Ecological Indicators 95 (2018) 735–740

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Short Note

Applicability of butterfly transect counts to estimate species richness in different parts of the palaearctic region

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ARTICLE INFO

Keywords:
Transect counts
Butterfly richness
Butterfly diversity
Rarefaction curves

ABSTRACT

Transect counts are one of the most popular approaches to assess and monitor butterfly diversity, especially with the background of biodiversity loss. This method was developed in Europe, but its transferability is seldom tested across the world. To assess transferability, we compared butterfly richness estimates based on transect counts in Spain, Germany and central China, a region with a considerably different biogeographic history and more diverse butterfly fauna compared to Europe. We found that the efficiency of transect counts was much lower in China than in the other two regions. Apart from the fact that traditional transect counts may undersample canopy species which are predominant in central China, higher efficiency in Europe may be primarily attributed to different patterns of butterfly richness likely caused by different biogeographic and anthropogenic land-use history. Our results highlight that great caution is needed when transect count methods are transferred to other regions of the world, especially to particularly species rich areas with a high number of rare species. Low detectability of certain species can substantially mask species richness estimates, and we suggest to carefully adapt sampling effort and perhaps combine transect counts with other methods to ensure more realistic assessment of species richness in such regions.

1. Introduction

Biodiversity loss is a critical issue and halting this process is at present one of the major global challenges. To assess how biodiversity changes with global change, comprehensive monitoring schemes, especially at species, community, and habitat levels, are indispensable (Dobson, 2005; Balmford et al., 2005). Butterflies stand for one of the most frequently monitored taxonomic groups (Thomas, 2005; de Heer et al., 2005) because of their popularity among amateur naturalists, short life cycles, and their sensitivity to environmental change (Warren et al., 2001). In addition, this group has also been facing dramatic declines in the last decades (Warren et al., 2001; Van Swaay et al., 2016). Consequently, a sound technique is needed for accurate estimations of decline and its relationship to relevant drivers of global change.

There are numerous methods to assess the butterfly fauna of a given site or region (reviewed in Pellet et al., 2012; Van Swaay et al. 2015; Basset et al., 2013), but transect counts are one of the most popular methods in terms of costs, effectiveness and efficiency in butterfly studies and monitoring programs across the globe (Van Swaay et al., 2015). However, their applicability across regions differing considerably in terms of habitat type and structure, species richness and community compositional patterns and, finally, detection probability of different species is only dealt with in few studies (Walpole and Sheldon, 1999; Caldas and Robbins, 2003; Kéry and Plattner, 2007; Van Swaay et al., 2015; Basset et al., 2013).

Although there are many studies assessing butterfly richness with transect counts, only few of them evaluated the performance of transect counts outside Europe (Walpole and Sheldon, 1999; Basset et al., 2013), where they were initially invented; to the best of our knowledge, there

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https://doi.org/10.1016/j.ecolind.2018.08.027
Received 5 May 2018; Received in revised form 22 July 2018; Accepted 13 August 2018

is no work that directly analyzes transferability between Europe and other geographic regions. Because detectability can vary among habitat types and species (Isaac et al., 2011), we can assume that the effectiveness of transect counts may differ among geographic regions wherever they are associated with different habitat structures or community compositional patterns. For instance, canopy species are more difficult to observe than grassland species when conducting transect counts, which means that a higher proportion of the former in the local fauna may lead to a higher bias in richness estimates.

The purpose of this study is to test the applicability of the transect count method to estimate species richness in regions with considerable differences in the history of butterfly evolution, environmental conditions and structural complexity, and butterfly richness and community structure. With this background, we (i) assess completeness of local butterfly faunas in Germany, Spain and central China; (ii) compare the effectiveness of transect counts to estimate species richness in these three countries; and (iii) estimate the minimum effort required to reach a pre-defined minimum level of sample completeness.

2. Material and methods

2.1. Study regions

We used monitoring data from Germany and Spain, and collected data in China (see Supplementary Material Fig. S1). In China, there is no monitoring scheme covering the entire country but the first author of this paper performed standardized transect counts in the Shaanxi Foping National Nature Reserve (33.65° N, 107.80° E). This reserve is 350 km^2 and is located at the southern slopes of middle Qin Mountains, lying near the boundary between the Palearctic and the Oriental regions. For Spain, we used monitoring data from Catalonia (centre at 41.59° N, 1.52° E) covering 32,108 km^2 with marked geographical diversity and – for European conditions – high butterfly richness. For Germany, we relied on data from the national monitoring scheme, which covers the entire country. To control for potential impacts of the different spatial extents of the monitoring schemes in Germany (357,376 km^2) and Catalonia, we selected two datasets in Germany (centre at 51.16° N, 10.45° E). For the first dataset, called cluster dataset, we selected a region with comparable spatial extent as Catalonia while maximizing the number of transects within a minimum convex hull (Fig. 1A). The second dataset, hereafter called random dataset (Fig. 1B), was selected randomly across the entire set of sites of the German butterfly monitoring scheme in order to obtain a sampling effort comparable to Catalonia and China. Transect density in Europe did not allow for a reduction in spatial extent to match that of China. However, we assured comparability in terms of sampling time and total length of the transects considered (see below).

The known richnesses of the butterfly faunas of the 3 regions comprise exactly 200 species for Catalonia, about 140 species in the area covered by all transects across Germany and at least 240 species (in this study) for the Shaanxi Foping NNR in China.

2.2. Butterfly data collection

All butterfly data were based on standardized transect counts ('Pollard walk'; Pollard and Yates, 1993). Records were made of all butterflies (Papilionoidea) seen within an 'invisible box' of 5 m in front of the recorders, 2.5 m to each side and 5 m above. The investigation was paused during the time for identification of the species and subsequently resumed. Observations were documented using a butterfly net and identified to species level. The pace of walking depended on habitat, accessibility and butterfly density, but was in general approximately 2 km/h. Double counting of individuals cannot be completely ruled out, but was avoided as far as possible.

Butterfly data from China were collected in Shaanxi Foping National Nature Reserve. To avoid unsuitable weather conditions (i.e. rain), the frequency of investigation had to be reduced to once a month and, therefore, transects were visited monthly from May 1 to October 1 during 2014 and 2015. Five transects were established in the reserve. They were also subdivided into 50 m sections and covered a total length of ca. 50 km. All transect walks were carried out by the first author, who has ample experience of the regional butterfly fauna from previous projects.

Butterfly data from Germany were obtained from the German monitoring program (www.tagfalter-monitoring.de). In this program transects of variable length are deployed and subdivided into 50 m sections. Frequency of observation is every 1–2 weeks. In our study, 47 transects were covered by the cluster dataset and 125 transects by the random dataset. For means of comparability among the three regions, we only considered monitoring data from May 1 to October 1 in the

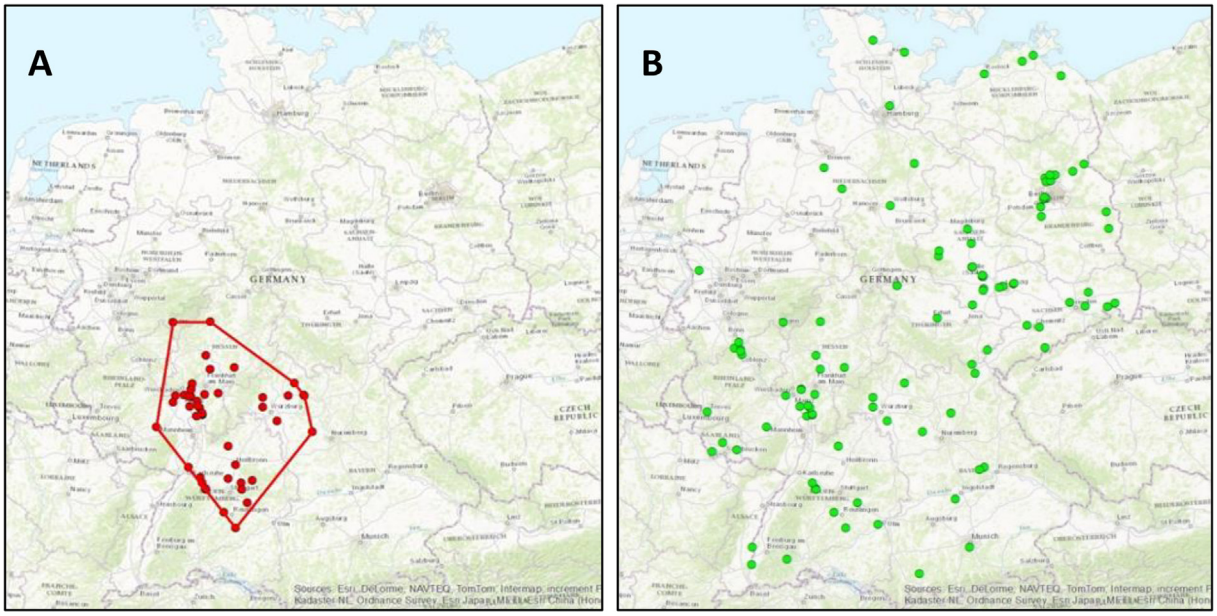

Fig. 1. A The region in Germany within a minimum convex hull that has a comparable spatial extent as Catalonia is outlined in red. The transects therein were used as cluster dataset denoted by red points. **B** Randomly selected transects, which were used as random dataset for Germany in our analysis, marked by green dots.