Ecological Indicators 58 (2015) 216–224

Contents lists available at ScienceDirect

Ecological Indicators

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

Non-lethal rapid biodiversity assessment

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ARTICLE INFO

Article history:
Received 12 February 2015
Received in revised form 29 May 2015
Accepted 1 June 2015

Keywords:
Arthropods
Morphospecies
Richness estimates
Sampling technique
Survey

ABSTRACT

For several animal taxa, non-lethal techniques that do not rely on collecting individuals are routinely used to assess biodiversity (e.g. point counts in birds). Identification often relies on the ability of the observer, are subjected to errors, but populations are not impacted. Thus, multiple counting sessions (MCS) that allow using robust analyses (e.g. unbiased Chao richness estimate) are available. However, for most species (e.g. arthropods), trap systems must be set up. Killed individuals are collected and later accurately identified in the laboratory, but unbiased MCS become unavailable. Environmental DNA bar-coding provides an alternative, yet it requires important technical support and is not designed for MCS. Lethal rapid biodiversity assessments (RBA), derived from classical trap surveys and based on less accurate identifications (morphospecies are used), have been successfully developed to relax technical constraints. In this study, we combined non-lethal and RBA approaches to address logistical, analytical and ethical issues. We tested five versions of a protocol to visually survey the macro-fauna of hedgerows. A large number of individuals were directly identified in the field, mostly arthropods but also vertebrates. Identification error varied with taxonomic level and lineage, but remained low at the morphospecies level. Importantly, estimates tended to reach asymptotes, suggesting that local richness was appropriately appraised. Like any technique, non-lethal RBA (NL-RBA) present both advantages and weaknesses, and may improve the toolbox to survey biodiversity.

1. Introduction

Most biodiversity surveys that focus on small organisms (e.g. Invertebrates) are based on lethal techniques (e.g. pitfall traps); large numbers of individuals are collected, generally killed, and later identified in the laboratory. This raises conservation and ethical concerns. Especially because most animal populations decline, including common invertebrate species (Biesmeijer et al., 2006); and because recent researches demonstrated that invertebrates are subjected to pain (Sneddon, 2004; Elwood, 2011; Magee and Elwood, 2013). Furthermore, important numbers of individuals belonging to non-targeted species are accidentally killed (by-catch) including protected species (Pearce et al., 2005). More constraining regulations that will include invertebrates are expected in the future. Testing the usefulness of alternative non-lethal (or less destructive) methods to sample biodiversity is thus timely.

Several efficient non-lethal techniques are routinely used: notably point counts and visual sampling to monitor birds, anurans, and several invertebrate species (Roy and Sparks, 2000). Because successive surveys can be performed without taking-off individuals from the environment, these techniques permit to implement multiple counting sessions (MCS) and thus to take into account species detectability, time and observer heterogeneity (Williams et al., 2002). Multiple counting sessions are essential to obtain robust estimates of species richness or abundance. Unfortunately, these techniques are currently limited to conspicuous or easily sampled taxa and to particular periods: diurnal butterflies, birds, and anurans during the breeding season notably. They remain inappropriate for the far more diverse array of cryptic organisms represented by various insects, arachnids, crustaceans, annelids or vertebrates for instance.

Environmental DNA bar-coding is an alternate technique that considerably increased the efficiency and span of field surveys (Hebert et al., 2003; Hajibabaei et al., 2007; Bohmann et al., 2014). Although highly effective in identifying species from potentially any taxonomic group, this technique offers presence/absence information (i.e. mitochondrial CO1 gene is poorly variable at the species level). It cannot provide reliable estimates of individual numbers and does not provide information regarding individual status (e.g. body size). Environmental DNA sampling is also a non-lethal technique; species are detected by the trace of their DNA on environmental samples and thus disturbance is minimized

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http://dx.doi.org/10.1016/j.ecolind.2015.06.004
1470-160X/

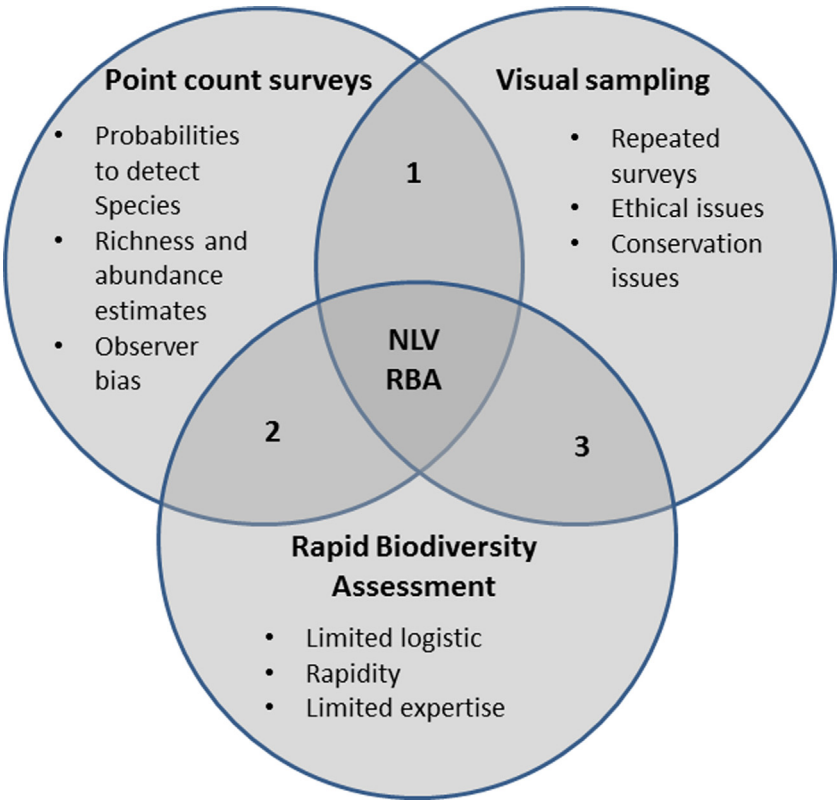

Fig. 1. Schematic position of non-lethal visual RBA (NL-RBA) relative to three approaches to survey biodiversity respectively represented with a circle. Several important features are listed. Point count surveys are limited to few taxa (e.g. birds, anurans); they allow multiple count sessions (MCS) to take into account probabilities of detection for instance. Visual samplings have been used on different taxa (e.g. butterflies), however not yet to survey cryptic terrestrial species; they do pose ethical problem. Rapid Biodiversity Assessments offer logistical advantages and are usually based on lethal trap sampling, especially to study cryptic species. Approaches are not exclusive: e.g. participative surveys (e.g. butterfly crowd survey) occupy the overlapping area #3. In this study we combined for the first time the characteristics of the three approaches, notably to survey cryptic species (central area) without capturing and killing individuals.

compared to other approaches. However, to have species names on environmental barcoding data reference, DNA barcoding library is required (Cristescu, 2014). It also entails important laboratory work, and thus necessitates substantial funds and access to relatively sophisticate technical resources. In addition, although vertebrate species are often accurately identified, name/species assignment is more problematical in other taxonomic groups (Funk and Omland, 2003; Meyer and Paulay, 2005). Thus, Environmental DNA bar-coding is currently considered as complementary to other classical approaches (DeSalle, 2006; Hajibabaei et al., 2007; Valentini et al., 2009). Using a given taxon as a surrogate to estimate other groups species richness is another alternative (Cardoso et al., 2004); but studies that incorporated a wide range of taxa (e.g. vertebrates, insects and plants) failed to support the surrogacy principle and suggested that multiple surveys are more reliable (Van Jaarsveld et al., 1998). Overall, there is no ideal sampling method to estimate biodiversity and lethal trapping is often inevitable for accurate identification of species.

Nonetheless, different studies demonstrated that, depending upon the question addressed, identification at the species level is not compulsory. Rapid biodiversity assessment (RBA) based on lethal trap systems but where individuals are assigned to morphospecies through rapid visual inspection have been successfully used in different taxa (Oliver and Beattie, 1993, 1996; Cardoso et al., 2004; Ward and Larivière, 2004; Biaggini et al., 2007; Obrist and Duelli, 2010; Braga et al., 2013). RBA are fundamentally less accurate in terms of taxonomic information compared to classical laboratory methods; they nonetheless provide useful data to picture biodiversity and they are considerably less constraining in terms of logistic. The major advantages of RBA are represented by the low cost/efficiency ratio and the relatively low level of expertise required: it is usually easier to identify individuals at the family than at the species level.

Three other potential but currently untested advantages of RBA can be listed: (1) adopting non-lethal approach, notably to survey cryptic species; (2) performing wide taxonomic surveys, e.g. monitoring invertebrates and vertebrates; (3) implementing MCS to calculate unbiased richness estimates. In this study, we combined for the first time these three potential advantages (Fig. 1). We tested five different versions of a visual protocol to survey the macrofauna in the hedgerows of cultivated fields: this type of habitat is important for biodiversity but is subjected to strong anthropogenic pressures (Baudry and Jouin, 2003; Midgley, 2012; Hooper et al., 2005). We notably focused on cryptic species (i.e. species that are difficult to observe in the field due to their camouflage, secretive lifestyle, etc.). For instance, instead of (lethal) traps we used corrugated concrete slabs positioned in the field to attract and spot cryptic animals (Bonnet et al., 1999; Ballouard et al., 2013). We also explored natural refuges (e.g. stones) and performed classical visual transects using different walking speeds. In all cases, we relied on visual determinations directly in the field and without capture. Importantly, we did not focus specifically on a particular taxonomic segment of the fauna (e.g. spiders); instead we attempted to include a wide range of taxa. To examine the usefulness of this non-lethal approach, two main issues were assessed.

(1) Does non-lethal RBA allows for the observation of sufficient numbers of morphospecies and individuals? Richness estimate analyses based on MCS were used to examine this issue.