Methods for Quantifying Pollinator Loss

Catrin Westphal, Riccardo Bommarco, Gabriel Carré, Ellen Lamborn, Nicolas Morison, Theodora Petanidou, Simon G. Potts, Stuart P.M. Roberts, Hajnalka Szentgyörgyi, Thomas Tscheulin, Bernard E. Vaissière, Michał Woyciechowski, Jacobus C. Biesmeijer, William E. Kunin, Josef Settele & Ingolf Steffan-Dewenter

To counteract the ongoing decline of pollinators, systematic and long-term pollinator monitoring schemes need to be established. Currently, several international initiatives aim at the documentation of shifts in pollinator diversity and abundance and the putative causes of these changes (São Paulo Declaration on Pollinators 1999). However, pollinator loss can only be identified if pollinator abundance and diversity are recorded with standardized sampling protocols, allowing the direct comparison of records across space and time. Within the ALARM Project, we evaluated the performance of six commonly used sampling methods with respect to their efficiency in assessing bee diversity to develop standardized sampling protocols for monitoring schemes. We focused on bee pollinators (Hymenoptera: Apiformes) since they represent the most important pollinator groups worldwide (Michener 2000).

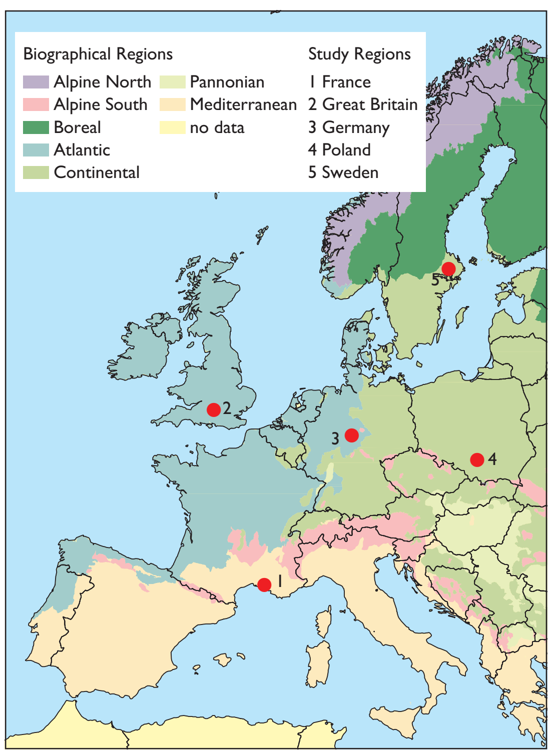

Figure 1. Overview of the study regions.

Methods tested

Using a highly standardized experimental set-up (Figure **3**), the methods were tested in five European countries (Figure **1**) and in two different habitat types: intensively managed agricultural habitats with mass-flowering annual crops and semi-natural habitats with low-level agricultural management (Figure **2**).

We analyzed the performance of three census methods: observation plots, standardized transect walks, and variable transect walks (Dafni et al. 2005, Figures **3** and **4**). In each study site, ten rectangular quadrats of 1 × 2 m were established as observation plots, in which all flowervisiting bees were recorded during 6 min observational periods. For the standardized transect walks, a permanently marked 250 m long and 4 m wide corridor (transect) was established and all bees within the corridor were collected during 50 minutes recording time. For the variable transect walks, a 1 ha plot was established. Within this plot bees were recorded at the most attractive resource patches during an observational period of 30 min. The variable transect walks were only performed in the semi-natural habitats in which the floral resources are heterogeneously distributed.

Moreover, three passive sampling methods were tested: pan traps, trap nests with reed internodes and paper tubes (Dafni et al. 2005, Figures **3** and **4**). We set up UV-bright yellow, white, and blue pan traps, which represented the prevailing floral colours of the study sites. A commonly used method to sample cavity-nesting bees is the introduction of artificial nesting substrates known as trap nests. Ten poles with two different types of trap nests were established in the semi-natural habitats from early spring to autumn. We used trap nests with reed internodes and trap nests with paper tubes (www.birdfood.co.uk). The trap nests were not established in agricultural habitats due to the frequent disturbances in crops (i.e., applications of fertilizers or pesticides and harvesting activities).

Performance of the methods

The three methods that were tested in both habitat types differed greatly in their sample coverage, which was defined as the number of species that were detected per individual method divided by the total number of species per study site. The most efficient method was the pan trap method, followed by the standardized transect walks, while the observation plots performed poorly (Figure **5a**). We found a higher sample coverage in the homogeneous and species-poor agricultural habitats than in the more heterogeneous and species-rich semi-natural habitats (Figure **5b**).

Comparing the efficiency of the methods that were tested in the semi-natural habitats, the pan traps were again the most efficient method. The second most efficient were the transect methods. In comparison with the observation plots, the trap nests with reed internodes performed relatively well despite being restricted to sampling cavity-nesting bees only. The lowest sample coverage of all methods tested was recorded for the trap nests with paper tubes (Figure **5c**).

Recommendations

We recommend UV-bright pan traps as the most suitable method for long-term and large-scale pollinator monitoring schemes, because it proved to be highly efficient at sampling the overall bee fauna and was not biased by surveyor experience. Hence, it is likely to provide reliable results when operated by many surveyors in different habitats, regions, and years. If the aim of monitoring schemes is to maximize the number of bee species recorded within a site, then trap nests with reed internodes represent a complementary, unbiased method for detecting additional species. Because of their collector bias, the transect methods can only be recommended for large-scale and long-term monitoring schemes after prior taxonomic training and standardization of surveyor experience.

Generally, the recommended methods operate efficiently in a wide range of entomophilous crops and extensively used European grassland habitats, and they may also be efficient in other habitat types and geographical regions. For all methods, the preparation and identification of the collected specimens are substantial parts of the work and thus should not be underestimated.

References

Dafni A, Kevan PG & Husband BC (2005) Practical Pollination Ecology. Enviroquest, Cambridge, Ontario, Canada.

Michener CD (2007) The bees of the world. 2nd ed. The John Hopkins University Press, Baltimore, Maryland, USA.

São Paulo Declaration on Pollinators (1999) Report on the recommendations of the workshop on the conservation and sustainable use of pollinators in agriculture with emphasis on bees. Brazilian Ministry of the Environment, Brasilia, Brazil.

Westphal C, Bommarco R, Carré G, Lamborn E, Morison N, Petanidou T, Potts SG, Roberts SPM, Szentgyörgyi H, Tscheulin T, Vaissiére BE, Woyciechowski M, Biesmeijer JC, Kunin, WE, Settele J., Steffan-Dewenter I (2008) Measuring bee biodiversity in different European habitats and biogeographical regions. *Ecological Monographs* 78: 653-671.

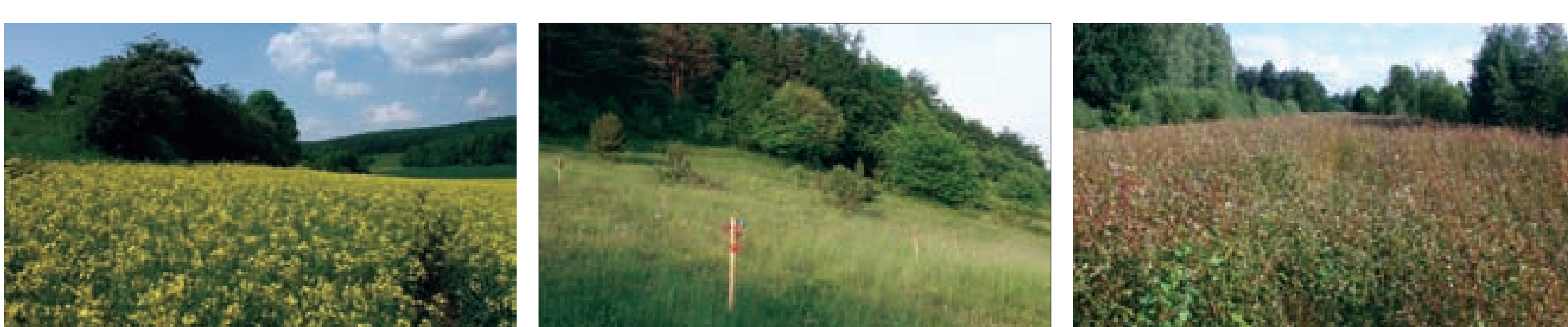

Figure 2. Examples of two study sites: an oilseed rape field and a calcareous grassland in Germany and a buckwheat field in Poland. Photos: C. Westphal and H. Szentgyörgyi.

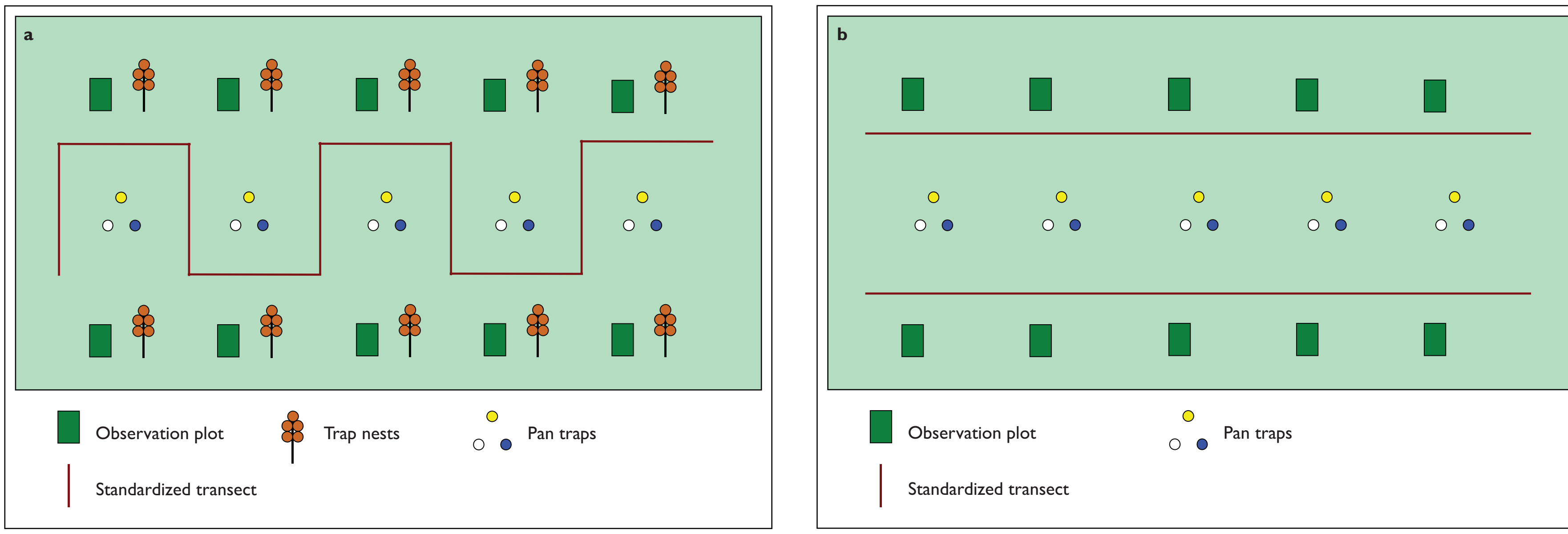

Figure 3. Standardized experimental set-up (a) in semi-natural habitats and (b) in agricultural habitats. The 1 ha plot for the variable transects is not shown. Modified from Westphal et al. (2008).

Figure 4. The tested methods: (a) UV bright pan traps, (b) observation plots, (c) transect walks, (d) trap nests and observation plot, (e) trap nests with reed internodes and paper tubes. Photos: R. Bommarco and C. Westphal.

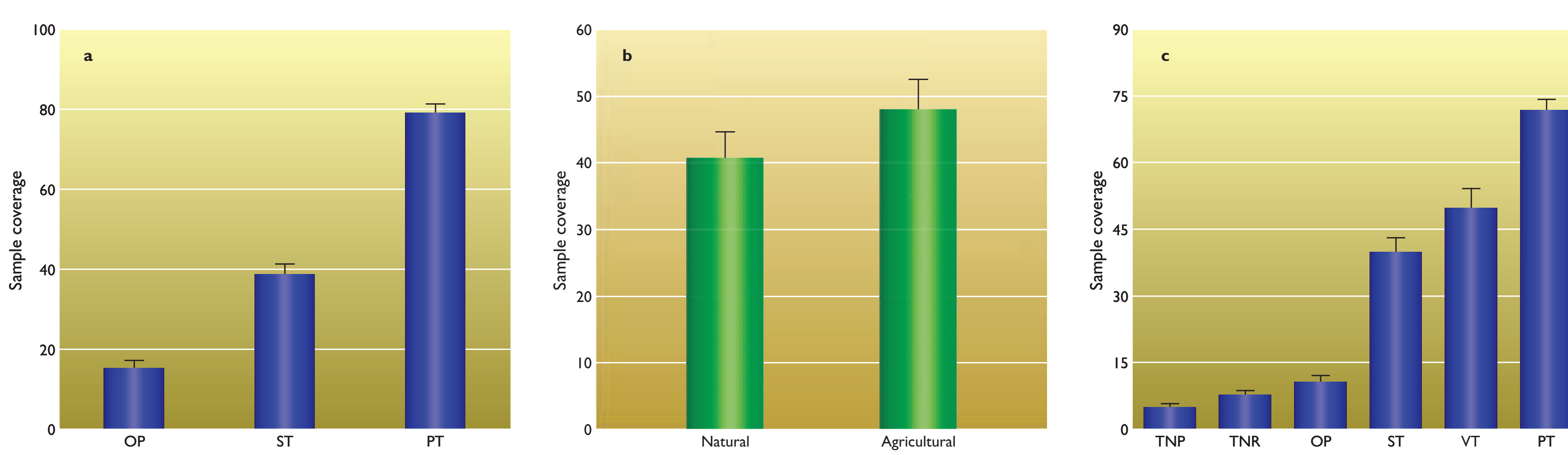

Figure 5. (a) Differences in sample coverage between the methods that were tested in both habitat types and (b) between the agricultural and semi-natural habitats. (c) Differences between the sample coverage among the methods that were tested in the semi-natural habitats. Trap nests with paper tubes (TNP) and reed internodes (TNR), observation plots (OP), standardized (ST) and variable (VT) transect walks, and pan traps (PT). Modified from Westphal et al. (2008).