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The diversity of ladybirds (Coleoptera: Coccinellidae) and grasshoppers (Orthoptera) surveyed on coal tips in the Walloon Region (Belgium)

J.-F. GODEAU[1], M. DERUME[2] & C. BAUFFE[2]

Projet Interreg IV "Agir pour la connaissance, l'évaluation, l'interprétation et la gestion du patrimoine naturel et culturel du Bassin Minier franco wallon"
[1]: Rue de la Gare 66, 6560 Solre-sur-Sambre (E-mail: jfgodeau@gmail.com).
[2]: CARAH asbl, Rue Paul Pastur 11, 7800 Ath (E-mail: derume@carah.be).

Abstract

Coal tips are artificial hills characterized by very heterogeneous soil. Nowadays, the natural colonization is taking place and coal tips are more and more considered as highly valuable habitats for the biodiversity. We detail the results of standardized sampling of Ladybird beetles (*Coccinellidae*) and grasshoppers (Orthoptera) performed during 2009 and 2010 in 55 sites in the Province of Hainaut (Belgium). The species richness and the diversity are analysed and discussed at the level of sites and habitats within sites. Coal tips are likely to host rare or endangered species which find there substitute habitats of their natural sites. 21 species of ladybirds and 21 species of Orthoptera were identified and counted by mean of the method that we implemented. A special focus was dedicated to the invasive Multicoloured asian ladybird *Harmonia axyridis* (Pallas, 1773). Our method seems to be convenient to detect the species composition of ladybirds but it has some weaknesses in the detection of few grasshopper species. On the other hand, we emphasize that the list of Orthoptera can be easily supplemented with use of good knowledge of their songs. In addition, we evaluated the possibility of adding other insect group such as Lepidoptera Rhopalocera into the methodology.

Keywords: Coccinellidae, Orthoptera, coal tips, diversity index, Belgium, biological assessment

Introduction

The coal-mining extraction stopped in 1984 in the Walloon Region and left behind numerous coal tips along the coal-mining basin: ca. 340 sites in the Walloon Region and 250 in France (data Service Public de Wallonie; PETIT, 1980 *in* RASMONT & BARBIER, 2000). These hills, which are made of a mixture of soil, rock and coal, are characterized by very heterogeneous soil composition, soil grain size, exposition of the slopes to the sun, albedo (i.e. the reflecting

power of a surface) and porosity (RASMONT & BARBIER, 2000). Nowadays, natural colonization is taking place on disused coal tips, which are more and more considered as highly valuable habitats sheltering a precious biodiversity.

In this context, a French-Belgian Interreg program was started in 2005 and prolonged in 2008. One of the goals of the program consisted in creating a method to assess the biological value of disused coal tips. For this purpose, we selected taxa whose species are easily identified in the field (no need to collect, storage and preserve animals) and of which the identification is accessible to non-specialists, in order to be easily implemented by various practitioners (Municipalities, N.G.O., etc.). We assessed the diversity of four selected groups of animals: breeding birds; (macro-) *Coccinellidae*; grasshoppers; reptiles and amphibians.

By means of this method, an assessment of ca. 120 coal tips in the western part of the Belgian coal-mining basin is planned. During the same period of time, the French team of the Interreg program is sampling the same amount of sites in France. This amount of sites is realistic for a 3-year project hiring 1 to 2 full-time field scientist, only because it focuses on well defined taxa, that are not time-consuming to sample. Conversely, it was estimated that a comprehensive biological assessment of the flora, the fauna and the abiotic parameters of coal tips is such a work that a full time scientist can perform the expertise of only 1 to 2 coal tips during one year (RASMONT & BARBIER, 2000).

Such a large investigation of the biodiversity of coal tips was never performed nor published, neither in Belgium nor in France. Many publications deal with accurate investigations on a reduced amount of sites about invertebrates families which need expertises of specialists, such as Apoidea (BARBIER *et al.*, 1990), Vespoidea (RASMONT *et al.*, 1990), Carabidae (DUFRÊNE *et al.*, 1990) or Araneae (LAMBRECHTS *et al.*, 2004). Other studies dealing with phytosociology and plants successions on Belgian coal tips are also available in the literature (e.g. HUGHES *et al.*, 1988; FRANKARD, 2000; VANOPPEN & GORA, 2004).

We here present the results about the coal tips surveyed in 2009 and 2010 and we comment the choice of the diversity index used in the method.

Material & Method

The standardized method which was used to assess the invertebrates diversity is described below, whereas the details of the part of the method concerning vertebrates is shortly summarized and those results are not detailed in the present paper. More details can be found on the website of the Interreg project (http://chainedesterrils.eu/) where description of the project is available as well as a copy of the poster dedicated to the description of the method (DERUME *et al.*, 2010).

Invertebrates

The (macro-)*Coccinellidae* refer to the sub-families *Coccinellinae*, *Chilocorinae* and *Epilachninae*. The grasshoppers refer to every Belgian families of this order: *Tettigoniidae*, *Acrididae*, *Tetrigidae* and *Gryllidae* (*Gryllotalpidae* was never observed so far).

The sampling effort was directly determined by the relative coverage of the three main types of habitats: forests, open fields and wetlands.

The insects were surveyed by means of net sweeping (in open fields and wetlands) or branches beating (in forests). Each sampling unit was an homogeneous portion of the habitat, in which 80 samplings (branches beating or net sweeping) were performed. Additionally, a direct visual search was performed in each sampling unit during 5 minutes in open fields and wet habitats or 10 minutes in forests.

This sampling strategy was repeated two times at the same place, with one month of interval between 1.V and 15.IX in 2009 and 2010. One sampling unit was located for each 25% of area of habitat. If only one type of habitat was present (100% of one habitat), then four sampling units were surveyed in this habitat.

The results of the surveys of *Coccinellidae* previously performed on walloon coal tips in 2006, were published by DERUME *et al.* (2007).

Vertebrates (not presented here)

The breeding birds were identified and counted during 10 minutes within a circle of 150 m diameter during two sessions in each type of habitat. The survey of reptiles and amphibians consisted in summing up all the available information collected during our field investigations and those available in the literature from 2008 and 2009.

The results of the survey of breeding birds, reptiles and amphibians performed in 2006 and 2007 on walloon coal tips were published by HAUTECLAIR *et al.* (2008).

Diversity index : the Biological Value Index (Ibv)

Computation of the Biological Value Index (Ibv) for each coal tip were i species were sampled:

$\mathbf{Ibv = \Sigma_i R_i}$,

With the rarity indices (R) computed for each species as:

$\mathbf{R_j = 10 * (1 - N_j/Tot)}$

N_j: number of sites occupied by the species j

Tot: total number of sites investigated (here Tot = 55)

The core of the rarity index is multiplied by 10, giving a specific score R which ranged from 0 to 10.

Data analysis

1. Validation of the method

The number of species found during the first sampling session is compared to those found after both sessions and tested with Wilcoxon-Mann-Whitney test.

The number of new species found during the additional visual search which complemented the standardized sampling of ladybirds is presented.

2. Comparison of the diversity indices

The Biological Value Index (Ibv), the species richness (S) and the Shannon index (H) is computed for each site, with the species of ladybirds and of grasshoppers counted together. S and H are conspicuous to understand and are commonly used as basic estimates of diversity. We compared the Biological Value Index Ivb with S and H with Spearman correlation index (+ significance test) to evaluate the strength of association with each of them.

3. Comparison of the densities of ladybirds found in 2009 and 2010

The densities of ladybirds (number of individuals per sampling unit) are compared between years with a special focus on the invasive Multicoloured asian ladybird *Harmonia axyridis* (Pallas, 1773), using a Wilcoxon-Mann-Whitney test.

Results

Our samplings on 55 sites revealed the presence of 42 species: 21 *Coccinellidae* and 21 Orthoptera. For both taxa Shannon index = 3.79. Nevertheless, it is noteworthy that 7 species of ladybirds were found on more than 25 (~50%) of the sites, whereas this was the case for only 3 species of grasshoppers (Figs 1-2).

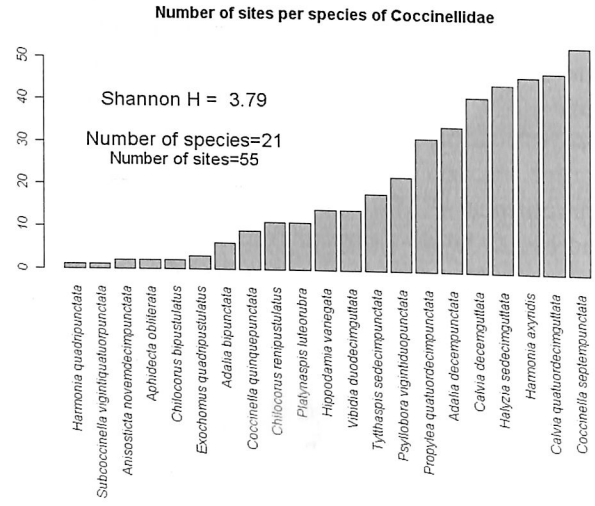

Fig. 1. Total number of sites where each species of ladybird was found. The evenness of the presence of the species at the scale of the whole study area is provided by the Shannon index.

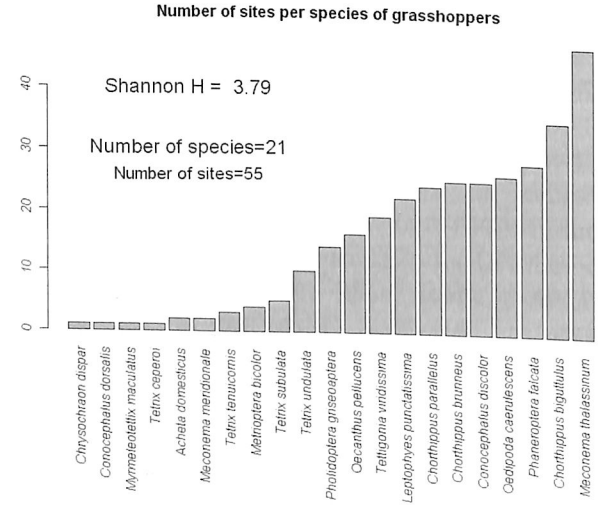

Fig. 2. Total number of sites where each species of Grasshopper was found.

1. Validation of the method

Two sessions of sampling

The mean number of sampled species significantly increased when comparing the

results of the first sampling session and those of the two sessions merged together (ladybirds: W=387, p~0; grasshoppers: W=847.5, p=0.001). The first session provided 4.4 ± 1.92 and 3.7 ± 2.66 species respectively for ladybirds and grasshoppers. When adding the results of the second session these values increased to 7.5 ± 1.81 and 5.6 ± 3.07 (Figs 3-4).

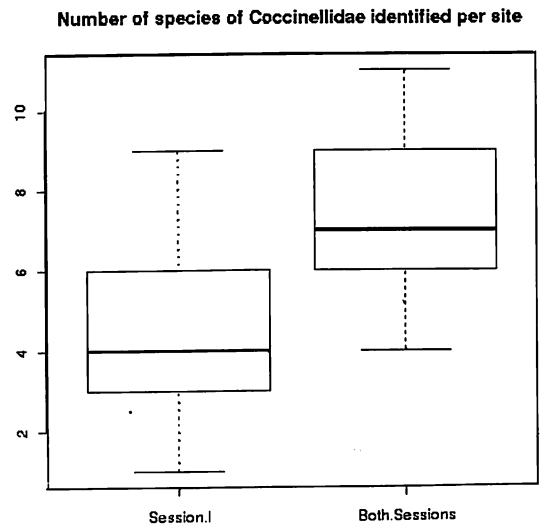

Fig. 3. Boxplot of the number of Ladybird species found during the first and both sampling sessions (Wilcoxon-Mann-Whitney, W=387, p=0).

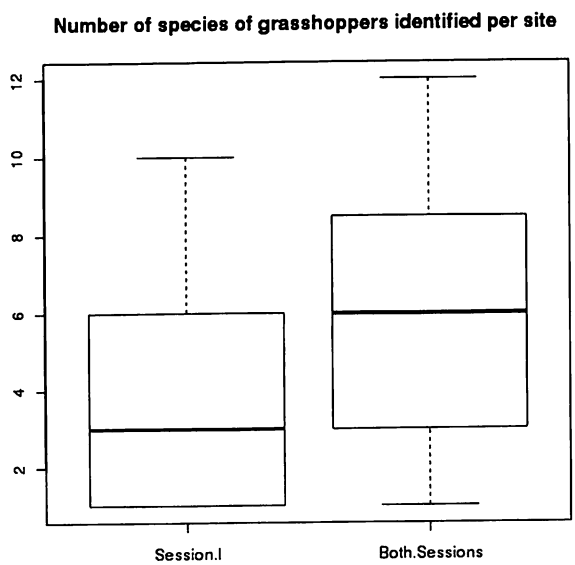

Fig. 4. Boxplot of the number of grasshoppers species found during the first and both sampling sessions (Wilcoxon-Mann-Whitney, W=847.5, p=0.001).

Additional visual search

The visual search of ladybirds performed after each sampling rarely revealed the presence of previously undetected species. We found one more species only in 6 out of 55 sites.

2. Comparison of the diversity indices

To estimate the diversity of the sampled taxa we decided to use the Biological Value Index as an estimation of the diversity of the sampled taxa. The Ibv of sites were significantly correlated with their specific richness 'S' (r(Spearman)= 0.93, p<<0.001). Though, Ibv was less correlated with Shannon index 'H', the correlation remained highly significantly positive (r(Spearman)= 0.74, p<<0.001; Fig. 5).

In both taxa some rare species for the

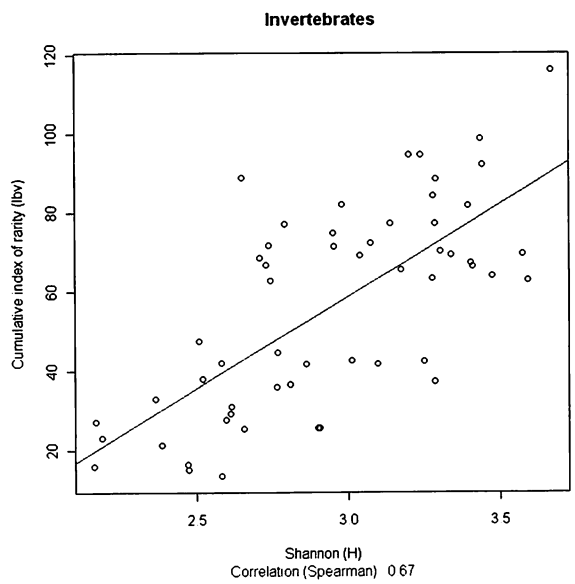

Fig. 5. Cumulative rarity index and Shannon diversity inedx of invertebrates (ladybirds and grasshoppers) collected at each sampling unit (Spearman = 0,67)

Walloon coal mining basin have been detected (e.g. *Vibidia duodecimguttata* (Poda, 1761); *Chilocorus bipustulatus* (Linnaeus, 1758); *Conocephalus fuscus* (Fabricius, 1793); *Chrysochraon dispar* (Germar, 1834)) as well as species associated with pioneer habitats (e.g. *Myrmeleotettix maculatus* (Thunberg, 1815); *Tetrix ceperoi* Bolivar, 1887; *Hippodamia variegata* (Goeze, 1777)).

3. Comparison of the densities of ladybirds found in 2009 and 2010. An apparent regression of the invasive ladybird *Harmonia axyridis*?

In the forests, the densities of ladybirds were slightly lower in 2010 (mean: 0.58 individual per sampling unit) than in 2009 (mean: 0.97), however not significant (W=122.5, p=0.69). The most striking difference of densities between years was observed for the invasive *Harmonia axyridis* which shifted from the first (2009) to the sixth place (2010) in the ranking of abundances (Fig. 6). On the other hand, the ranks of four other most common species (*Coccinella septempunctata* Linnaeus, 1758; *Calvia decemguttata* (Linnaeus, 1758); *Calvia quatuordecimguttata* (Linnaeus, 1758) and *Halyzia sedecimguttata* (Linnaeus, 1758) remained the same in 2009 and 2010, although in a different order.

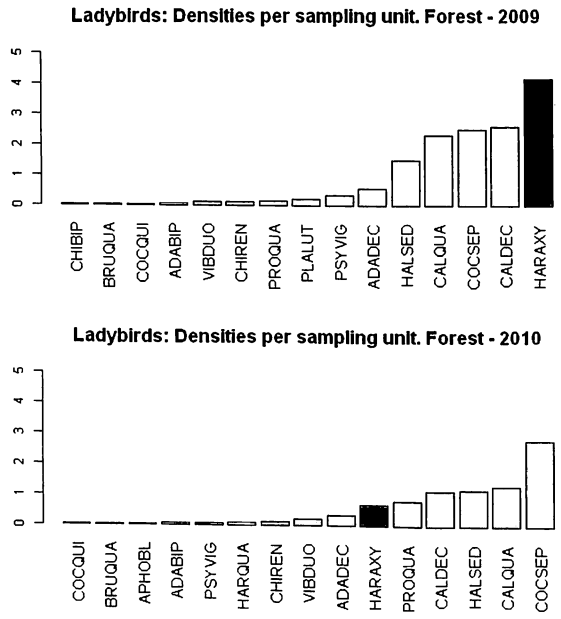

Fig. 6. Comparison of the densities of ladybirds (=number of individuals per sampling unit) in 2009 and 2010.

In the open habitats (graphs not presented), *Harmonia axyridis* was never as abundant as in the forests, with densities of 0.32 and 0.23 individuals per sampling unit in 2009 and 2010 respectively. Only *Coccinella septempunctata* was commonly found with densities of 2.5 and 4.9 individuals per sampling unit in open habitats in 2009 and 2010 respectively.

Discussion

Validity of the method and the choice of the diversity index

Assessing the diversity of very different organisms, such as invertebrates families and vertebrates together can be troublesome for field practitioners. Field investigations should be performed with different techniques, at different dates and daytime for each taxa. To counter this, we decided to assess the diversity of coal tips by means of sampling of a restricted amount of animal taxa which are easily collected and identified in the field. Therefore, no specimens should be collected besides, in case of doubt, some *Tetrix spp.* or *Chorthippus spp.* The results presented here do not yet include the complete list of coal tips involved in the Interreg program. So far, we conclude that the second session of sampling in the same sampling unit after one month provided a significant increase in the number of detected species, which supports the goodness of our method. The active search (only analysed for *Coccinellidae*) rarely revealed the presence of previously undetected species during the standardised sampling. Conversely, the active search allowed to detect many grasshopper species by identifying their stridulations (not detailed here). We conclude that it is worthwhile to keep on investing some minutes to search actively after the standardised sampling, mainly to complement the list of grasshopper species. Nevertheless, we noted that our method seems to underestimate the presence of some grasshoppers species which are especially active in the evening (e.g. *Pholidoptera griseoaptera* (De Geer, 1773) and *Tettigonia viridissima* (Linnaeus, 1758)).

We choose to value the diversity of species on coal tips by means of a cumulative rarity index (called here Ibv). This index provides the species richness per site weighted by the actual commonness of each species. It represents the species richness because it is a simple sum of values, each value being the rarity index of species found in one site. These rarity indices were calculated on the basis of the number of sites where the species were observed, so it depicts well the status of the species in the studied region (i.e. the walloon coal mining basin). The index is therefore more adequate than the species richness (S) or the evenness index of Shannon (H) as it includes the local species commonness.

Ladybird densities

The populations of predatory ladybirds are known to vary from year to year, following the variations of prey densities. The correlation between aphid abundance and the subsequent ladybird densities has been shown by many authors (see review in DIXON, 2000). Thanks to our method and to the structure of our data set, we could point out trends in relative abundances of ladybirds between 2009 and 2010. This is particularly valuable for monitoring the evolution of the populations of the invasive species *Harmonia axyridis*. We seemingly observed a regression of this species in 2010, in agreement with observations in other European countries (pers. observation).

Perspectives

One of the aims of our method was to be **easily implemented in the field** by various field practitioners to obtain a **comparable "index of biological value"**. Our field experience tells that it satisfies this expectation, as now (end of 2010) 77 Index of biological value of coal tips have been assessed. However, this method can always be improved by including other taxa with a minimal addition of time investment: e.g. Lepidoptera Rhopalocera can be studied by mean of transects (a method which is already well described in the literature; see for example LANGLOIS & GILG, 2007), as it is done on French coal tips for *Cupido minimus* (Fuessly, 1775) (Cossement B., unpublished).

The method described here is easy to implement and to repeat in different types of habitats. It provides a good starting point for a long-term and large scale monitoring of the fauna of coal tips or even with other habitats.

Acknowledgements

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