Magic Roundabouts? Teaching conservation in schools and universities

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Pitfall trap sampling of Carabid beetle species on roundabouts in Bracknell, Berkshire, was used to assess the biodiversity of this taxon by its use as an indicator. The aim of the study was to discover the role of traffic islands in the provision of refugia for invertebrate fauna in fragmented urban habitats. Sampling was performed on 15 roundabouts where a total of 24 species were recorded during four trapping periods over a total of 10 days. The resulting asymptotic curves indicated that the total number of species present on all but two of the sites had been represented in the samples taken. There was found to be a positive correlation between the area of the islands and the number of ground beetle species and between the log of the area and the number of individuals found. The log/log relationship between the area of the islands and the number of species was significant. The total abundance of the beetles present was also positively and significantly correlated with roundabout area when both variables were logged. The number of habitats on the islands was positively correlated with the total abundance and species richness. The relationship between species, area and habitat was also positively and significantly correlated. In conclusion, it is obvious that roundabouts of large area with higher numbers of habitat types are greater in Carabid beetle diversity than small, sparsely vegetated roundabouts. Thus, roundabouts can promote the maintenance of biodiversity in fragmented urban habitats. We present this study as an example of a simple method that could be used or easily adapted for educational use, and suggest how some of the perceived problems in its use may be overcome. We discuss how such a study could be useful in illustrating concepts such as biodiversity and species richness, and some of the factors that influence it, as well as demonstrating the level of biodiversity that can be found in urban environments.

Key words: Carabid; Ground beetles; Biodiversity; Fragmentation; Biogeography; Species-area relationships; Urban ecology

Introduction

The study of ecology has for a long time been seen as a very important part of education (Booth and Sinker, 1979), and the inclusion of the concepts of conservation and biodiversity in the National Curriculum could be seen as a reflection of the value these issues are given in the education system. Conservation is certainly part of the Key Stage 3 National Curriculum, as is the idea of habitats. At Key Stage 4 (GCSE) level, the concept of biodiversity and how it is affected by conservation practices is taught, as well as other aspects of the impact of humans on the environment. AS and A-level courses typically involve the further consideration of the impact of conservation management on biodiversity, the use of field techniques, and concepts such as *indicator species*, primarily in terms of freshwater and air pollution. The idea of indicator species is that the presence or absence of certain species of organisms can be related to some measure of the wider environment, such as pollution level or local species richness.

Thus the use of indicator species allows the assessment of a combination of factors present in a habitat, some of which may be antagonistic or synergistic in effect. Using indicator species as a measure of biodiversity has the great benefit of being inexpensive in comparison with the corresponding chemical tests e.g. soil analysis. In the Netherlands, interest in beetles by amateur naturalists has augmented data collection of Carabidae over the past 30 years providing a history of change in the invertebrate fauna of the region (Heijerman and Turin, 1994). This work has highlighted the usefulness of this group as an ecologically meaningful indicator. Carabid beetles have recently been specifically used as bioindicator species (Butovsky, 1994) and have often been used as an indicator of species recovery after a major disturbance (e.g. Walsh *et al*, 1993).

With the increasing pressure of human populations on wildlife, the provision and design of nature reserves is an important facet of modern life. Nature reserve design has its roots in the field of island biogeography (MacArthur and Wilson, 1967) and more recently has generated great debate over whether a Single Large Or Several Small reserves (SLOSS debate) is the best strategy to adopt when conserving species (Murphy,1989; Quinn and Harrsion, 1988). The growth of the theory of metapopulations (Hanski, 1999) has also had an impact on this debate.

Teacher notes
The choice of Carabidae as an indicator taxon for this study was made for a number of reasons. Carabid beetles occur widely in most terrestrial ecosystems. They are well-studied, relatively easy to identify (figures 7 and 8) and trapping is relatively straightforward and inexpensive (Forsythe 1987). In addition, as the trapping methods are universal (Butovsky, 1994) valid comparison between studies in other regions is possible. As more and more is discovered about the biology and ecology of Carabidae, it is becoming increasingly apparent that they have the potential to be included in a portfolio of taxa used for environmental assessments (New, 1984). Changes in land use are mirrored by changes in arthropod diversity (Altegrim *et al*, 1997) and human impacts e.g. trampling and settlement, can have a measurable impoverishing effect on Carabidae as they are particularly sensitive to changes in land use (Riversmoore and Samways, 1996; Nunes *et al*, 2000). The assemblages of Carabidae present in a habitat relate to the environmental conditions and to vegetation management of the area in question (Desender and Bosman, 1998) making the taxon ideal as a faunal representation of the sites chosen for this study.

Methodology

Bracknell is a 'New Town' and as such was planned with a ring road system that incorporates many traffic islands and roundabouts: these are, by design, fragmented by the road system into which they are incorporated. This lends itself as an ideal environment in which to use the theory of island biogeography (MacArthur and Wilson, 1967) and in particular the species/area concept (Darlington, 1957), to assess the usefulness of traffic islands or other urban green spaces as refugia for invertebrates or other organisms. It is not necessary to use roundabouts, especially given the potential dangers inherent in exposing students to traffic; any green, well delineated space within an urban habitat, school grounds or campus, or urban and suburban gardens will, if a large enough number of sampling sites is utilised, provide suitable data for analysis and discussion. Suburban gardens for example, are a well-documented source of certain types of biodiversity (Owens, 1991) as are city parks (Fernandez-Juricic, 2000).

Methods and Materials

Roundabout selection

The sites used in the example study were selected in order to provide a wide range of features. Sites were chosen to represent as many sizes and habitat types as possible.

Beetles were trapped using wet pitfall trapping as this is perhaps the most efficient way to gather information on Carabid abundance and diversity (Eversham *et al*, 1996; Luff, 1975) over a short and defined period. The aim of the trapping method was to catch the most beetle species possible in order to accurately represent the beetle assemblages on the sites. The pitfall traps were 200ml plastic coffee cups, with a diameter of 7.5 cm and a depth of 10 cm (Figure 1).

The traps were sunk using a bulb planter that allowed a plug of earth to be removed from the designated trapping area corresponding exactly to the volume of the trap. Each trap was set into the ground so that the lip of the liner cup was slightly lower than the surface of the ground. The base of each liner cup was perforated so as to reduce the possibility of flooding during rainy periods. A second plastic cup, the actual trap, was then placed in each liner cup so that its rim was flush with, or slightly lower, than the soil surface. The cups were then covered and left for a

Teacher notes
It is important that where public areas are to be used, appropriate permission should be obtained from the controlling authority. In the case of the present study, permission was obtained from Bracknell Forest Borough Council, a safety course was attended and all persons involved in sampling wore fluorescent safety jackets.

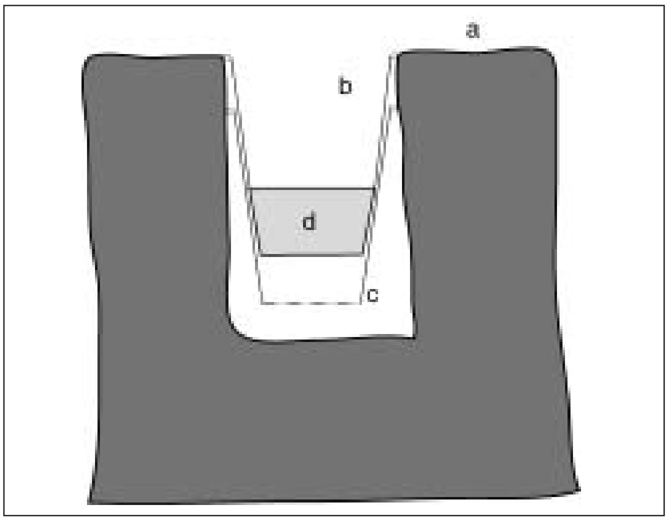

Figure 1. Cross-section through a pitfall trap: a) ground surface; b) pitfall trap (coffee cup); c) liner cup with perforated base; d) trapping liquid (water and detergent).

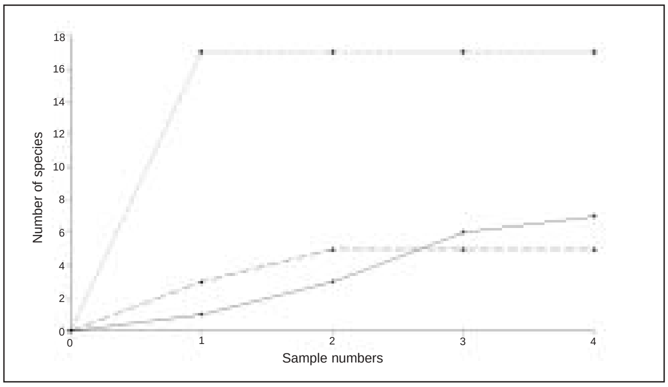

Figure 2. Species accumulation graphs showing asymptotic curves from three of the sites (n, site 3; l, site 2; s, site 6b).

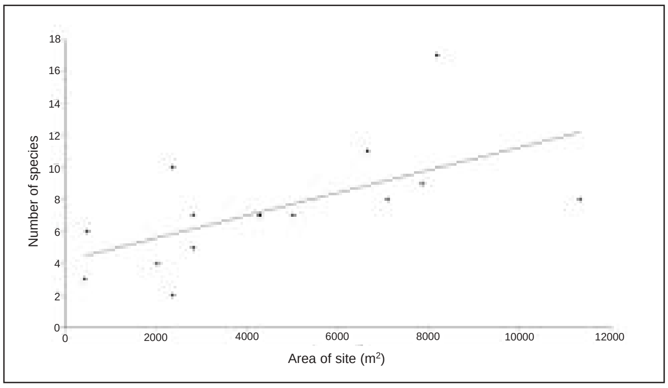

Figure 3. Relationship between area of roundabout and the number of different species of carabid caught in pitfall traps ($y = 0.0007x + 4.179$, $r = 0.610$, $df = 13$, $P < 0.05$).

week. This effectively reduces disturbance of the trapping area when the trapping regime starts. Consequently, the traps were able to be set immediately as the trap sinking method did not require a period of settling down before the traps were charged.

Teacher notes

Care should be taken that no grass or twigs fall into the traps when they are set: these can act as ladders to provide a means of escape for animals. Trowels can be used instead of bulb planters to set the traps.

If traps are to be checked at infrequent intervals they should be filled to a depth of 30 mm with water plus a small amount of odourless detergent in order to reduce surface tension and prevent smaller beetles escaping. Using wet traps reduces the likelihood of beetles consuming each other and allows a more accurate count of the animals. If traps are to be checked more frequently then dry traps are acceptable. The pro and cons of the use of wet and dry traps can also provide a useful focus of discussion in terms of dangers of the larger trapped predators eating the smaller individuals in dry traps and also the ethics of killing organisms in the pursuit of science and accuracy, when using wet traps.

Note that there is an ongoing debate concerning the use of pitfall traps as a means of obtaining absolute population estimates. Differing activity rates can influence the numbers of individuals of different species caught. For true population estimates, removal trapping or mark-recapture methods would need to be used. For a very readable review of this debate see Woodcock (2005).

The area of each roundabout and the habitat types present (Table 1) were all recorded prior to setting the traps. At each site traps were set in every habitat type present. The sites were visited by bicycle as the amount of traffic on the roads and lack of suitable parking areas at the sites made the use of motor vehicles impractical. This consideration also placed constraints on the number of traps that could be set or collected in one day, the number not exceeding in total the number that could be carried on a bicycle. The number of traps set on each roundabout corresponded to the number of habitats present on the islands (Table 1).

Traps were collected every 2–3 days so there was no need to charge the traps with a preservative mixture. The traps were initially set on the 12 May 1999, collected and reset on the 14 and 17 May and finally collected again on the 20 May. Initial data analysis (using asymptote curves – see teacher notes) indicated that further trapping was necessary, so a further two days of trapping were carried out from 9–11 June.

Sorting of the samples in the laboratory was performed on the same day as collection to prevent deterioration of the insects by putrefaction. The samples were washed, debris was removed and the insects were placed in screw-top Sterilin® containers with alcohol as a preservative. These were marked with date of collection, site number and habitat details and placed in a refrigerator at 4°C.

The insects were identified under a binocular microscope and using the keys of Lindroth (1974), Unwin (1984), Forsythe (1987) and Harde (1998).

Once identification was complete, further data analysis involved the plotting of graphs and regression analysis to indicate the presence of correlative relationships between the variables. When studying the species-area relationship, three types of graph are possible. The number of species (y) can be plotted against the area (x) of each site without transforming the data. Alternatively a semi-log plot can be used in which the area data is log transformed, or a log-log plot in which both sets of data are log transformed.

Table 1: *Profile of site in terms of habitats, traps set, and area.*

Site	*Habitat Types*	*Traps Set*	*Area (m^2)*
1a	a, b	2	452
1	a,b,d,e,h	5	2376
2	b,e,j	3	5026
3	a,b,c,f,g,h	6	8171
4	a,j,c	3	4301
5	c,j,g,	3	509
6	a,c,g	3	2827
6b	a,k,h	3	2827
7	a,d,h	3	4273
9	a,f,h	3	6648
11	a,b,e	3	2376
13	a,e	2	2043
14	a,j,d,f	4	7088
15	c,f,d	3	7853
16	c,f,e	3	11309

Habitat key: a long grass, b short grass, c lawn, d long grass under trees, e short grass under trees, f mature trees, g immature trees, h banks with long grass, i banks with short grass, j herbaceous borders, k hedges.
Habitats were characterised by:
(a) long grass (over 15cm in height); (b) short grass (between 5-15 cm in height); (c) lawn (regularly mown grass less than 5cm in height); (d) long grass under trees; (e) short grass under trees; (f) mature trees; (g) immature trees; (h) banks with long grass; (i) banks with short grass; (j) herbaceous borders; and (k) hedges.

Which kind of plot is best to use will vary between different studies, but the best approach is to try all three to find which gives the best correlation. Most species-area relationship studies have used the log-log plot as it usually results in the data approximating most closely to a straight line. In some cases the semi-log plot or untransformed data give the best correlation. This was the case in two of the three graphs reported in this study, such that the best correlations were found using untransformed data for number of species against both area and number of habitats, while log transformation of both data sets was best when considering number of individuals against area.

Results

Significantly more species of carabid beetles were caught from larger roundabouts (Figure 3, Table 2). In addition, significantly more individuals of each beetle species were caught on the larger roundabouts than on the smaller ones (Figure 4). Moreover,

Teacher notes

The use of asymptote curves

The function of plotting asymptotic curves of the number of species gathered on each of the sites sampled (Figure 2, Tables 3 and 4) was to provide an indication of the point at which all species estimated to be on the site were represented in the samples. Sampling of site 3 produced a level asymptotic curve after the first sample. Sites 1, 6b, 7 and 11 plateau after the second collection period. Most of the remainder of the sites plateau after the third collection period leaving sites 2,5 and 6 still showing an increase in species accumulation after the fourth collection, although the rate of capture of new species was decreasing. A further sample would have almost certainly shown the asymptote to have been reached.

Note that time of year will affect both the numbers and species caught, as carabids can be spring or autumn active depending on species. This is not a problem if samples are taken over a relatively short period of time as in the present study. An additional exercise would be to compare the catches from different times of year.

Teacher notes

Although much of the mathematics used in analysing the results and plotting graphs will be unfamiliar to many AS and A level students, if approached in a straightforward way they are not difficult to grasp. All students should be familiar with the general formula for a straight line, $y = mx + c$, from their GCSE mathematics, but the concept of log values are likely to have been met only by those studying AS or A-level mathematics, chemistry or physics. For those unfamiliar with log, and depending on their mathematical confidence, their use might be explained as simply a way of transforming data to produce a straight-line graph. Alternatively graphs could be produced using computer software to plot logarithmic scales. Few students, except those studying AS or A-level statistics, are likely to be familiar with regression, and most students would probably find the mathematics involved too difficult, or at least perceive it to be too difficult, although they are expected to understand the idea of regression by some examining boards. Therefore the best way to approach regression may be to use computer software (simple spreadsheet packages are readily available) to add a best fit line and an r^2 value, without tackling the mathematics directly. Alternatively regression could be avoided by using Spearman Rank Correlation, a technique that is frequently used at AS and A-level, to produce an r^5 value from log transformed data. Whichever mathematical approaches are used will be dependent on the ability, experience and confidence of students, and as this may be quite variable within a group, there is considerable possibility for differentiated tasks.

roundabouts with more habitat types had significantly more species of beetle than those with a limited number of habitats (Figure 5). There was a significant interaction between the number of habitats and the size of the roundabouts. Put simply, a large roundabout with many different types of vegetation (Figure 6) will have more species and more individual carabid beetles than a small roundabout with few types of vegetation.

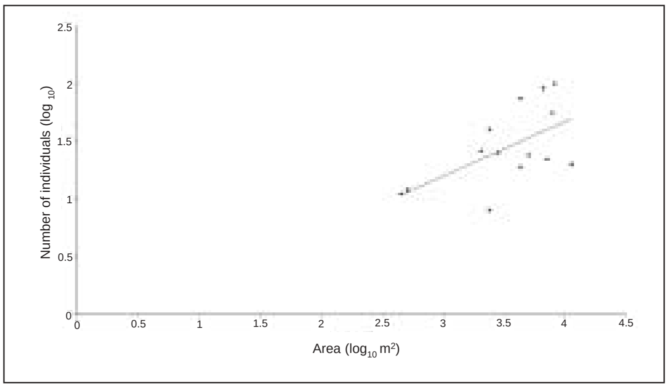

Figure 4. Relationship between log10 area of roundabout and the log10 number of carabid beetles caught in pitfall traps ($y = 0.474x - 0.221$, $r = 0.586$, $df = 13$, $P < 0.05$).

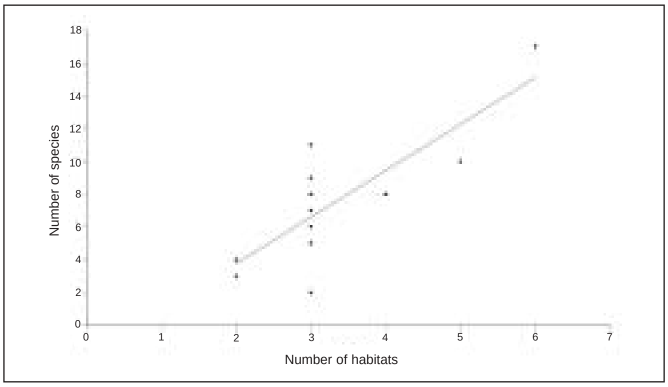

Figure 5. Relationship between number of habitats present and number of species of carabid beetles present on each roundabout ($y = 2.839x - 1.875$, $df - 13$, $r = 0.810$, $P < 0.001$).

Figure 6. Example of one of the study sites.

Discussion

Roundabouts within the town of Bracknell show a significant species-area relationship, with larger roundabouts having larger numbers of species of carabid species, as well as larger numbers of individuals. The results indicated that a major factor explaining this pattern is that large roundabouts tend to have a greater number of habitats than smaller ones. This is consistent with the habitat diversity hypothesis, used to explain species-area relationships, which proposes that larger areas contain a greater number of habitats, each with different species composition, and so the overall species richness increases with area (Lomolino, 2001).

In urban environments, the number and characteristics of different habitats is likely to be strongly influenced by human activity, including direct management practices. Effects of human activity on habitats will also influence the species richness of carabid beetles and other organisms. Consequently the use of careful management practices has the potential to enhance and support species richness through the maintenance of habitat diversity.

Studies within urban areas have shown that there is considerable biodiversity within towns and cities (McIntyre 2000). As a result it is possible, as we have done, to use parts of the urban environment to investigate ecological principles such as the species-area relationship, or simply to demonstrate the concept of biodiversity.

Although we used roundabouts, which may be more appropriate for individual study and not school group fieldwork due to the danger of access, similarly informative studies could quite easily be carried out in other areas such as parks, school grounds or urban woodlands. As well as developing ecological understanding, the use of the local environment for fieldwork has a number of wider advantages such as relatively low cost, avoidance of timetable disruption, and the development of a greater sense of value for the place in which students live (Hale 1986).

Apart from illustrating the concept of biodiversity within a local setting, the work described in this paper could be used to teach a number of other aspects which are typically found in AS and A-level courses. These include the demonstration of simple field techniques; pitfall trapping was employed in this case although other methods, such as tree beating or using a sweep net, could equally be used.

Figure 7. Notiophilus biguttatus. *Photo courtesy of Roy Anderson*

Figure 8. Pterostichus niger. *Photo courtesy of Roy Anderson*

Table 2: *Number of different species of carabid beetle and their abundance on Bracknell roundabouts 1999.*

Site	*Total Species*	*Total Abundance*
1a	3	11
1	10	40
2	7	24
3	17	100
4	7	75
5	6	12
6	7	25
6b	5	25
7	7	19
9	11	91
11	2	8
13	4	26
14	8	22
15	9	56
16	8	20

Table 3. *Species of Carabids caught on 15 Bracknell roundabouts in 1999*

Species	*Roundabout*
Agonum assimile	3
Amara aenea	1a,1,2,3,4,5,6,6b,7,9,11,13,14,15,16
Amara bifrons	3
Amara familiaris	2,3,4,7
Amara plebeja	1,6,11,13,14,15
Badister bipustulatus	9
Bembidion lampros	1a,1,2,3,4,5,6,7,9,13,14,15,16
Bembidion testaceum	3
Calathus fuscipes	16
Calathus micropterus	15
Harpalus aeneus	3,6b,7,13
Harpalus rufipes	9
Loricera pilicornis	1,3,7,9,15
Metabletus truncatellus	3
Microlestes minutulus	4
Miscodera arefica	3
Nebria brevicollis	1,2,3,4,5,6,6b,7,9,14,15,16
Nebria salina	3
Notipohlius biguttatus	1,3,4,5,9,14,15,16
Pterostichus cupreus	3,6b,16
Pterostichus madidus	1,3,4,5,6,6b,9,14,15,16
Pterostichus melanarius	14
Pterostichus niger	1,2,3,6,9
Stomis pumcatus	9

It could also help in the study of grassland and woodland management, covering such aspects as the relationship between management and the number of habitats or to gain a measure of how different management techniques affect biodiversity. The concept of indicator species can also been demonstrated. We have used the Carabidae as indicators of more general biodiversity, which can provide an alternative to the more usually considered lichens and freshwater macrofauna, not only as they are from different taxa and habitats but also to demonstrate that the concept is not limited to that of a pollution indicator.

One of the main problems that many teachers perceive with regard to fieldwork of this type is their lack of ecological experience and expertise, particularly in terms of identifying organisms (Booth and Sinker, 1979; Hale, 1986; Openshaw and Wittle, 1993). One of the reasons for choosing carabid beetles for our study was that they are relatively easy to identify. Good, scientifically sound biodiversity studies can, however, be carried out without the need for identification to species level (Oliver and Beattie, 1993). Invertebrates collected can be grouped into a number of morphospecies, in other words recognisably different types, without the need to determine and name the correct species.

Table 4. *Species accumulation data*

	Number of species caught in samples			
Sample days	*1*	*2*	*3*	*4*
Roundabout				
1	6	11	11	11
1a	0	1	3	3
2	1	3	6	7
3	17	17	17	17
4	4	5	7	7
5	2	5	6	6
6	2	5	6	7
6b	3	5	5	5
7	5	7	7	7
9	5	8	11	11
11	1	2	2	2
13	3	3	4	4
14	2	5	8	8
15	5	9	9	9
16	3	5	8	8

This approach has been suggested as being particularly valuable for the rapid assessment of biodiversity and can enable non-specialists to make useful contributions to a number of areas of ecology (Oliver and Beattie 1993, 1996). From an educational point of view the use of morphospecies may also be used to illustrate how during history the first steps in taxonomy were taken.

Conclusion

If roundabouts are managed in such a way as to provide a diversity of habitats they can add significantly to the biodiversity of the urban environment. Future studies should concentrate on the age of the roundabout, the frequency with which management practices occur and the species composition of the plant communities present. Predictions from ecological theory would suggest that older, larger roundabouts with diverse vegetation (preferably native) will encourage a greater diversity of beneficial arthropods.

Pitfall trapping of discrete urban areas, such as roundabouts, can be used within the educational system to illustrate a number of important ecological themes. These include the concepts of species richness and biodiversity, how biodiversity can be measured, and how habitat type, management and area affect it. In addition, it provides the opportunity to demonstrate local biodiversity and show that urban and other strongly human-influenced environments can support surprisingly high biodiversity.

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References

Altegrim O, Sjoberg K and Ball J P (1997) Forestry effects on a boreal ground beetle community in spring: selective logging and clear-cutting compared. *Entomologici Fennici,* 8, 19-26.

Booth P R and Sinker CA (1979) The teaching of ecology in schools. *Journal of Biological Education* 13, 261-266.

Butovsky R O (1994) *Carabid Beetles Ecology and Evolution*. Kluwer.Press, Netherlands.

Darlington P J (1957) *Zoogeography: The Geographical Distribution of Animals*. John Wiley & Sons Inc, New York.

Desender K and Bosmans R (1998) Ground beetle (Coleoptera, Carabidae) on set-aside fields in the Campine region and their importance for nature conservation in Flanders (Belgium). *Biodiversity and Conservation*, 7, 1485-1493.

Evesham B C, Roy D B, Telfer M G (1996) Urban, industrial and other man made sites as analogues of natural habitats for Carabidae. *Annales Zoologici Fennici,* 3, 149156.

Fernández-Juricic E (2000) Bird community composition patterns in urban parks of Madrid: The role of age, size and isolation. *Ecological Research*, 15, 373-383.

Forsythe T G (1987) *Common Ground Beetles*. Richmond Publishing Company, Richmond.

Hanski I (1999) *Metapopulation Ecology*. Oxford University Press, Oxford.

Hale M (1986) Approaches to ecology teaching: the educational potential of the local environment. *Journal of Biological Education,* 20, 179-184.

Harde K W (1998) *A Field Guide in Colour to Beetles*. Blitz Editions.

Heijerman T and Turin H (1994) Towards a method for biological assessment of habitat quality using carabid samples (Coleoptera: Carabidae). *Carabidae Beetles: Ecology and Evolution,* (ed. by K Desender *et al*), pp: 305-312. Academic Publishers, Netherlands.

Lindroth C H (1974) *Handbook for the identification of British Insects Vol.: Coleoptera: Carabidae*. Royal Entomological Society, London.

Lomolino M V (2001) The species-area relationship: new challenges for an old pattern. *Progress in Physical Geography,* 25, 1-21.

Luff M L (1996) The use of Carabids as environmental indicators in grassland cereals. *Annales Zoologici Fennici,* 33, 185195.

Luff M L (1975) Some factors influencing the efficiency of pitfall traps. *Oecologia,* 19, 345-357.

MacArthur R H and Wilson E.O. (1967) *The Theory of Island Biogeography*. Princeton University Press, Princeton, NJ, USA.

McIntyre (2000) Ecology of urban arthropods: a review and a call to action. *Annals of the Entomological Society of America* 93, 825-835.

Murphy D D (1989) Conservation and confusion: wrong species, wrong scale, wrong conclusions. *Conservation Biology*, 3, 82-84.

Nunes L F, Leather S R and Rego F C (2000) Effects of fire on insects and other invertebrates: A review with particular reference to fire indicator species. *Silva Lusitanica*, 8, 15-32.

New T R (1984) *Insect Conservation: An Australian Perspective*. Dr Junk. Netherlands

Oliver I and Beattie A J (1993) A possible method for the rapid assessment of biodiversity. *Conservation Biology,* 7, 562-568.

Oliver I and Beattie A J (1996) Invertebrate morphospecies as surrogates for species: a case study. *Conservation Biology,* 10, 99-109.

Openshaw P H and Whittle S J (1993) Ecological field teaching: how can it be made more effective? *Journal of Biological Education,* 27, 58-65.

Owens J (1991) *The Ecology of a Garden: the first fifteen years*. Cambridge University Press.

Quinn J F and Harrison S P (1988) Effects of habitat fragmentation and isolation on species-richness - evidence from biogeographic patterns. *Oecologia*, 75, 132-140.

Riversmoore N A and Samways M J (1996) Game and cattle trampling, and the impacts of human dwellings on arthropods at a game park boundary. *Biodiversity and Conservation,* 5, 15451556.

Unwin D M (1984) *A key to the families of British Beetles*. Field Studies Council.

Walsh P J, Leather S R and Day K R(1993) The effects of aerial application of fenitrothion on the carabid community of defoliated and non-defoliated lodgepole pine, *Pinus contorta*. *Journal of Applied Entomology,* 115, 134-138.

Walsh P J , Day K R, Leather S R and Smith A J (1993) The influence of soil type and pine species on the carabid community of a plantation forest with a history of pine beauty moth infestation. *Forestry,* 66, 135-146.

Woodcock B A (2005) Pitfall trapping in ecological studies, pp 37-57 [In] *Insect Sampling in Forest Ecosystems* (ed. S R Leather), Blackwell Publishing, Oxford.

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