Mammalian Biology 95 (2019) 26–30

Contents lists available at ScienceDirect

Mammalian Biology

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

Original investigation

Evaluating trap performance and volunteers' experience in small mammal monitoring programs based on citizen science: The SEMICE case study

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ARTICLE INFO

Article history:
Received 12 August 2018
Accepted 16 January 2019
Available online 17 January 2019

Handled by Adriano Martinoli

Keywords:
Small mammals
Volunteers
Citizen science
Experience
Monitoring

ABSTRACT

Citizen science projects have proliferated in the last decades, becoming a critical form of public engagement in science. However, monitoring based on citizen science must take special care on the analyses and/or standardization of volunteer's variation in sampling and identification skills. Key aspects such as detectability of species and ability to determine individual traits (i.e., sex and reproductive state) are expected to vary with observer's experience. We analysed how volunteer experience influenced results of a small mammal monitoring program (SEMICE) based on a standardized trapping design. This protocol aims at monitoring common species easy to catch with the two most widely used commercial live traps (Sherman and Longworth traps). We analysed sampling inaccuracies due to problems with trap performance according to trap type and observer experience, and how experience influenced the ability to determine sex and reproductive state of individuals trapped. Sampling inaccuracies were low (4.0 inaccuracies/100 traps-night) and were not influenced by experience, so that experience did not affect abundance estimates. Aptitude to sex shrews *Crocidura russula* and *Sorex* spp. was positively influenced by experience (31% sexed by short-experienced people *vs.* 78% by people with longer experience), but not for sexing rodents (> 90% individuals sexed irrespective of experience). No differences among volunteers and professionals were evident despite longer experience by professionals (9.32 ± 0.54 *vs* 18.42 ± 0.62 sampling sessions, respectively). Data collected by volunteers provided accurate information on species abundance, but less information than professionals provided for some biological traits such as shrews' sex and reproductive condition. Effect sizes of experience were small enough to utilize volunteer's data to obtain unbiased monitoring results. Overall, the SEMICE protocol can be validated for its use as a small mammal monitoring program based on citizen science.

Introduction

Monitoring programs are essential tools to estimate ecosystem response to global change drivers (McGill et al., 2015), as well as to evaluate the performance of conservation policies aimed at stopping human-driven biodiversity change (EEA, 2010, 2012; Díaz and Concepción, 2016). Drivers (changes in climate, land use, atmosphere and soil composition) act at global scales and show a high spatiotemporal heterogeneity (Sirami et al., 2017), so that detecting their influences on biodiversity requires large spatial replication of monitoring programs, as well as ensuring its long-term maintenance (Munson et al., 2010).

Support for long-term monitoring programs by means of projects funded by national or international research agencies (e.g. the Spanish Research Agency, the European Research Council or the American Science Foundation) is seriously hampered because of limited resources and short- rather than long-term funding strategies (Hall, 2002). The global economic crisis has further directed funding to provide quick answers to urgent applied questions (Cagnacci et al., 2012). Fortunately, citizen science projects have proliferated in the last decades, becoming a critical form of public engagement in science. These projects are an increasingly important research tool, especially for the study of large-scale patterns in nature (Dickinson et al., 2010). Citizen science provides replicated information on ecological systems at unprecedented spatial reso-

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https://doi.org/10.1016/j.mambio.2019.01.004
1616-5047/

lution, maintained over long timescales (see Bonney et al., 2009 for selected examples). Monitoring programs based on citizen science may thus overcome research funding limitations, as far as methods for data gathering, processing and submission are standardized and tested to ensure its validity (Dickinson et al., 2010; Cagnacci et al., 2012).

Monitoring requires the development of standardised sampling protocols for target groups (e.g. Satterfield et al., 2017; Voříšek et al., 2010). Key aspects of standardisation such as detectability of target species and ability to determine individual traits such as sex or reproductive state are expected to vary with observer's experience (Dickinson et al., 2010). Hence, monitoring based on citizen science must take special care on the analyses and/or standardization of volunteer's variation in sampling and identification skills.

Here we analyse how volunteer experience influences results of a monitoring program for small mammals based on a standardized trapping design, the SEMICE protocol (Torre et al., 2016, 2018). Specifically, we analyse (1) whether experience influences trapping efficiency (measured as the proportion of inaccuracies due to problems with trap performance such as accidental sprung, escapes or death rates); (2) how experience influences the ability to determine sex and reproductive status of trapped individuals; and (3) whether volunteers and professionals differ in sampling skills. We expect a general improvement of trapping efficiency and observer performance with increasing experience, as well as effect sizes of experience small enough to utilize volunteer's data to obtain unbiased monitoring results. If this was true, the SEMICE protocol will be validated for its use as a small mammal monitoring programs based on citizen science. In addition, this result can provide important indications about the suitability of using volunteers in small mammal monitoring programs, thus encouraging the launch of volunteers-based monitoring projects.

Material and methods

We used the information generated by the SEMICE monitoring scheme (Torre et al., 2016, 2018, for details of sampling design), which has been operative from 2008 until present in 107 sampling stations situated in Spain and Andorra. The SEMICE live-trapping scheme consists in two annual trapping sessions (spring-summer, from April to August, and fall, from October to December) spanning three days each. Sessions are based on grids of 36 traps (6×6, spaced 15 m) with a single trap type (Sherman) or two types (Longworth and Sherman) arranged in intercalated positions. The program is aimed at monitoring common small mammal species with high detectability to compute reliable estimates of population change (Torre et al., 2018). SEMICE is based partly on the participation of volunteers, which work in the monitoring program without any economic profit. All volunteers were trained with both theoretical and practical sessions (Barlow et al., 2015) until they are able to maintain a sampling station autonomously. Volunteers were trained during at least one three-days sampling session under the supervision of an experienced investigator. Volunteers participated in 4.42 (1–28) sampling sessions on average (including training). Professionals, who are hired to work in the SEMICE protocol, participated in 54.6 (6–232) sampling sessions between 2008 and 2017. A single professional (the program coordinator) was in charge of 24 stations and participated in 9.6 sampling sessions per station, on average. Traps and all additional material, like spring balances (100 g and 500 g), numbered ear-tags and pliers, waterproof cotton for bedding, tweezers, scissors, Eppendorf containers for tissue samples, etc., were provided to volunteers. Formative supplementary material (record sheets, identification keys, tutorials) was available from the web of the project (www.semice.org).

All volunteers, as well as scientific and technical coordinators, uploaded trapping information from February 2016 onwards, when the web of the project was made operational. At present, complete information is available from the four trapping campaigns performed between spring 2016 and fall 2017, involving 64 sampling stations (42 operated by volunteers and 22 by professionals). These data were downloaded from the database containing a total of 14,484 records (February 2018) in a. csv file that was processed with Microsoft Excel.

First, we analysed performance of the two types of traps used (Longworth and Sherman) working simultaneously in alternate position within plots. Sampling efficiency for small mammal inventories and communities was analysed elsewhere (Torre et al., 2016, 2018). We here focus on sampling inaccuracies related to problems with trap performance according to trap type and observer experience. Estimates of the relative abundance of small mammals depend on accurate estimates of sampling effort, that are affected by several inaccuracies (Beauvais and Buskirk, 1999). We defined three kinds of inaccuracies: 1) closed traps, that were found closed (sprung) but without any capture; 2) open traps with signs, that were open (not sprung) but showed clear evidences of use by small mammals (i.e. faeces, cotton removed, etc.); 3) other inaccuracies, when traps were moved or attacked by large animals (i.e., carnivores or wild boars *Sus scrofa*). These three kinds of inaccuracies were summed into a "Total inaccuracies" variable. Also, we considered 4) escapes, that is, animals that escaped from the trap before being handled; and 5) deaths, animals found dead within traps. This information was only available for sampling sessions performed in the last two years (2016 and 2017; see above). A large amount of information was collected by a single experienced investigator (59 sampling sessions from 16 stations). We used data for this observer to obtain baseline estimates for differences among trap types according to inaccuracies affecting its performance. Data were analysed by means of Wilcoxon Matched Pair Tests (WMP Test) for dependent samples, considering inaccuracies of the two types of traps by trapping campaign.

Aptitudes of people involved in the SEMICE program were classified considering their experience according to the number of sampling sessions they have carried out from 2008 to 2017. We considered non-experienced people those who carried out 1–3 sampling sessions, people with intermediate experience those who carried out 4–16 sampling sessions, and experienced people those who carried out more than 17 sampling sessions. These quantities were translated into years of experience bearing in mind that, for a person in charge of a single station, two sampling sessions (spring and fall) will represent a year of experience. We analysed whether trapping performance was influenced by the experience of people in charge of the stations using the same variables as above (five variables). Aptitudes to sex and establish the sexual condition of shrews and rodents were also analysed. Shrews can be sexed with difficulty (even during preparation of museum specimens; Carraway, 2009) when secondary sexual traits (i.e. nipples in females, musk glands in males) were not fully developed, since shrews have a unique urogenital external hole (Churchfield, 1990). Rodents can be always sexed since the external position of genitalia is always well separated from the anus (especially in Muridae, which are the bulk of captures in the SEMICE project; Torre et al., 2018). Apart from sexing, in the case of rodents, we also used information provided on sexual condition (i.e. the location -scrotal/abdominal- of testes in males; open/closed vagina, pregnancy signs, or the presence of nipplesin females; Gurnell and Flowerdew, 2006).

Statistical analyses considered five variables related to trap performance, four variables related to abilities to establish sex and sexual condition, and the fixed factors "experience" (three levels), "volunteer" (two levels), and "sampling design" (two levels: mixed type Longworth-Sherman, single type: Sherman). Response vari-

Table 1
Trap inaccuracies detected under the SEMICE small mammal monitoring scheme by Sherman and Longworth traps intercalated in position in 16 mixed live-trapping plots working in 118 sampling sessions (Closed: trap sprung without capture; Open: trap not sprung; Other: trap moved, lying on a side, attacked by large mammals). We used data for a single professional observer to obtain baseline data for differences among trap types according to inaccuracies affecting its performance. Variables expressed in events / 100 traps-night. WMPT: Wilcoxon Matched Pair Tests.

VARIABLES	LONGWORTH		SHERMAN			
	Mean	SD	Mean	SD	WMPT	P
Closed	0.75	1	2.23	2.02	5.02	0.0001
Open	0.06	0.23	0.63	0.97	4.17	0.0001
Other	0.41	0.82	0.21	0.71	1.63	0.1
Total inaccuracies	1.23	1.37	3.08	2.36	5.2	0.0001
Captures	6.53	6.96	5.36	4.96	1.69	0.09
Traps available	92.23	7.38	91.55	6.6	1.2	0.22

ables were modelled with Generalized Linear Models (GLZs), since most variables were counts of rare events greatly departing from normal distributions. Accordingly, we used the negative binomial distribution as the link function of models (O'Hara and Kotze, 2010). Variables were expressed in units/100 traps-night, to account for differences in sampling intensity performed between stations. Binomial variables related to proportions (i.e. sexed/non-sexed) were analysed by means of log-linear models for contingency tables considering "experience" as a factor, and their interaction.

Results

During 2016–2017 a total of 799 inaccuracies for 21,348 traps-night (3.74%) were reported in 177 sampling sessions corresponding to 55 different stations in the Iberian Peninsula (Spain and Andorra; mean: 3.62 inaccuracies/100 traps-night; range: 0–25). GLZs showed that trapping inaccuracies were mostly influenced by experience (Wald = 26.30, df = 7, P < 0.0001) and by trapping design (Wald = 18.41, df = 1, P < 0.0001), once controlling for sampling effort (Wald = 0.12, df = 1, P = 0.72). The "volunteer" effect was not significant (Wald = 1.66, df = 1, P = 0.19). This lack of effect was interesting owing that volunteers showed less experience than professionals (9.32 ± 0.54 *vs* 18.42 ± 0.62 sampling sessions, respectively: Wald = 119.61, df = 1, P < 0.0001). Higher inaccuracies were detected for less experienced people (1 year: 5.60 ± 1.42 inaccuracies/100 traps-night), but also for people with long experience (10 years: 7.59 ± 1.77 inaccuracies/100 traps-night), with intermediate values for people with intermediate experience. Escapes before handling decreased with experience (Wald = 38.84, df = 2, P < 0.0001) and in single-Sherman as compared to mixed type Longworth-Sherman trap designs (Wald = 28.74, df = 1, P < 0.0001). Two-trap design (1.52 ± 0.38 in./100 traps-night) showed lower inaccuracies than the single-Sherman design (6.67 ± 2.07 in./100 traps-night). Sherman traps showed higher inaccuracies than Longworth traps in sampling stations with the two trap types working together in alternate positions (Table 1). In this latter case, we recorded 293 inaccuracies per 13,896 traps-night in 118 sampling sessions (16 two-trap-types stations) conducted by a single professional during the same period in Catalonia and Andorra (NE Iberian Peninsula mean: 2.16 in./100 traps-night; range: 0–12.04 in./100 traps-night). Sherman traps showed more inaccuracies than Longworth traps working in alternate positions within live-trapping grids (Table 1). Significant differences were detected in the case of closed traps without captures, and in the case of open traps with evidences of small mammals that entered traps but were not actually captured. Nonetheless, despite these differences, the number of traps involved in inaccuracies was very small, barely influencing the possibility of additional captures. After all, both Sherman and Longworth traps showed roughly similar number of captures.

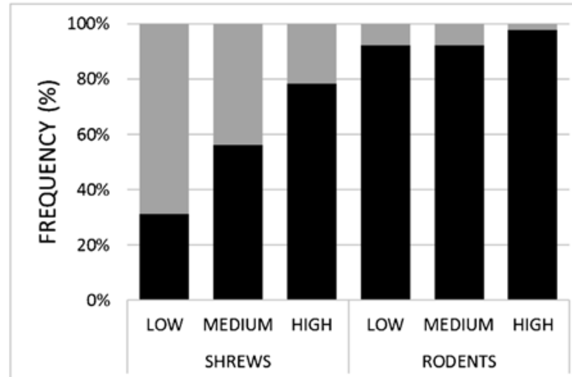

Fig. 1. Proportion of shrews and rodents attempted to sex (black) according to the experience of people (low, medium, and high) involved in the SEMICE monitoring program.

Besides, lower inaccuracies for Longworth traps did not result in higher numbers of traps available for trapping additional individuals (92.23 and 91.55 traps available/100 traps-night, for Longworth and Sherman traps, respectively), and differences were irrelevant considering the low average trapping success (5.36 and 6.53 in./100 traps-night, respectively). Small mammals' escapes before trap handling and death casualties were also very infrequent and similar for both kinds of traps (WMPT: Z = 0.59, p = 0.55, n = 7 non-tied pairs; WMPT: Z = 0.15, p = 0.87, n = 23 non-tied pairs; respectively).

During 2016–2017 we captured 418 shrews (*Crocidura russula* and *Sorex* spp.) in 78 sampling sessions corresponding to 35 different stations. Volunteers attempted sexing shrews half the occasions than professionals did (45% *vs* 82%, respectively). Attempts to sex shrews increased with experience from 31% to 78% (interaction sex x experience: G_2 = 40.78, p < 0.0001, Fig. 1), with higher proportion of shrews non-sexed in the case of people with short experience (<= 3 sampling sessions: Chi^2_1 = 36.51, p < 0.0001; 4–16 sampling sessions: Chi^2_1 = 61.19, p < 0.0001; respectively), and higher proportion of shrews sexed in the case of more experienced people (>17 sampling sessions: Chi^2_1 = 53.23, p < 0.0001). In the case of the short-experienced people, 62 out of 123 captures (50.40%) were not sexed, and, when sexed, 47.36% of individuals were not assigned to a sexual condition class. In the case of long-experienced people, 64 out of 231 captures (27.75%) were not sexed, and, when sexed, 31.1% of individuals were not assigned to a sexual condition class. Further, we captured 1801 individual rodents (families Muridae, Microtidae and Gliridae) in 145 sampling sessions corresponding to 54 different stations. Volunteers attempted to sex almost all individuals, as professionals did (92% *vs* 97%, respectively). Attempt to sex rodents was also influenced by experience (interaction sex x experience: G_2 = 27.76, p < 0.001), with higher proportion of rodents non-sexed for short-experienced people (Chi^2_1 = 6.90, p < 0.01), and higher proportion sexed for long-experienced people (Chi^2_1 = 18.10, p < 0.01). In the case of less experienced people, 74 out of 942 captures (7.85%) were not sexed. For long-experienced people, only 20 out of 868 captures (2.32%) were not sexed (mostly due to errors in data transcription from field book-notes to the web application). From the individuals that were sexed, 23.78% were not assigned to a sexual condition class in the former. For long-experienced people this number was significantly lower (11.41%).

Discussion

In a former study we showed the utility of the SEMICE monitoring scheme in detecting trends of common small mammal species (Torre et al., 2018). Since the data obtained by that monitoring scheme was partly collected by volunteers, we further investigated the aptitude of volunteers when setting trap devices and when obtaining biological information when handling small mammals. Setting traps incorrectly will increase the number of inaccuracies within sampling sessions, thus biasing estimates of species abundances. Hence, it is necessary to control for sampling inaccuracies (i.e. sprung traps) to obtain accurate estimates (Beauvais and Buskirk, 1999). On the other hand, establishing sex and sexual condition in shrews and rodents offer additional information to model and interpret their population dynamics and demography. Some authors recognised that accurate training and use of standardised methods are crucial to the success of volunteer surveys (Newman et al., 2003). However, data collected by volunteers still can be biased (Dickinson et al., 2010), so that it is essential to assess the quality of the information collected and the influence of experience on this quality (Battersby, 2005). Several monitoring programs have shown that species' detectability increase with experience due to the improvement of identification skills (Jiguet, 2009). One of the advantages of using a standardised live-trapping protocol is that species' detectabilities (i.e. the capture of a species when it is present) are intrinsic to trapping devices and species' behaviour (i.e. trap-shy *vs* trap-happy species, hypogeous *vs* epigeous species, etc.), and are mostly independent to observer' skills. Detection probabilities for common small mammal species are high under the SEMICE scheme, hardly influencing occupancy estimates (Torre et al., 2016, 2018). Nonetheless, skills will be necessary for correct identification when captures are handled. Besides, incorrectly setting trapping devices will bring biased estimates of species' abundances when sampling inaccuracies are important (i.e. less individuals detected than present due to trap failure). Unexpectedly, volunteers (with shorter experience) incurred in less inaccuracies than more experienced professionals. Sampling inaccuracies reached small values on average (4.0 inaccuracies/100 traps-night) barely influencing abundance estimates due to low trapping success during the study period, which left a large number of empty traps available. Population abundance of some common small mammals showed a significant decline between the years 2008 and 2017 (Torre et al., 2018, authors unpub.), so that these results were produced in a period of minimum small mammal abundance. Being aware that in periods of low abundance competence for traps may be trivial, in periods of high abundance trap failure may result in population underestimation due to lower trap availability (Beauvais and Buskirk, 1999). Besides, captures and inaccuracies were associated, albeit showing a weak correlation ($r = 0.28$, $p < 0.05$, $r^2 = 0.07$), suggesting that small mammal activity increased sampling inaccuracies. However, as far as inaccuracies are concerned, we are confident that information collected by either volunteers or professionals showed no significant bias. Slightly higher inaccuracies were observed for professionals since some local stations experienced attacks by wild boars (Collserola Natural Park, Barcelona), increasing the number of sprung traps.

In a next step, skills will be necessary for species identification and sexual determination once individuals are captured. Sexual determination can be challenging in shrews when there are no external evidences of breeding, thus resulting in higher error rates (Carraway, 2009). Our results suggested that experience played a significant role in attempting to sex shrews: Short-experienced people were unable to assign sex to less than a half of captured shrews (44.85%), whereas long-experienced people were able to attempt sexing 81.91% of the individuals captured. These results agreed with the fact that experience will improve the ability to correctly sex live shrews (Croin Michielsen, 1966). This was not the case for rodents, since almost all individuals were sexed (> 90%) but showing subtle (but significant) differences between volunteers and professionals. These differences could be due to the difficulties to sex young individuals by short-experienced people. Unfortunately, we have no way to test if volunteers (and professionals) correctly determined sex and sexual condition of individuals handled. Indeed, our results showed the degree of self-confidence of volunteers and professionals to attempt sexing shrews and rodents. Obviously, self-confidence will improve with experience as far as more individuals are handled and attempted to sex. In the interim, training resources will be necessary to ensure that volunteers gain the skill levels required to complete the different surveys (Barlow et al., 2015).

Summarising, the data collected by volunteers was of high quality at the quantitative level (i.e. providing unbiased and accurate information on species abundance), but low at the qualitative level (i.e. providing less information than professionals for some biological traits of individuals). Nonetheless, volunteers' work increased the number of monitoring sites, a fact that enhances the sensitivity of the monitoring scheme for detecting changes in small mammals' numbers (Flowerdew et al., 2004). Effect sizes of experience were small enough to utilize volunteer's data to obtain unbiased monitoring results. Hence, the SEMICE protocol, and probably other similar protocols based on standardized trapping schemes, can be used as monitoring program based on citizen science. This result encourages the launch of volunteers-based monitoring projects for small mammals, and provides a standardized method for checking their accuracy.

Acknowledgements

We are indebted to all SEMICE coordinators and volunteers. Diputació de Barcelona and Parc de Collserola (and their technical staffs), gave financial and logistic support during the study period [2008–2018], allowing the establishment of the small mammal monitoring scheme in their Natural Parks network. The project SEMICE was incorporated in the Biodiversity inventories by the Spanish Ministry of the Environment and received financial support from that Institution from years 2011–2013. The project SEMICE benefitted from a grant to the Spanish Society of Conservation and Study of Mammals (SECEM) by Fundación Biodiversidad from the Ministerio de Agricultura, Alimentación y Medio Ambiente de España [2015]. We are especially grateful to Luis J. Palomo for his support during the preparation of the project, and for advancing funds through the SECEM institution. The comments of two anonymous reviewers improved the final version of the article.

References

Barlow, K.E., Briggs, P.A., Haysom, K.A., Hutson, A.M., Lechiara, N.L., Racey, P.A., Walsh, A.L., Langton, S.D., 2015. Citizen science reveals trends in bat populations: the National Bat Monitoring Programme in Great Britain. Biol. Conserv. 182, 14–26, http://dx.doi.org/10.1016/J.BIOCON.2014.11.022.
Battersby, J.E., 2005. UK Mammals: Species Status and Population Trends. In: First Report by the Tracking Mammals Partnership.
Beauvais, G.P., Buskirk, S.W., 1999. Modifying estimates of sampling effort to account for sprung traps. Wildl. Soc. Bull. 27, 39–43.
Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V., Shirk, J., 2009. Citizen science: a developing tool for expanding science knowledge and scientific literacy. BioScience 59 (11), 977–984.
Cagnacci, F., Cardini, A., Ciucci, P., Ferrari, N., Mortelliti, A., Preatoni, D., Amori, G., 2012. Less is more: researcher survival guide in times of economic crisis. Hystrix 23 (2), 1–7.
Carraway, L., 2009. Determining sex of Sorex shrews (Soricomorpha: soricidae). Am. Midl. Nat. 162, 87–97.
Churchfield, S., 1990. The Natural History of Shrews. Christopher Helm, London.
Croin Michielsen, N., 1966. Intraspecific and interspecific competition in the shrews Sorex araneus L. and S. minutus L. Arch. Néerland. Zool. 17, 73–174.
Díaz, M., Concepción, E.D., 2016. Enhancing the effectiveness of CAP greening as a conservation tool: a plea for regional targeting considering landscape constraints. Curr. Landsc. Ecol. Rep. 1, 168–177.
Dickinson, J.L., Zuckerberg, B., Bonter, D.N., 2010. Citizen science as an ecological research tool: challenges and benefits. Annu. Rev. Ecol. Evol. Syst. 41, 149–172, http://dx.doi.org/10.1146/annurev-ecolsys-102209-144636.
Environment Agency (EEA), 2010. Assessing Biodiversity in Europe — The 2010 Report. EEA, Copenhagen, 45 pp.

European Environment Agency (EEA), 2012. Streamlining European Biodiversity Indicators 2020: Building a Future on Lessons Learnt from the SEBI 2010 Process. EEA, Copenhagen, 50 pp.

Flowerdew, J.R., Shore, R.F., Poulton, S.M.C., Sparks, T.H., 2004. Live trapping to monitor small mammals in Britain. Mamm. Rev. 34, 31–50, http://dx.doi.org/10.1046/j.0305-1838.2003.00025.x.

Gurnell, J., Flowerdew, J.R., 2006. Live Trapping Small Mammals. A Practical Guide. The Mammal Society.

Hall, B.H., 2002. The financing of research and development. Oxf. Rev. Econ. Policy 18, 35–51.

Jiguet, F., 2009. Method learning caused a first-time observer effect in a newly started breeding bird survey. Bird Study 56, 253–258, http://dx.doi.org/10.1080/00063650902791991org/10.1080/00063650902791991.

McGill, B.J., Dornelas, M., Gotelli, N.J., Magurran, A.E., 2015. Fifteen forms of biodiversity trend in the Anthropocene. Trends Ecol. Evol. 30 (2), 104–113.

Munson, M.A., Caruana, R., Fink, D., Hochachka, W.M., Iliff, M., Rosenberg, K.V., et al., 2010. A method for measuring the relative information content of data from different monitoring protocols. Methods Ecol. Evol. 1 (3), 263–273.

Newman, C., Buesching, C.D., Macdonald, D.W., 2003. Validating mammal monitoring methods and assessing the performance of volunteers in wildlife conservation: “Sed quis custodiet ipsos custodies?” Biol. Conserv. 113, 189–197, http://dx.doi.org/10.1016/s0006-3207(02)00374-9.

O’Hara, R.B., Kotze, D.J., 2010. Do not log-transform count data. Methods Ecol. Evol. 1, 118–122, http://dx.doi.org/10.1111/j.2041-210X.2010.00021.x.

Satterfield, L.C., Thompson, J.J., Snyman, A., Candelario, L., Rode, B., Carroll, J.P., 2017. Estimating occurrence and detectability of a carnivore community in Eastern Botswana using baited camera traps. Afr. J. Wildl. Res. 47 (1), 32–46, http://dx.doi.org/10.3957/056.047.0032.

Sirami, C., Caplat, P., Popy, S., Clamens, A., Arlettaz, R., Jiguet, F., et al., 2017. Impacts of global change on species distributions: obstacles and solutions to integrate climate and land use. Glob. Ecol. Biogeogr. 26 (4), 385–394.

Torre, I., Freixas, L., Arrizabalaga, A., Díaz, M., 2016. The efficiency of two widely used commercial live-traps to develop monitoring protocols for small mammal biodiversity. Ecol. Indic. 66, 481–487, http://dx.doi.org/10.1016/j.ecolind.2016.02.017.

Torre, I., Raspall, A., Arrizabalaga, A., Díaz, M., 2018. SEMICE: an unbiased and powerful monitoring protocol for small mammals in the Mediterranean Region. Mamm. Biol. 88, 161–167, http://dx.doi.org/10.1016/j.mambio.2017.10.009.

Voříšek, P., Klvaňová, A., Wotton, S., Gregory, R.D., 2010. A Best Practice Guide for Wild Bird Monitoring Schemes. Brussels, European Union.