parasitoids emerged from the mummies of the pupae, comprising two species of Chalcids namely *Dibrachys cavus* and *D. boarmiae*.. Chi square (Kruskal Wallis Test) analysis showed that the significant number found between lacewings, spiders, earwigs, beetles and flies ($\chi^2_{[4]} = 58.50$, $P < 0.000$) in guarded nest-boxes, and also in woodland, forest plots and tree rows ($\chi^2_{[4]} = 18.32$, $P < 0.001$), ($\chi^2_{[4]} = 43.64$, $P < 0.000$) and ($\chi^2_{[4]} = 36.06$, $P < 0.000$), respectively.

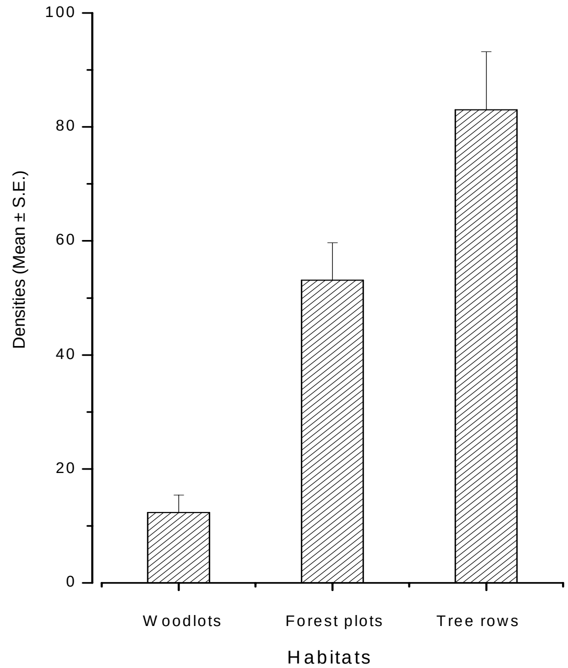

Fig.3. Comparison of the total arthropods within the habitats.

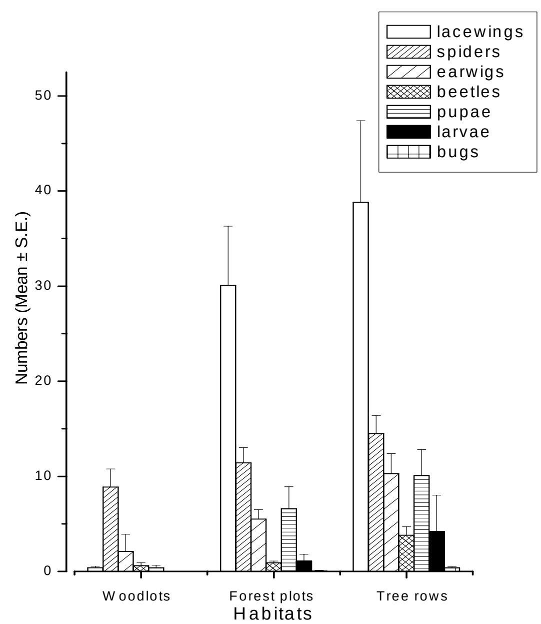

Fig. 4. Comparison of the arthropods between three different habitats.

Between-habitat comparison

Based on nest-box survey, the total number of arthropod was found to be higher in tree rows as compared to both in forest plots and natural woodlot ($F_{[2,39]}$ = 13.64, P < 0.000) (Fig. 3). Within the taxa, the number of green lacewings, flies and beetles were significantly higher in the tree rows than both in natural woodlot and forest plots (Table II, Fig. 4). The number of bugs were very low and no significant effect was present ($\chi^2_{[2]}$ = 5.62, P < 0.06). However, spiders were found to be insignificant, greater number was observed for the tree rows than in forest plots and natural woodland, ($F_{[2,39]}$ = 1.91, P < 0.16).

Table II.- Comparisons between the number of arthropods (Mean/box ± S.D.) present in the guarded nest-boxes treatments (Woodland, WL; Forest plots, FP; Tree rows, TR) (n=40).

Arthropods	Treatment	Mean ± S.D	Kruskal-Wallis Test	P
Green lacewings	FP	22.37±17.59	19.75	0.000***
	WL	0.83±1.99		
	TR	38.81±34.51		
Spiders	FP	12.62±8.53	3.31	0.191
	WL	3.33±3.20		
	TR	14.56±7.99		
Earwigs	FP	7.50±4.86	12.10	0.002**
	WL	1.25±2.30		
	TR	10.39±8.52		
Coleoptera	FP	1.00±1.06	6.34	0.04
	WL	0.72±1.00		
	TR	3.87±3.96		
Flies	FP	7.50±11.42	13.15	0.001**
	WL	0.37±0.37		
	TR	14.37±19.22		
Bugs	FP	0.06±0.06	5.56	0.06
	WL	0.00±0.00		
	TR	0.37±0.61		

*significant

Significantly, greater number of *F. auricularia* obereved in the tree rows associated with natural woodlot and forest plots ($F_{[2,77]}$ = 7.35, P< 0.001) (Fig. 4). There were no significant differences found by the earwig parasitoids (Fig. 5).

Between content of nesting materials comparison

There were no significant differences of arthopoda found between different nesting materials for the experiment ($F_{[7,32]}$ = 0.55, P< 0.78 NS) (Fig. 6), however, lower number of arthropods were found non significant in horse hairs and wool type nests. There were insignificant differences of arthropods observed between the different resources of artificial nest boxes.

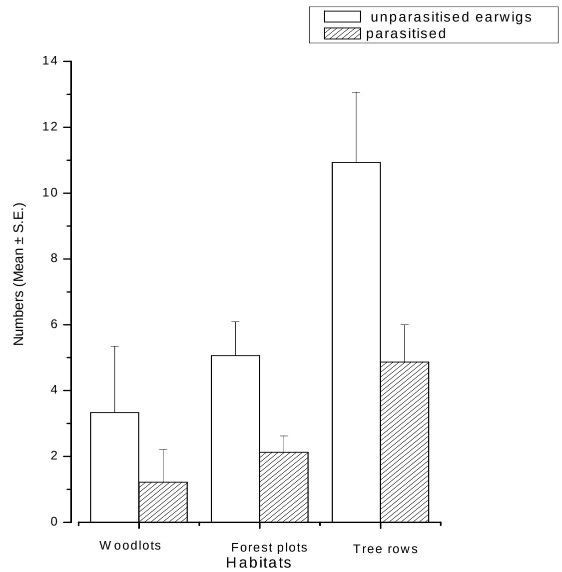

Fig. 5. Comparison the parasitized of the common earwig *F. auricularia* by Tachinid flies within three habitat.

*Parasitism on earwig (*F. auricularia*)*

Primary species of tachnid parasitoids *Triarthria setipennis* (Fallen) emerged from earwigs in the tree sparrow nests. Tachinid puparia collected from the different resources of the nesting materials were hyperparasitized by two species of Hymenoptera, the pteromalid *Dibrachys cavus* (Walker) and *D. boarmiae.* The rate of parasitism was 43%.

DISCUSSION

The results indicated that the arthropod fauna are influenced by the different habitats. The population densities were significantly greater in tree rows as compared to both forestry plots and natural woodlot trees. Several factors like orientation, vegetation structure in relation to exposure and tree rows which are separated by the arable alleys might have facilitated insect movement. The population was also influenced by environmental factors like wind speed and direction, crop density, vegetation structure associated to exposure and the surrounding crops (Naeem, 1997).

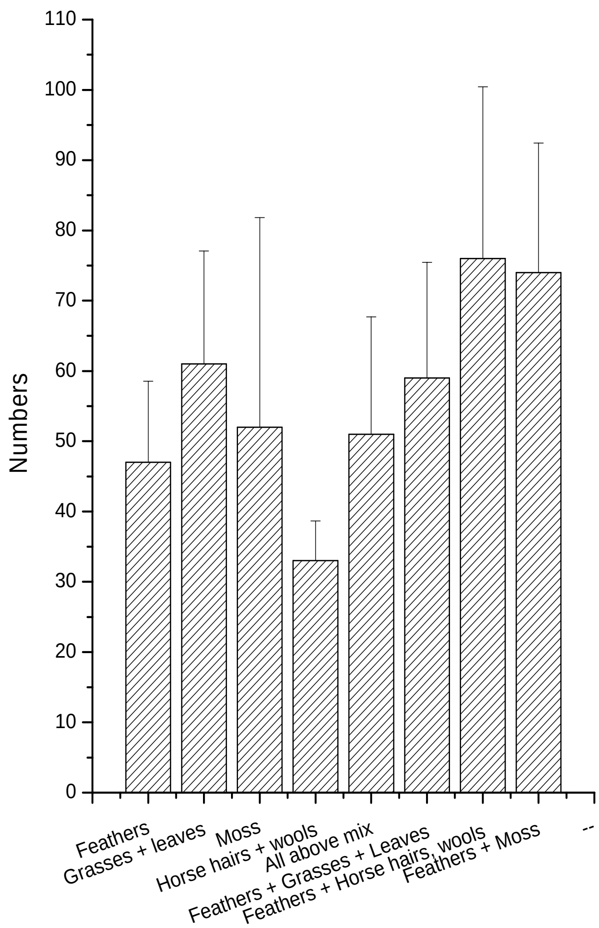

Fig. 6. Comparison of total arthropods density/box in relation to different resources of the artificial nest boxes.

The lower population of the arthropod was observed in both woodlot and forest plots as compared to tree rows, which might be due to dense tree populations influenced of the flying insects in both forest plots and natural woodlot. Small bodies insects were more sensitive to air movement than large bodies insects (Peng *et al*., 1993), and wind direction greatly affected insect mobility, influencing their ability to locate food, shelter and mates (Epila, 1988; Strong, 1984). The wind speed varied in woodlots and forestry plots as compared to tree rows due to the presence of trees density. The body temperature, flight activity and distribution of insects are influenced by wind movement patterns (Thomson, 1962). The wind speed might be vary between the three habitats due to tree density, as the flight direction, landing and distribution of most insects within habitats depends almost exclusively on the horizontal speed and direction of the wind (Hagen, 1962; Lewis and Stephenson, 1966; Lewis, 1967; Dean and Luuring, 1970; Moran *et al*., 1982).

Insignificantly differences of arthropods were observed between the different resources of artificial nest boxes. This may be due to the most of the predators are used the nest boxes as for shelter. Various insects were observed to use artificial nests as pupation sites or for shelter, however, the abundant nest inhibitors were larvae of tineid moths (Lepidoptera: Tineidae), fed on the feathers that composed the nest from 4-6 months (Robinson, 1990).

The greater rate of parasitism was observed on earwigs in tree sparrow nest. There are no significant differences observed between the brood size of the tachinid hyperparasitoid. The highest rate of parasitism of the European earwig was found by the *T. setipennis*, the greater rate of parasitism in the field was also observed (Kuhlmann, 1995). Population of these parasitoids were surveyed in central Europe during 1989-1991 and individual insects reared to identify available biotypes that may be more effective than biotypes already established in Canada. This species was introduced into North America from Europe early this century as a biological control agent against its host, the European earwig (*F. auricularia*) (OHara, 1996).

CONCLUSIONS

The responses of arthropod communities in guarded nest boxes were significantly higher in tree rows as compared to both the forest plots and woodlot. There were no significant differences observed between the varying resources of artificial nesting materials in total fauna. The common earwig, *Forficula auricularia* were attacked by a tachinid fly, *Triarthria. setipennis* and the rate of parasitism was found about 43% present.

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REFERENCES

CANARD, M. AND PRINCIPI, M.M., 1984. Life histories and behaviour development of Chrysopidae. In: *Biology of Chrysopidae* (eds. M. Canard, Y. Semeria and T.R. New). Junk, The Hague, pp. 57-75,

CHINERY, M., 1986. *Collins Pocket Guide*: *Insect of Britain and North-West Europe*. pp. 320.

COLLIAS, N.E. AND COLLIAS, E.C., 1984. *Nest building and bird behaviour*. Princeton University Press, Princeton, pp. 318-20.

DEAN, G.J. AND LUURING, B.B., 1970. Distribution of aphids in cereal crops. *Ann. appl. Biol.* **66**: 485-496.

DIANE, S.S., KOLASA, J., BENGTSSON, J., GONZALEZ, A., LAWLER, S.P., MILLER, T.E., MUNGUIA, P., ROMANUK, T., SCHNEIDER, D.C. AND TRZCINSKI, M.K., 2004. Are natural microcosms useful model systems for ecology? *Trends Ecol. Evolut.,* **19**:379-385.

EPILA, J.S.O., 1988. Wind, crop pests and agroforest design. *Agric. Syst.,* **26**: 99-110.

FIGUEROLA, J., 2000. Ecological correlates of feather mite prevalence in passerines*. J. Avian Biol.,* **31**:489-94.

GUNNARSSON, B., 1990. Vegetation structure and the abundance and size distribution of spruce-living spiders. *J. Anim. Ecol.,* **59**, 743-752.

HAGEN, K.S., 1962. Biology and ecology of predacious Coccinellidae. *Ann. Rev. Ent.,* **7**: 289-326.

HATLEY, C.L. AND MACMAHON, J.A., 1980. Spider Community organization: Seasonal variation and the role of vegetation architecture. *Environ. Ent.,* **9**: 632-639.

HERTING, B., 1960. Biologie der westpaläarktischen Raupenfliegen. In: *Monographein für angewandte Entomologie* (ed. W. Zwölfer) Nr. 16. Paul Parey Verlag. Hamburg und Berlin, pp. 1-188

HOPKIN, S.P., 1991. *A key to the woodlice of Britain and Ireland*. AIDGAP (Aids to the identification of Difficult Groups of Animals and Plants). *Field Stud. Counc. Publ*., 204, pp. 52.

JONES, D.N., 1983. The Suburban bird community of Townsville, a Tropical city. *Emu*, **83**: 12-18.

JONES-WALTERS, L.M., 1989. *Keys to the families of British spiders*. *Field Stud. Counc. Publ*., 197, pp. 79.

KITCHING, R.L., 2001. Food webs in Phytotelmata: "Bottom-Up" and "Top-Down" explanations for community structure. *Annu. Rev. Ent*., **46**:729-60.

KUHLMANN, U., 1995. Biology of Triarthria setipennis (Fallen) (Diptera: Tachinidae), A native parasitoid of the European earwig, *Forficula auricularia* L. (Dermaptera: Foriculidae), in Europe. *Can. Ent.*, **127**: 507-517.

LEWIS, T., 1967. The horizontal and vertical distribution of flying insects near artificial windbreaks. *Annls. appl. Biol.,* **60**: 23-31.

LEWIS, T. AND STEPHENSON, J.W., 1966. The permeability of artificial windbreaks and the distribution of flying insects in the leeward sheltered zone. *Annls. appl. Biol*., **58**: 355-363.

MOERKENS, R., LEIRS, H., PEUSENS, G. AND GOBIN, B., 2009. Are populations of European earwigs, *Forficula auricularia*, density dependent? *Ent. exp. Appl.,* **130**: 198-206.

MOLLER, A.P., 1984. On the used of feathers in birds' nests: predictions and tests. *Ornis Scand.,* **15**: 38-42.

MORAN, V.C., GUNN, B.H. AND WALTER, G.H., 1982. Wind dispersal and settling of first-instar crawlers of the cochineal insect *Dactylopius austrinus* (Homoptera: Coccoidea: Dactylopiidae). *Ecol. Ent.,* **7**: 409-419.

NAEEM, M., 1997. *Responses of aphid and their natural enemies in a silvoarble agroforestry environment*. Ph.D. thesis. Leeds University. UK. pp. 272.

OHARA, J.E., 1996. Earwig parasitoids of the genus *Triarthria stephens* (Diptera: Tachinidae) in the New World. *Can. Ent.,* **128**:15-26.

PENG, R.K., INCOLL, L.D., SUTTON, S.L., WRIGHT, C. AND CHADWICK, A., 1993. Diversity of airborne arthropods in a silvoarable agroforestry system*. J. appl. Ecol*., **30**: 551-562.

PHILLIPS, J.R., 1977. Raptor nests as a habitat for invertebrates: a review. *Raptor. Res*., **11**: 87-96.

RENDELL, W.B. AND VERBEEK, N.A.M., 1996. Old nest material in nestboxes of tree swallows: effects on reproductive success. *The Condor,* **98**: 142-152.

ROBERTS, M., 1985. *The spiders of Great Britain and Ireland*. Vol. 3. Harley Book, Colchester.

ROBERTS, M., 1995. *Collins field guide to the spiders of Britain and Northern Europe*. Harper Collins, London, pp. 383.

ROBINSON, G.S., 1988. Keratophagous moths in tropical forests-investigations using artificial birds nests. *Entomologist,* **107**: 34-45.

ROBINSON, G.S., 1990. Clothes moths and keratin in Asian rainforest. In: *Insects and the rain forests of south east Asia (Wallacea)* (eds. W.J. Knight and J.D. Holloway), Royal Entomological Society of London. pp. 305-308.

SOLOMON, M.G., CROSS, J.V., FITZGERALD, J.D., CAMPBELL, C.A.M. AND JOLLY, R.L., 2000. Predators for biocontrol in apple and pear in Northern and Central Europe 3. Predators. *Biocontr. Sci. Techn.,* **10**: 91-128.

STRONG, D.R., 1984. Density-vague ecology and liberal population regulation in insects. In: *A new ecology*: *Novel approaches to interactive system.* John Wiley, New York, pp. 313-327.

THOMPSON, C., 1962. Microclimates and the distribution of terrestrial arthropods. *Ann. Rev. Ent.,* **7**: 199-220.

TURNBULL, A.L., 1973. Quantitative studies of the food of *Linyphia triangularis* (Clerck) (Araneae, Lenyphiidae). *Can. Ent.,* **94**: 1233-1249.

UETZ, G.W., 1991. Foraging strategies of spiders. *Trends Ecol. Evolut.,* **7:** 155-159.

WHEATER, C.P. AND READ, H.J., 1996. *Animals under logs and stones-naturalists handbook*. Richmond Publisher, pp. 90.

WILSON, E.O., 1987. The little things that run the world (the importance and conservation of invertebrates). *Conserv. Biol.,* **1**: 344-346.

WISE, D.H., 1993. *Spider in ecology webs*. Cambridge University Press, Cambridge.

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