Österreich forscht

www.citizen-science.at

wasser cluster lunz

Austrian Citizen Science Conference 2016

Lunz am See, Austria

February 18-19, 2016

www.citizen-science.at

BOKU

Ludwig Boltzmann Gesellschaft

bmwfw
Bundesministerium für Wissenschaft, Forschung und Wirtschaft

frontiers Abstract Book

AUSTRIAN CITIZEN SCIENCE CONFERENCE 2016

Citizen Science – Quo vadis?

ISBN: 978-2-88945-005-3

DOI: 10.3389/978-2-88945-005-3

Edited by Florian Heigl, Daniel Dörler, Gabriele Weigelhofer and Johann G. Zaller

February 18-19, 2016, WasserCluster Lunz am See, Austria.

Austrian Citizen Science Conference 2016, February 18-19, 2016, Lunz am See, Austria

Citizen Science is gaining momentum in various scientific fields. Under the motto “Citizen Science – Quo vadis?”, the platform www.citizen-science.at and the Wassercluster Lunz welcomed stakeholders from science, humanities and economy to present and discuss their citizen science projects and initiatives. The aim of the conference was to further increase the quality of citizen science in Austria and to demonstrate, to what extent this method can generate scientifically robust results. The conference featured international keynote speakers, oral presentations and a poster session. Workshops and a mini bar camp addressed urging questions regarding data quality, developments and challenges for citizen science in Austria and beyond.

We thank all our participants for traveling to the conference venue in the beautiful Lunz am See and for the lively discussions. Special thanks go to our keynote speakers and the participants who gave a talk or presented a poster – a selection of their contributions is compiled in this book of abstracts.

We are also grateful to the Federal Ministry of Science, Research and Economy and the Ludwig Boltzmann Gesellschaft for their financial support.

Last but not least we would like to thank the many helping hands at the Wassercluster Lunz for the excellent organisation of the conference and the accompanying social events that considerably contributed to the success of this meeting.

Looking forward to seeing you all at the next Austrian Citizen Science Conference 2017, the organizing committee

Florian Heigl, Daniel Dörler, Gabriele Weigelhofer and Johann G. Zaller

Table of Contents

05 Citizen science: advantages of shallow versus deep participation

08 The impact of outdoor lighting on ecosystem function – gaining information with a Citizen Science approach using a questionnaire

14 Hedgehogs on their way – citizen scientists discover wildlife in their backyard

19 Where pathways cross: citizen science project StadtWildTiere in Vienna, Austria

24 The scientific value of small mammal observation reports – the project GeoMaus

27 Addressing bumblebee faunistic and ecology using Citizen Science – reviewing a 2-year experience

31 Checking snails – pupils as snail watchers

35 The CAPTOR project: joint efforts reducing ozone pollution

39 Factors influencing data quality in citizen science roadkill projects

44 Data quality in citizen science projects: challenges and solutions

51 Artistic knowledge production for another planet? Participation as cultural practice and scientific approach for quality enhancement in citizen science

Citizen science: advantages of shallow *versus* deep participation

Steven Loiselle, Ian Thornhill, Neil Bailey

Earthwatch Institute, Oxford, UK
loiselle@unisi.it

The participation of non-experts in the acquisition or analysis of scientific data (citizen science) is a major opportunity for environmental scientists and agencies. In recent years, web and mobile technologies have enabled the proliferation of such programmes with studies showing that they provide a range of benefits. Citizen science projects can deliver increased temporal and spatial resolutions of key environmental data that strengthen research on ecological dynamics and environmental conditions. Another major benefit is an increased engagement in environmental management by members of the public and an increased awareness of the importance of research and monitoring (Dickinson et al., 2013). A central aspiration of citizen science is to create an informed community that supports sustainable environmental management (Conrad and Hilchey, 2011).

These dual objectives, social and scientific, would initially appear to be complimentary; an increased public participation in data gathering should result in both increased social capital and an expanded information base. However, in the design of citizen science projects, an important compromise is often made between participation and data quality, for example, raising awareness through mass participation across a larger geographical/temporal space *versus* gaining more robust, repeat measurements from fewer “expert” citizen scientists. This trade-off assumes a learning curve, where the proficiency of the person repeating the same measurements improves along with their knowledge and understanding of the data acquired (Jaber and Glock, 2013). A project with expert citizen scientists should have a relatively higher data quality compared to projects with a higher number of participants with limited experience. On the other hand, a larger number of people involved in the data gathering results in greater public engagement and awareness.

The number of participants to include in a citizen science project and the duration of their commitment are also economic ones. Training and equipping citizen scientists has a per capita cost, and longer term projects require feedback and post-training of citizen scientists by the project initiator (scientist, agency, and association) to provide recognition and a continuous learning environment.

FreshWater Watch is a global citizen science programme exploring freshwater ecosystem dynamics in 30 local projects in 20 countries. To date, over 15,000 datasets have been collected by more than 2,000 citizen scientists working in teams (average 3.2 participants per team). These measurements support local research priorities and agency monitoring as well as comparative freshwater studies undertaken by an international network of freshwater scientists (Castilla et al., 2015).

We analysed the data from FreshWater Watch to explore the relationship between projects in terms of participation (more users taking fewer measurements) and data quality (more measurements taken per user). Projects were grouped together into countries, and only projects with at least 100 datasets were considered. France, Singapore, and the UK were seen to have the most measurements per user, allowing for more experience per measurement and therefore a potentially higher measurement quality. Malaysia, Mexico, Brazil, China, the USA, and India had relatively few repeat measurements per active participant (Figure 1). Indonesia was excluded from the present analysis as the highly elevated number of samples per user (31) was considered a far outlier.

This information becomes even more interesting when viewed from the point of view of engagement level, the number of participants active in each measurement event with respect to the number of users trained. In this case, there was an exceptionally high level of engagement in Singapore, Brazil, and Mexico and a lower than average level in France, the UAE, and Australia. Interestingly, many projects showed an engagement level near or above 1, where the number of persons participating in the measurement events was higher than the number of persons trained. This suggests that the programme was successful at reaching a wider audience than those originally trained.

The projects which combined above average measurements per user and wide engagement were the UK, Singapore, and Canada. Projects with high levels of engagement and moderate levels of measurements per user were located in Brazil, Mexico, Malaysia, Argentina, China, India, and the USA. It should be noted that relative differences in data quality between projects are only speculative, given that all data are quality controlled and corrected by users, initiators, and Earthwatch once uploaded to the online database.

Interestingly, projects in the UK, France, and Canada allowed participants to self-select sampling sites, while sampling sites were assigned to participants by the project initiators in Malaysia, Argentina, Mexico, Brazil, and China. This may indicate that self-selection favours repetition (e.g., adoption of a site), while assigned sites favour increased participation (multiple users adopting the same site).

The design of citizen science projects should consider both objectives of data quality and goals related to engagement and awareness. In the FreshWater Watch, sampling methods and training follow a common approach. However, projects showed a range of outcomes with respect to engagement and potential data quality. This is a result of differences in the sampling design between individual projects. Ultimately, a successful citizen science project balances engagement and scientifically robust data acquisition by situating itself on the nexus between the two. Providing multiple points of entry for participants interested in limited engagement and for those interested in more commitment provides options to meet both goals.

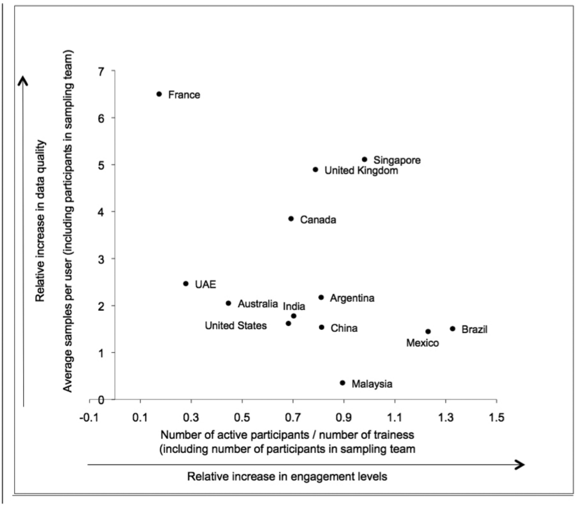

FIGURE 1: Comparing FWW engagement levels and number of samples per participant across 13 FWW local projects (>100 datasets).

Keywords: awareness, engagement, freshwater, data quality, long-term projects

REFERENCES

Castilla, E. P., Cunha, D. G. F., Lee, F. W. F., Loiselle, S., Ho, K. C., and Hall, C. (2015). Quantification of phytoplankton bloom dynamics by citizen scientists in urban and peri-urban environments. *Environ. Monit. Assess.* 187, 1–11. doi: 10.1007/s10661-015-4912-9 PMID:26471276

Conrad, C. C., and Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environ. Monit. Assess.* 176, 273–291. doi: 10.1007/s10661-010-1582-5 PMID:20640506

Dickinson, J. L., Crain, R. L., Reeve, H. K., and Schuldt, J. P. (2013). Can evolutionary design of social networks make it easier to be 'green'? *Trends Ecol. Evol.* 28, 561–569. doi: 10.1016/j.tree.2013.05.011 PMID:NOPMID

Jaber, M. Y., and Glock, C. H. (2013). A learning curve for tasks with cognitive and motor elements. *Comput. Ind. Eng.* 64, 866–871. doi: 10.1016/j.cie.2012.12.005 PMID:NOPMID

The impact of outdoor lighting on ecosystem function – gaining information with a Citizen Science approach using a questionnaire

Sibylle Schroer[1], Katja Felsmann[1], Franz Hölker[1], Stephan Mummert[2], Michael T. Monaghan[1,3], Christian Wurzbacher[1,3], Katrin Premke[1]

[1]*Leibniz Institute of Freshwater Ecology and Inland Fishery (IGB), Berlin, Germany*
[2]*Institute of Earth and Environmental Science, University Potsdam, Potsdam-Golm, Germany*
[3]*Berlin Center for Genomics in Biodiversity Research, Berlin, Germany*
Schroer@igb-berlin.de

Introduction: Artificial light at night (ALAN) is an irreplaceable technology, providing visibility for human activity after the onset of darkness. Nonetheless, outdoor lighting has manifold side-effects. It can disturb nightscapes, ecosystems, and consequently biodiversity (Schroer and Hölker, 2016). ALAN is increasing rapidly (Hölker et al., 2010), including in protected areas (Gaston et al., 2015). It is the most visible pollutant of our planet, perceptible even from space. One instrument to measure ALAN is therefore via remote sensing by satellite. The Visible Infrared Imaging Radiometer Suite Day-Night Band (VIIRS-DNB) takes images of the entire Earth at around midnight local time. The camera detects lighting below streetlight emission levels (≥0.2 nW/cm^2sr) (Elvidge et al., 2013), but has low sensitivity in the spectral emission below 500 nm (Kyba et al., 2015). This is a weakness because modern street lights such as LEDs have considerable emission in the range 450–480 nm (Elvidge et al., 2010). Second, the measurement is restricted to the overpass; hence, temporary lighting before midnight is not recorded. Additional measurements are required to supplement these disadvantages. One approach is exemplified by the citizen science (CS) application "Loss of the Night" which asks participants to detect stars of different brightness, in order to estimate light pollution from the ground (Kyba et al., 2013). Unfortunately, the application depends on weather conditions and the position of the moon and cannot be used in direct proximity of light sources. Hence, a questionnaire was developed to gain more information about outdoor lighting conditions.

Our aim is to determine whether we can use CS methods to detect potential impact of ALAN on the microbial community composition and its ecological function at a nationwide scale. Hölker et al. (2015) observed increases in biomass and abundance of photosynthetic microbes in freshwater sediments that were exposed to ALAN for more than 1 year, indicating that ALAN can alter communities and ecosystem processes. The CS project "Tatort Gewässer" (crime scene freshwater) was developed to gain new knowledge about the role of inland waters in the carbon cycle and what effects ALAN may have. Here, we discuss the usefulness of a questionnaire for information on local ALAN.

Material and Methods: A CS sampling campaign of Germany's inland waters was conducted in early November 2015. Citizens could register online using an interactive inland water map (http://tatortgewässer.de/) that indicates the registered location, the successful return of the sample and information of the respective freshwater system. Participants were asked to take samples at a freshwater body close to their home to measure CO_2 and CH_4 concentrations and microbial diversity. A sampling kit was developed to ensure standardized sampling (Figure 1). In total, 742 sampling kits were distributed to registered citizens, including nature conservation organizations, schools, kinder-gardens, diving and angling associations, national parks, nature conservation authorities, and provincial offices.

Participants recorded the exact time and location of the sampling (using Google Maps GPS data) and other sampling metadata. The CS records were supplemented by data from the German Digital Landscape Model (ATKIS Base-DLM), for more information on the environmental context of the sample.

For the determination of the night-time brightness, a questionnaire was provided (http://tatortgewässer.de/wp-content/uploads/2015/07/Druckdokument-Befragung-künstliches-Licht_19.10.15.pdf). Citizens were asked about the distance to the nearest light source, the number of visible light sources, and the estimated intensity. Further questions referred to lamp cover and form, maintenance condition, and the colour of emitted light. For professional measure, VIIRS-DNB data were used as recorded in November 2015. Additionally, the "Loss of the Night" App was offered to participants.

Results: From the 742 sampling kits that were distributed, 86% were returned from throughout Germany (Figure 2). These contained samples from 161 streams, 103 rivers, 94 ponds, and 276 lakes. The sample sites were distributed among naturally dark rural to central urban areas with variable levels of upward radiation (Figure 3). Of all sample kits returned, 609 contained information on the questionnaires about visible artificial light sources (Table 1). Of these, 226 sites had no visible artificial light sources, of which 85 sites were in areas below 0.43 nW/cm^2sr upward radiation, which is rated as natural dark areas. Another 107 sites were in areas with 0.43–2.2 nW/cm^2sr, which is rated as rural low district lighting; 34 sites were in areas with 2.2–5.6 nW/cm^2sr, which can be reached in outskirts of smaller cities. Three hundred eighty-three sites had visible light sources; 16 of these sites were in areas with 19–36 nW/cm^2sr upward radiation, which are light levels of small cities or urban areas, 140 sites were from rural low district lighting areas and 43 were recorded in natural dark areas. From the total of 128 sites in natural dark areas, 6 were <50 m away from a light source and had more than 1 lamp (Table 2). Figure 4 presents the distribution of sample sites indicating the upward radiation of the area and the recorded distance to visible lamps. Overall, the citizens' responses match the satellite data and additionally offer more detailed information about direct or indirect radiation on inland waters.

Discussion: The data required to answer the question if ALAN has an impact on the microbial community composition and its ecological function demands large numbers of comparable samples from non-illuminated and illuminated sites in natural dark to relative bright urban areas. The broad spatial distribution of sampled inland waters in this short collecting period could only be gained with citizen scientists. The CS approach was therefore proven to be a powerful tool for sampling and characterizing sample sites. The results present only a few artificial light sources, which were undetected by VIIRS imaging. With the questionnaire we gained information to distinguish between sample sites with direct illumination or background lighting of the area. We are currently processing CO_2, CH_4, and microbial community data to test for ALAN effects. Adding other collected metadata, it may be possible to detect additive, antagonistic, or synergistic interactions of ALAN and other stressors, for example, land use or climate change.

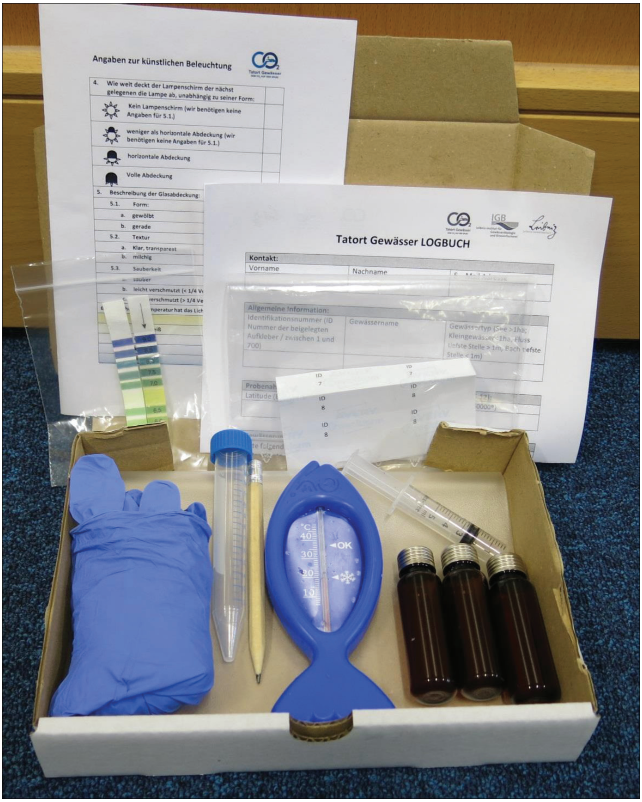

FIGURE 1: Citizen science sampling kit, including vials for sediments and water samples, syringe, thermometer, pH-measuring paper, gloves, a pencil, logbook, questionnaire on illumination, and instruction manual.

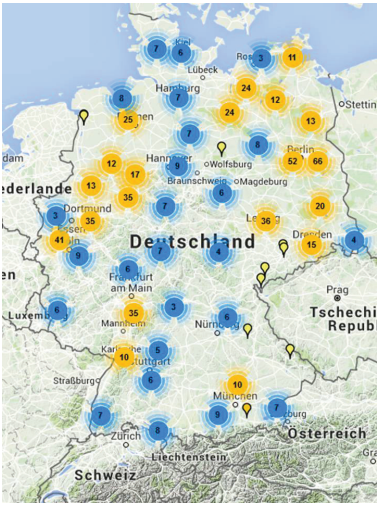

FIGURE 2: Image of the interactive map, in which citizens registered the sampling locations. Blue and orange points indicate the number of single sample sites. The orange pins indicate registered sampling sites, when the kits were returned the pin turned to yellow.

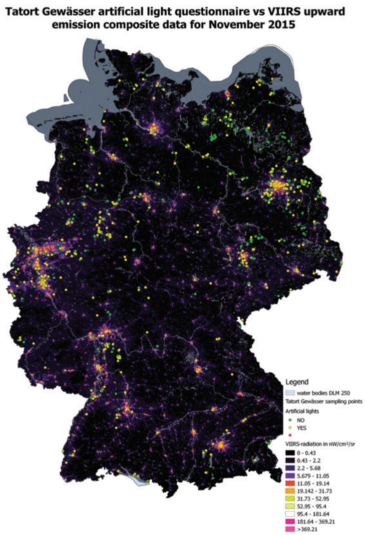

FIGURE 3: Location of sampling sites incorporated in a map of Visible Infrared Imaging Radiometer Suit (VIIRS) day/night band (DNB) sensor data from 0.0 to >52.9 nW/cm^{2}sr, ranked in eight categories and indicated with different colours. Sample sites without any artificial light source in visible distance are indicated with green, with artificial light sources in visible distance with yellow.

TABLE 1: Number of sampling sites with artificial light sources in visible distance according to the upward radiation measured by VIIRS-DNB in November, 2015.

VIIRS radiation nW/cm²sr	Visible artificial light source	
	No	Yes
<0.43	85	43
0.43–2.2	107	140
2.2–5.7	28	82
5.7–11	4	57
11–19	2	45
19–32	0	14
32–36	0	2

TABLE 2: Number of sampling sites in natural dark areas (<0.43 nW/cm²sr) with visible light sources, the distance to the next lamp and the recorded number of lamps.

Distance to the next lamp (m)				Number of visible lamps
<5	5–20	20–50	>50	
0	0	1	2	**0**
0	1	1	5	**1**
0	1	2	11	**1–5**
1	0	1	9	**5–10**
0	0	1	7	**>10**

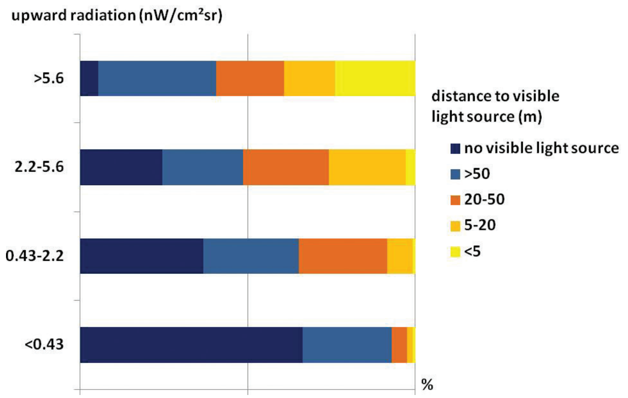

FIGURE 4: Distribution of sampling sites in areas with variable upward radiation measured by the VIIRS-DNB in November 2015 and recorded distance to the next visible light source.

Keywords: sediment, inland waters, light pollution, carbon sink, carbon source, carbon dynamics, artificial light at night, lighting factors, lake heterotrophy

Acknowledgements

We want to thank all citizen scientists involved for their dedication, their great contribution to this work, and the many photos and comments that were sent in addition. The study was supported by the IGB Seed Money Program.

REFERENCES

Elvidge, C. D., Baugh, K. E., Zhizhin, M., and Hsu, F.-C. (2013). Why VIIRS data are superior to DMSP for mapping nighttime lights. *Proc. Asia Pacific Adv. Netw.* 7, 62–69. doi: 10.7125/APAN.35.7 PMID:NOPMID

Elvidge, C. D., Keith, D. M., Tuttle, B. T., and Baugh, K. E. (2010). Spectral identification of lighting type and character. *Sensors (Basel)* 10, 3961–3988. doi: 10.3390/s100403961 PMID:22319336

Gaston, K. J., Duffy, J. P., and Bennie, J. (2015). Quantifying the erosion of natural darkness in the global protected area system. *Conserv. Biol.* 29, 1132–1141. doi: 10.1111/cobi.12462 PMID:NOPMID

Hölker, F., Moss, T., Griefahn, B., Kloas, W., Voigt, C. C., Henckel, D., et al. (2010). The dark side of light: a transdisciplinary research agenda for light. *Ecol. Soc.* 15, art.13. doi: NODOI PMID:NOPMID

Hölker, F., Wurzbacher, C., Weißenborn, C., Monaghan, M. T., Holzhauer, S. I., and Premke, K. (2015). Microbial diversity and community respiration in freshwater sediments influenced by artificial light at night. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 370, 20140130. doi: 10.1098/rstb.2014.0130 PMID:NOPMID

Kyba, C. C. M., Garz, S., Kuechly, H., Sánchez de Miguel, A., Zamorano, J., Fischer, J., et al. (2015). High-resolution imagery of earth at night: new sources, opportunities and challenges. *Remote Sens. (Basel)* 7, 1–23. doi: NODOI PMID:NOPMID

Kyba, C. C. M., Wagner, J. M., Kuechly, H. U., Walker, C. E., Elvidge, C. D., Falchi, F., et al. (2013). Citizen science provides valuable data for monitoring global night sky luminance. *Sci. Rep.* 3, 1835. doi: 10.1038/srep01835 PMID:NOPMID

Schroer, S., and Hölker, F. (2016). "Impact of lighting on flora and fauna," in *Handbook of Advanced Lighting Technology*, eds R. Karlicek, C. C. Sun, G. Zissis, and R. Ma (Springer International Publishing).

Hedgehogs on their way – citizen scientists discover wildlife in their backyard

Kristina Plenk[1], Stefanie Stadler[1], Julia Kelemen-Finan[2], Silvia Winter[1]

[1]Institute for Integrative Nature Conservation Research, University of Natural Resources and Life Sciences Vienna, Vienna, Austria
[2]Lower Austrian Nature Conservation Academy (Niederösterreichische Naturschutzakademie), Stockerau, Austria
kristina.plenk@boku.ac.at

Introduction: The ongoing intensification of agricultural land use and the increasing soil sealing in (sub)urban areas drastically influence natural habitats of wildlife species. This is true not only for rare and endangered taxa but also for more common species, which have previously not been considered as affected by habitat loss (Gaston and Fuller, 2007). Gardens and public green in rural and urban areas may represent important refugia for wildlife as has been demonstrated for different species (Baker and Harris, 2007; Hubert et al., 2011).

As a synanthropic species, hedgehogs live in the close vicinity of human settlements. Despite their popularity, only little is known about abundance and population trend in Austria. Although being common in the past, recent studies from England verified the predicted long-term decline of hedgehogs over the last years (Hof and Bright, 2016). In Austria, the general abundance of hedgehogs remains unclear, but at least one of the two occurring species, *Erinaceus europaeus*, is classified as near threatened (Spitzenberger, 2005).

To get an estimation of their abundance, one has to take a closer look at those areas, where the species can easily be observed. As private gardens are usually not accessible for scientists, a Citizen Science project offers the opportunity to obtain this information by involving the citizens living there (Roos et al., 2012).

In our Citizen Science project, Hedgehogs in gardens' citizens observe these nocturnal animals with the so-called hedgehog tracking tunnels (developed by R. Yarnell, Notthingham Trent University) or report direct sightings in private and school gardens all over Austria. Citizens also provide information on management and structures of the surveyed garden. We aim at investigating the relation of hedgehog presence or absence and garden parameters resulting in the following questions:

(1) Can the presence or absence of hedgehogs be related to garden management and existing structures within the garden?

(2) Is there a relationship between hedgehog presence or absence and the surrounding land use?

Material and Methods: In the ongoing Sparkling Science project "Nature in your backyard," which has been carried out together with 16 schools from Vienna and Lower Austria, the hedgehog tracking method was tested as one of the four different methods to record biodiversity in gardens. Due to the simplicity of this method, it is appropriate for children of different ages. The associated Citizen Science project "Hedgehogs in gardens" invites everyone with access to a garden to observe hedgehogs in gardens all over Austria. A regional network of co-operation partners was established to provide information and material for local citizen scientists. All information (protocols, determination material, contacts, etc.) is available online (http://igelimgarten.boku.ac.at). For data entry, citizens have to register on the website.

Garden survey: In the first step, citizens complete an online garden survey form to obtain relevant information on garden management intensity and structural diversity. Additionally, we ask for a subjective evaluation of the local trend of hedgehog abundance, last hedgehog observation date and if they offered hedgehog food in the garden.

Hedgehog observations: Presence or absence of hedgehogs is recorded with the tracking tunnel. The triangular shaped tunnel must be prepared with bait, non-toxic colour and white paper, and is positioned in the garden for five consecutive nights. Attracted by the bait, the hedgehogs pass through the tunnel and leave their footprints on the paper. The recorded presence or absence data of hedgehogs are uploaded together with scans or photographs of the animals' footprints for the respective garden. Alternatively, direct observations of hedgehogs can be reported by giving information on date, time, number of observed individuals, and photo evidence.

Preliminary results and discussion: In the first year of our Citizen Science project (season 2015), hedgehog observations were carried out in 89 gardens, predominantly in the eastern parts of Austria (Figure 1); thereof 72 observations contained garden management data. Participating pupils of the Sparkling Science project recorded hedgehog presence in 76 gardens (Figure 1). The tracking tunnel method worked very well in the Sparkling Science project where teachers and pupils received on-site training and all materials by the researchers. In the Citizen Science project, the citizens had to organise the equipment by contacting the co-operating partners or built the tracking tunnels on their own. Less than a quarter of participants set up tracking tunnels (21), while most reported direct sightings (from 68 gardens) of single individuals, mothers and offsprings, or pairs of hedgehogs. As a consequence, the Citizen Science project delivered mostly presence (not absence) data (see Figure 2).

Considering the results of both projects, hedgehogs could be observed in 72% of all gardens ($n = 148$). If only data from hedgehog tracking tunnels were included ($n = 86$), the detection rate of hedgehogs was 54%. This can be considered as quite a high rate compared to 35–38% reported from an urban garden study in England (Williams et al., 2015). Besides hedgehogs, the second most common footprints observed originated from cats, followed by small rodents. Preliminary analyses of the correlation of garden parameters and hedgehog presence showed that hedgehogs were observed most often in gardens of suburban areas and villages (Figure 2). Moreover, gardens without solid fences (i.e., accessible for hedgehogs) harbour hedgehogs more often than gardens with dense fencing. This effect had also been stated by Hof and Bright (2009) in Britain. Participants of the Citizen Science project estimated current hedgehog abundance as similar or more frequent compared to the last 5 years (Figure 3). However, this assessment might be biased towards people who observe hedgehogs regularly.

In the second step, the effect of the surrounding land use on hedgehog presence will be analysed. Based on these analyses, best-practice examples and suggestions for a "hedgehog-friendly" garden management will be derived. To obtain more presence/absence hedgehog data, the tracking tunnel method will be recommended for private garden owners, schools, and youth groups.

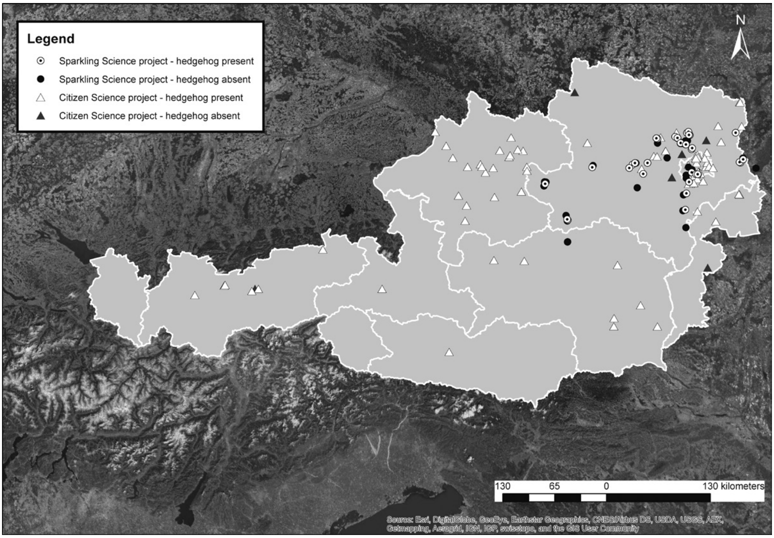

FIGURE 1: Hedgehog presence/absence data derived from the Sparkling Science (circles) and Citizen Science (triangles) project in 2015.

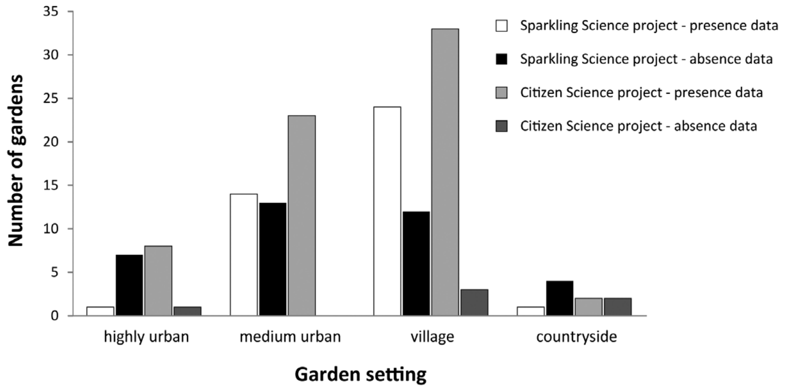

FIGURE 2: Hedgehog presence related to urbanization level (data from both projects).

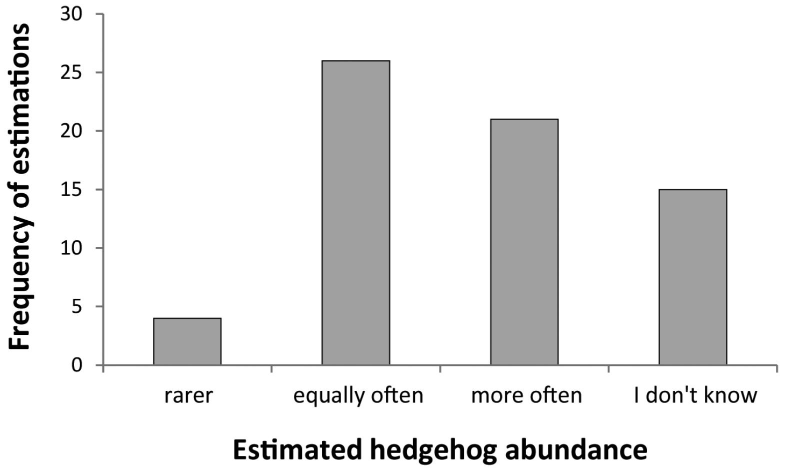

FIGURE 3: Participants' assessment of hedgehog abundance over the last 5 years.

Keywords: hedgehog, land use, citizen science, garden, *Erinaceus europaeus*, tracking tunnel, *Erinaceus roumanicus*

Acknowledgements

We are grateful for financial support from the Federal Ministry of Science, Research and Economy and for support and co-operation of all our project partners. We also thank all the citizen scientists for providing data on garden management and structures as well as for carrying out the hedgehog observations in their gardens. Special thanks go to the teachers, who participate with their students in the Sparkling Science project "Nature in your backyard – Citizen Science for schools."

REFERENCES

Baker, P. J., and Harris, S. (2007). Urban mammals: what does the future hold? An analysis of the factors affecting patterns of use of residential gardens in Great Britain. *Mammal Rev.* 3, 297–315. doi: NODOI PMID:NOPMID

Gaston, K. J., and Fuller, R. A. (2007). Commonness, population depletion and conservation biology. *Trends Ecol. Evol.* 23, 14–19. doi: 10.1016/j.tree.2007.11.001 PMID:NOPMID

Hof, A. R., and Bright, P. W. (2009). The value of green-spaces in built-up areas for western hedgehogs. *Lutra* 52, 69–82. doi: NODOI PMID:NOPMID

Hof, A. R., and Bright, P. W. (2016). Quantifying the long-term decline of the West European hedgehog in England by subsampling citizen-science datasets. *Eur. J. Wildl. Res.* 62, 407. doi: 10.1007/s10344-016-1013-1 PMID:NOPMID

Hubert, P., Julliard, R., Biagianti, S., and Poulle, M.-L. (2011). Ecological factors driving the higher hedgehog (*Erinaceus europeaus*) density in an urban area compared to the adjacent rural area. *Landscape Urban Plan* 103, 34–43. doi: 10.1016/j.landurbplan.2011.05.010 PMID:NOPMID

Roos, S., Johnston, A., and Noble, D. (2012). *UK Hedgehog Datasets and Their Potential for Long-Term Monitoring*. British Trust for Ornithology (BTO) Research Report No. 598. Thetford: Norfolk, UK, 63 pp.

Spitzenberger, F. (2005). "Rote Liste der Säugetiere Österreichs (Mammalia)", in Rote Liste gefährdeter Tiere Österreichs. Teil 1: Säugetiere, Vögel, Heuschrecken, Wasserkäfer, Netzflügler, Schnabelfliegen, Tagfalter, ed. K. P. Zulka, R. M. Wallner and Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft (Wien, Böhlau Verlag), 45–62.

Williams, R. L., Stafford, R., and Goodenough, A. E. (2015). Biodiversity in urban gardens: assessing the accuracy of citizen science data on garden hedgehogs. *Urban Ecosyst.* 18, 819–833. doi: 10.1007/s11252-014-0431-7 PMID:NOPMID

Where pathways cross: citizen science project StadtWildTiere in Vienna, Austria

Richard Zink, Theresa Walter

Research Institute for Wildlife Ecology, University of Veterinary Sciences Vienna, Vienna, Austria
richard.zink@vetmeduni.ac.at

Introduction: As more and more people move into cities and urban landscapes, these areas will also slide into focus as habitats for wildlife (United Nations Department of Economic and Social Population Affairs Division, 2015; Bateman and Fleming, 2012). Public parks, gardens, and other green areas provide habitats to live for foxes, badgers, and other mammals (Baker and Harris, 2007). Cities offer year-long food availability for many species as well as a warmer climate and abundant resources for building of nests and dens (Bateman and Fleming, 2012).

Monitoring wildlife in urban areas poses challenges for scientists: Covering large areas with standard monitoring methods such as transect sampling or camera traps is difficult, as not all land use classes in a city are freely accessible for research (Lepczyk et al., 2004; Colding et al., 2006; Cohn, 2008). Citizen science can bridge this gap in inaccessibility because people who have access to areas, such as private gardens or industrial areas, can, for example, report sightings on an Internet platform (Lepczyk et al., 2004; Dickinson et al., 2010; Weckel et al., 2010).

The citizen science project StadtWildTiere was established in Vienna in May 2015. The goals of the project are in-depth research in the area of urban wildlife ecology in consideration of relevant stakeholders and intensification and increase in professionalism of bilateral knowledge transfer between society and research. Here, we present first results of this citizen science project.

Materials and Methods: The study area is Vienna, the capital city of Austria (48° 12′ 30″ N, 16° 22′ 21″ E), with a total area of 414.87 km^2 and about 1.8 million inhabitants in 2015. Green areas such as parks and gardens make up 45.1% of the city area, 35.5% are building areas, 14.4% are traffic areas, and 4.7% of the area are waterbodies (MA 23 – Wirtschaft, Arbeit und Statistik, 2015).

Three thousand three hundred eighty-four sightings were gathered through the Internet platform of the project www.stadtwildtiere.at between May 27, 2015 and February 9, 2016. Citizen scientists entering data are required to enter a place *via* a Google maps map, species observed as well as time and date when the animal was seen. Registration is not mandatory. When registering, citizen scientists can upload photos of their sightings as well as data about their education and occupation voluntarily.

Data were evaluated and then ranked according to liability of sightings. Sightings with no photo but at reasonable places and times received the status "OK," sightings with a photo where identification of the animal is possible received the status "confirmed." Some sightings were not evaluated at the date of the analysis; therefore, they are shown with the status "new." For further analysis, only data on mammal sightings with one of those three statuses were used (n = 1975). All analyses were done using statistical software R 3.2.1 (R Core Team, 2014).

Results: Of the 3384 reported sightings, 60.4% were mammals, 33.6% were birds, 2.5% were amphibians and reptiles, and 3.4% were others such as fish and insects. When only looking at the reported mammal species, foxes (*Vulpes vulpes*) and bats (*Microchiroptera*) are the most often reported species, followed by hares (*Lepus lepus*) and badgers (*Meles meles*) (Figure 1).

Sightings of mammals (n = 1975) are not equally distributed across the day (X2 = 397.784, df = 23, $p < 0.001$). Sixty-four percent of sightings are reported between 6 p.m. and 6 a.m. When comparing fox (Figure 2A) and badger sightings (Figure 2B), a certain difference in distribution can be seen.

Of the reported 1975 mammal sightings, 9% were new, 45% were "OK," and 45% were confirmed. Half of the confirmed sightings were made by experts; a photo was handed in with 44.3%. The remaining sightings were confirmed because of descriptions and other reasons (Figure 3).

Seventy-five percent of the registered users (n = 355) entered data about their education (Figure 4). Forty-four percent indicated that they possess a university degree, followed by 16% with a finished secondary education.

Discussion: Citizen science proofed to be a valuable tool for monitoring especially mammal distribution in Vienna from the first results. The data gathered within eight and a half months could cover most mammal species present in Vienna with the exception of edible dormouse (*Glis glis*). We made the experience that certain species are reported more often than other species. This can be due to observability of different animal species on different land use classes as well as habitat use of different species and differences in utilization of land use classes of humans (Quinn, 1995; Wine et al., 2014). However, we assume that it can also be due to sympathy of humans towards different species. Foxes are very charismatic animals, whereas rats (*Rattus norvegicus*) and edible dormice are often regarded as pests. This also shows in the numbers of reported sightings: while 540 fox sightings were reported, there were only 9 rat sightings. Setting a special focus with intensive public relations work on species that are not often reported can probably improve reporting numbers.

The high amount of academics reporting sightings might also influence data distribution, as there are districts within Vienna with a higher number of academics compared to others (Statistik Austria, 2015). We want to investigate this issue in the future.

Data evaluation is carried out along guidelines. However, there are always cases when species identification is difficult from a photo or knowledge about very rare species is necessary (e.g., when insect species are reported). Although data evaluation is time intensive, it is a necessary effort to guarantee for good data quality. Sightings with photos have to be encouraged because within the project citizen scientists often refrain from sending in low-quality photos. However, also from low-quality photos, species identification is possible and adds to data quality within the project.

Since data are entered and evaluated in the same way, comparisons between cities with our project partners in Switzerland and further partner cities in Austria are made possible. This offers new perspectives on a wildlife monitoring citizen science project.

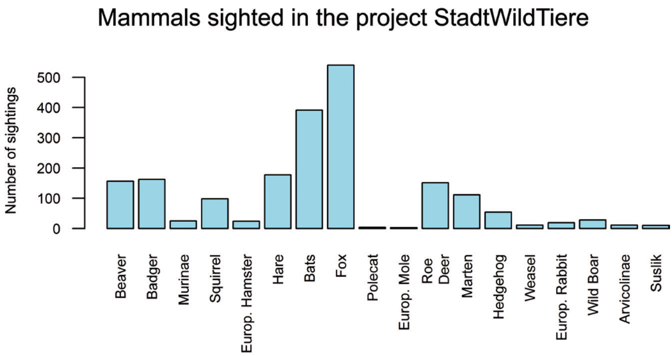

FIGURE 1: Number of sightings of different mammal species already entered in the database of the project StadtWildTiere (n = 1975).

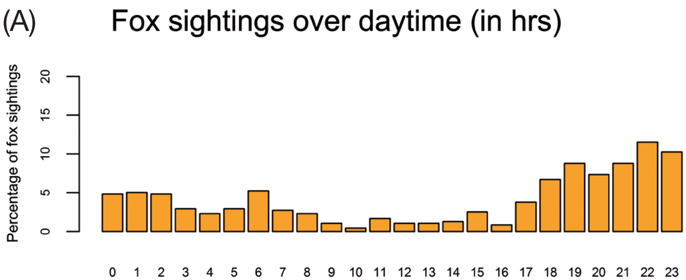

FIGURE 2: (*Continued*)

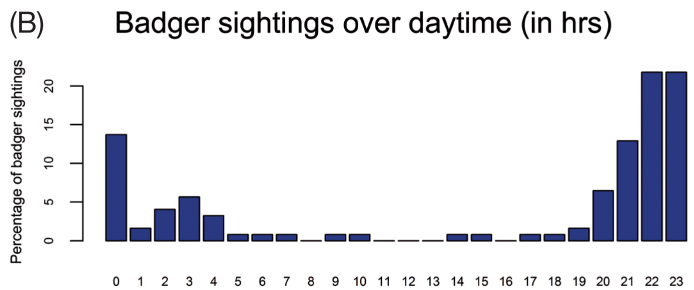

FIGURE 2: (**A**) Percentage of fox sightings per hour of the day (*n* = 478).
(**B**) Percentage of badger sightings per hour of the day (*n* = 124).

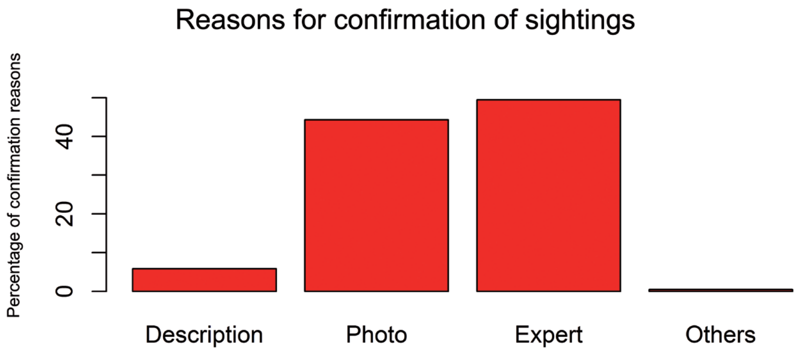

FIGURE 3: Percentage of different reasons for confirmation of sightings (*n* = 896).

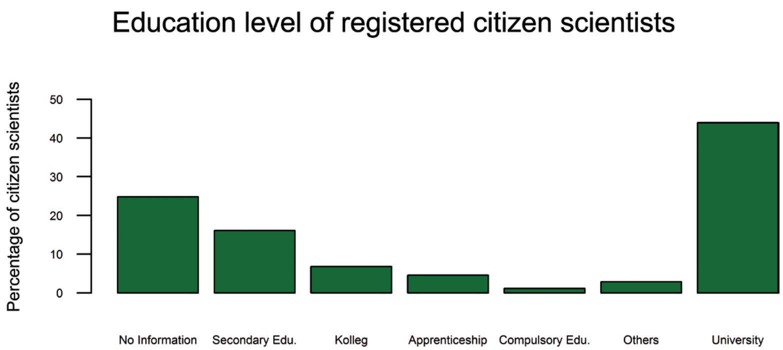

FIGURE 4: Percentage of different education levels by registered citizen scientists (*n* = 355).

Keywords: monitoring, urban ecology, citizen science, human–wildlife interactions, urban wildlife

REFERENCES

Baker, P. J., and Harris, S. (2007). Urban mammals: what does the future hold? An analysis of the factors affecting patterns of use of residential gardens in Great Britain. *Mamm. Rev.* 37, 297–315. doi: 10.1111/j.1365-2907.2007.00102.x PMID:NOPMID

Bateman, P. W., and Fleming, P. A. (2012). Big city life: carnivores in urban environments. *J. Zool.* 287, 1–23. doi: 10.1111/j.1469-7998.2011.00887.x PMID:NOPMID

Cohn, J. P. (2008). Citizen science: can volunteers do real research? *Bioscience* 58, 192. doi: 10.1641/B580303 PMID:NOPMID

Colding, J., Lundberg, J., and Folke, C. (2006). Incorporating green-area user groups in urban ecosystem management. *Ambio* 35, 237–244. doi: 10.1579/05-A-098R.1 PMID:16989508

Dickinson, J. L., Zuckerberg, B., and Bonter, D. N. (2010). Citizen science as an ecological research tool: challenges and benefits. *Annu. Rev. Ecol. Evol. Syst.* 41, 149–172. doi: 10.1146/annurev-ecolsys-102209-144636 PMID:NOPMID

Lepczyk, C. A., Mertig, A. G., and Liu, J. (2004). Assessing landowner activities related to birds across rural-to-urban landscapes. *Environ. Manag.* 33, 110–125. doi: 10.1007/s00267-003-0036-z PMID:14749899

MA 23 – Wirtschaft, Arbeit und Statistik. (2015). *Statistisches Jahrbuch der Stadt Wien 2015*. Vienna, Austria.

Quinn, T. (1995). Using public sighting information to investigate coyote use of urban habitat. *J. Wildl. Manag.* 59, 238–245. doi: 10.2307/3808936 PMID:NOPMID

R Core Team. (2014). *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. Available at: http://www.R-project.org/

Statistik Austria. (2015). *Bildungsstandregister 2013*. Available at: http://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/bildung_und_kultur/bildungsstand_der_bevoelkerung/index.html

Weckel, M. E., Mack, D., Nagy, C., Christie, R., and Wincorn, A. (2010). Using citizen science to map human–coyote interaction in suburban New York, USA. *J. Wildl. Manag.* 74, 1163–1171. doi: 10.2193/2008-512 PMID:NOPMID

Wine, S., Gagné, S. A., and Meentemeyer, R. K. (2014). Understanding human–coyote encounters in urban ecosystems using citizen science data: what do socioeconomics tell us? *Environ. Manag.* 55, 159–170. doi: 10.1007/s00267-014-0373-0 PMID:NOPMID

The scientific value of small mammal observation reports – the project GeoMaus

Christine Blatt, **Stefan Resch**

ARGE Kleinsäugerforschung GesbR, Salzburg, Austria
arge@kleinsaeuger.at

GeoMaus is a part of the website www.kleinsaeuger.at, which provides information about the appearance, geographic range, ecology, and protection of small mammals. Since the year 2012, it enables users to report observations online. In this way, GeoMaus collects data of the distribution of small mammals in Austria, Germany, and Switzerland.

Involving amateurs or nonprofessional scientists in ecological research is widespread and becoming increasingly popular (e.g., Cohn, 2008; Silvertown, 2009; Dickinson et al., 2010). One good example is the collection of distribution data in ornithology: since 1774 people interested in nature are involved in migration research by recording observations (Greenwood, 2007), and many organizations like Birdlife nowadays use volunteers to gain information about species distribution. In contrast, the knowledge about the distribution of many small mammal species is sparse. Their small body size, nocturnal activity, and their frequent occurrence in often impassable surroundings makes observations challenging. In addition, certain species can only be determined by experienced specialists, e.g., a reliable distinction of wood mice (*Apodemus sylvaticus*), yellow-necked mice (*A. flavicollis*), and alpine field mice (*A. alpicola*) is often only possible by comparing cranial features (Turni, 1999; Marchesi et al., 2008; Jenrich et al., 2010). Unfortunately, this results in complex and expensive research methods, thus the collection of information is widely based on random observations, e.g., carcasses, roadkill, or cat captures. A vital aspect of the GeoMaus project is to collect these accidental recordings, verify them, and make them available for interested people and further research.

But how to classify the input quality from amateurs and non-professionals from the scientific point of view?

At first, to avoid errors, it is highly important to provide adequate background knowledge to all people involved (Cohn, 2008). For this, GeoMaus provides tools to facilitate correct species determination: a picture key for inexperienced users as well as a text-based dichotomous key with body and skull features for professionals. Each report has to comprise locality, date, habitat, type of record, and the contact details for further queries. These information have to run through a plausibility check that covers a review of the external species characteristics, the potential distribution, and the habitat.

The quality level also depends on the species of the small mammal observed. Many species show certain characteristics that make them easily distinguishable even in the field. For example, the striped field mouse (*Apodemus agrarius*) shows a remarkable dark line that covers the back from head to tail and dormice can easily be determined through their tails and fur colorations. In these cases, the number of uncertainties or false determinations is low. On the other hand, there are groups that aren't that simple, e.g., the voles. In these cases, reports that are not fully unmistakable are only seen as "indicators" or "hints" on a potential abundance.

Records with photos showing the characteristics appearance of a species can be evaluated as high quality observation. So on GeoMaus users have the possibility to add a photo of the observed mammal to their reports. In many of these cases, the species identification by reviewing the photograph is possible. Unfortunately, the amount of these reports differs with species. For example, 40% of all reports for the garden dormouse (*Eliomys quercinus*) contain good quality images, this maybe because the animals can sometimes be observed in trees continuously for a relatively long period of time. On the other hand for the common vole (*Microtus arvalis*), we received images in just 28% of the reports. In contrast to the first example, voles mostly can be observed just a few seconds in high grass.

What is the scientific benefit of these reports?

Compared to distribution maps in literature, the reports on GeoMaus are easily accessible for all interested people all around the world for free. In addition, the data are up to date, so users get actual information. With a reasoned handling and the willingness to interpret low quality reports just as hints (quality over quantity), small mammal observations from amateurs and non-professionals can be an important addition to professional research. Since 2012 GeoMaus documented 828 (613 rodents and 215 shrews, moles, and hedgehogs) new occurrences of small mammals in Austria, Germany, and Switzerland. These incoming reports can help to improve the knowledge about current species distribution as well as potential changes in known distribution borders. For example with 47 observations, the distribution boundary of the striped field vole can be documented with a high accuracy for Germany. Finally, the additional information on the biology of small mammals with interesting texts and photos has the potential to arouse awareness of small mammals and their ecological importance.

Keywords: citizen science, online reports, small mammal observation, GeoMaus, kleinsaeuger.at

REFERENCES

Cohn, J. P. (2008). Citizen science: can volunteers do real research? *Bioscience* 58, 192–197. doi: 10.1641/B580303 PMID:NOPMID

Dickinson, J. L., Zuckerberg, B., and Bonter, D. N. (2010). Citizen Science as an ecological research tool: challenges and benefits. *Annu. Rev. Ecol. Evol. Syst.* 41, 149–172. doi: 10.1146/annurev-ecolsys-102209-144636 PMID:NOPMID

Greenwood, J. J. D. (2007). Citizens, science and bird conservation. *J. Ornithol.* 148, 77–124. doi: 10.1007/s10336-007-0239-9 PMID:NOPMID

Jenrich, J., Löhr, P.-W., and Müller, F. (2010). *Kleinsäuger: Körper- und Schädelmerkmale, Ökologie*. Fulda: Michael Imhof Verlag.

Marchesi, P., Blant, M., and Capt, S. (2008). *Säugetiere der Schweiz-Bestimmungsschlüssel*. Neuchâtel: CSCF & SGW.

Silvertown, J. (2009). A new dawn for citizen science. *Trends Ecol. Evol.* 24, 467–471. doi: 10.1016/j.tree.2009.03.017 PMID:19586682

Turni, H. (1999). Schlüssel für die Bestimmung von in Deutschland vorkommenden Säugetierschädeln aus Eulengewöllen (Mammalia). *Zoologische Abhandlungen Staatliches Museum für Tierkunde Dresden* 50, 351–399. doi: NODOI PMID:NOPMID

Addressing bumblebee faunistic and ecology using Citizen Science – reviewing a 2-year experience

Johann Neumayer[1], Bärbel Pachinger[2], Bernhard Schneller[3], Silas Bossert[4]

[1]*Österreichischer Naturschutzbund, Salzburg, Austria*
[2]*Institute for Integrative Nature Conservation Research, University of Natural Resources and Life Sciences, Vienna, Austria*
[3]*Bundesgymnasium Feldkirch Rebberggasse, Feldkirch, Austria*
[4]*Department of Entomology, Cornell University, Ithaca, NY, USA*
johann.neumayer@naturschutzbund.at

Introduction: The majority of historical entomological records is derived from the collecting activities of non-professionals, often non-biologists. Some of these "Citizen Scientists" have achieved an excellent knowledge of taxonomy, distribution, and ecology of species (Hopkins and Freckleton, 2002; Pohl, 2009). Modern Citizen Science in entomology uses the opportunities of the Internet to facilitate the identification, transfer records and photographs, and communication between lay observers and specialists. However, only a few insect groups can be reliably identified by observation or photographs, without the necessity of killing and subsequent preparation for identification purposes. Bumblebees (*Bombus*, *Apidae*, and *Hymenoptera*) are such a group, providing a great opportunity to conduct entomological Citizen Science projects. Bumblebees are common, can usually be identified by colour morphs, and identification can be verified using photographs. Last but not least, they evoke positive emotions – a prerequisite to motivate citizen scientists. In contrast to mass partitioning, i.e., Citizen Science projects with very simple observation tasks (e.g., Rüdisser et al., 2015; Roy et al., 2016), this project aims to generate high quality data from Citizen Scientists and to convey know-how in bumblebee identification and biology for participants in an interactive way.

Materials and Methods: Since 2007, distributional data on all kinds of animals and plants have been reported on the Austrian Citizen Science platform www.naturbeobachtung.at, with a particular focus on bumblebees beginning in 2014. A precondition for this approach is the availability of information for interested participants. We provide guidance from the participants' first step to becoming expert knowledge. To facilitate the outreach efforts, a set of supportive materials was developed:

- Free leaflets with basic insights in the recognition of the most common bumblebee species were designed and distributed. The leaflets further include basic, but essential, information on the ecology and biology of the six most common species in Austria.

- A more profound resource is provided by a convenient field identification key (Gokcezade et al., 2010, 2015). It is primarily based on colour patterns and hence allows an intuitive, but scientifically accurate, identification of the bumblebees of Austria, Germany, and Switzerland.

- To provide hands-on experiences, 14 one-day workshops on bumblebee identification, biology, and ecology were conducted in Austria over the past 2 years. The free-of-charge courses were led by the authors and accompanied carefully designed presentation materials, which were fully accessible to the participants.

However, the most important educational resource is provided by the online platform www.naturbeobachtung.at. Besides accessible learning materials, this platform hosts a frequently used online forum, which aims at bumblebee identification *via* photographs. As it is maintained by recognized bee biologists, reliable identification and accurate scientific data collection is ensured. Besides the emphasis on data acquisition, we further addressed the question if faunistic data achieved by Citizen Scientists can be used to meet applied ecological questions. Bumblebee data were collected under standardised conditions in 32 private gardens in 2015 and 2016 using the available facilities and guidance of the platform. The first results of 2015 are shown in Figure 2.

Results and Discussion: Since the start of the project, an increasing number of participants and records was achieved (Table 1). Moreover, the percentage of evaluable data with attached photograph that allows verification and geographical coordinates increased significantly. A total of 29 out of 42 bumblebee species occurring in Austria could be successfully recorded using Citizen Science. Among these were rare species such as the arctic-alpine *Bombus alpinus* or *Bombus haematurus* (see Figure 1). The first species is very rare and considered highly threatened by changing climatic conditions (Rasmont et al., 2015), whereas the latter species is rapidly spreading in the last decades (Bossert and Schneller, 2014). In total, 23.6% of all records were not identified correctly or not validated for lack of photographic support. In a few cases, an exact identification was possible, although only a species group had been recorded. Methods for facilitating recording in the database after asking for identification should be taken into account.

Presently, the bumblebee records of Citizen Scientists contribute about 1/3 of the annually recorded bumblebee data of Austria. Accordingly, Citizen Science delivers a notable amount of data, allowing the detection of ongoing trends in species composition among bumblebee communities. Moreover, ecological information about phenology and flower visits could be extracted from photographic documentation. By the end of the past season, a total of 142 visited plant species could be recorded, mostly with additional information about the flower visiting behaviour such as nectar and pollen foraging. Nonetheless, the maintenance of the online platform requires a considerable amount of working time. Validating observations required 30–50 h annually, and the guidance of ongoing Citizen Scientists required another 80 h.

The recorded datasets of the bumblebees in private gardens show that the conducted method is well suited to answer applied ecological questions. Thereby it was shown that *Bombus hortorum* is the most frequent bumblebee species in private gardens. *Rubus idaeus* and *Fabaceae*, such as red clover, are the most frequently visited plant taxa and attracted a number of different bumblebee species (Figure 2). Flower richness and bumblebee friendly plants turned out to be of great importance in private gardens.

Conclusion: The presented applied model of Citizen Science has the advantage that people get training that allows them to act as lay experts. The constant feedback provided by the experts *via* www.naturbeobachtung.at represents a main pillar for the motivation of long-term citizen scientists. Additional possibilities exist to expand monitoring of bumblebees to include qualitative and quantitative observational data about bumblebees. Such data about quality of various biotope types for wild bees and long-term trends in pollinator availability and species composition would provide important insights into local and global change.

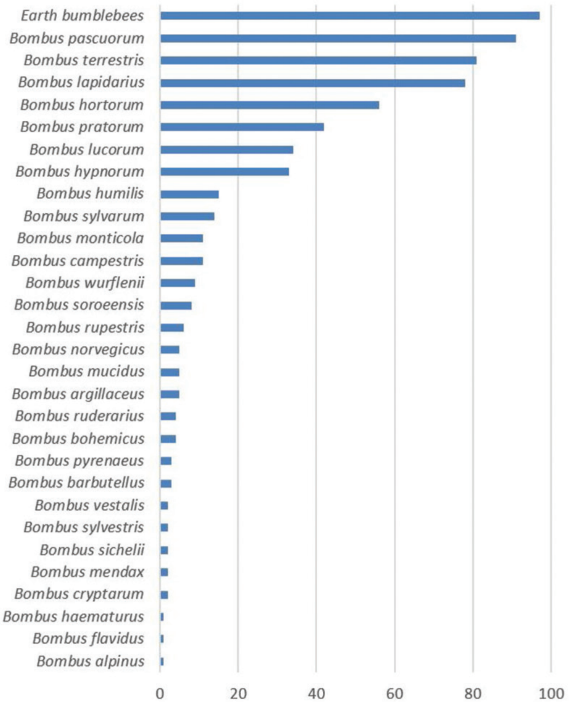

FIGURE 1: Frequency of the recorded bumblebee species. Mostly, *Bombus terrestris, B. cryptarum* und *B. lucorum* females cannot be identified reliably by means of photographs. Therefore, these species have been recorded under their trivial name “Earth bumblebees”.

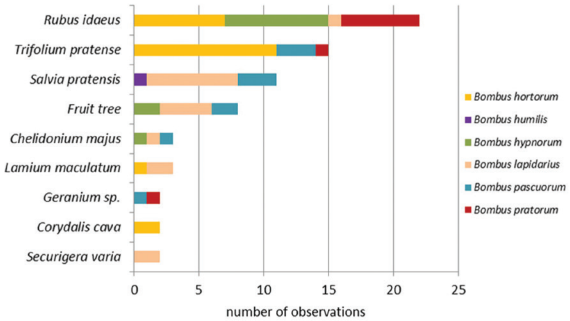

FIGURE 2: Recorded bumblebee species and respective flower visits in private gardens.

TABLE 1: The table summarizes the increasing number of recorded bumblebee individuals and participants of the past 10 years.

Years	Sum of	Evaluable	% evaluable	Species	Participants
2006–2013	45	17	37.8	1	13
2014	367	138	37.6	15	11
2015	1081	651	60.2	29	35

Keywords: pollination, monitoring, bumblebees, Citizen Science, nature conservation, *Bombus*

Acknowledgements

The project is accompanied by public relations in several media and co-financed by the "Hofer Bienenschutzfonds."

REFERENCES

Bossert, S., and Schneller, B. (2014). First records of *Bombus haematurus* Kriechbaumer, 1870 and *Nomada moeschleri* Alfken, 1913 (*Hymenoptera*: *Apidae*) for the state of Vienna (Austria). *Beiträge zur Entomofaunistik* 15, 95–100. doi: NODOI PMID:NOPMID

Gokcezade, J. F., Gereben-Krenn, B.-A., Neumayer, J., and Krenn, H. W. (2010). Feldbestimmungsschlüssel der Hummeln Deutschlands, Österreichs und der Schweiz. *Linzer Biol. Beitr.* 42, 5–42. doi: NODOI (2. edition: Linzer biologische Beiträge 47/1 (2015): 5–42), PMID:NOPMID

Hopkins, G. W., and Freckleton, R. P. (2002). Declines in the numbers of amateur and professional taxonomists: implications for conservation. *Anim. Conserv.* 5, 245–249. doi: 10.1017/S1367943002002299 PMID:NOPMID

Pohl, G. R. (2009). Why we kill bugs – the case for collecting insects. *Newsl. Biol. Surv. Can. (Terr. Arthropods)* 28, 10–17. doi: NODOI PMID:NOPMID

Rasmont, P., Franzén, M., Lecocq, T., Harpke, A., Roberts, S. P. M., Biesmeijer, J. C., et al. (2015). Climatic risk and distribution Atlas of European bumblebees. *Biorisk* 10, 1–236. doi: 10.3897/biorisk.10.4749 PMID:NOPMID

Roy, H. E., Baxter, E., Saunders, A., and Pocock, M. J. O. (2016). Focal plant observations as a standardised method for pollinator monitoring: opportunities and limitations for mass participation citizen science. *PLoS ONE* 11:e0150794. doi: 10.1371/journal.pone.0150794 PMID:26985824

Rüdisser, J., Tasser, E., Kapelari, S., Huemer, P., and Tappeiner, U. (2015). Viel-Falter: can schools contribute to biodiversity monitoring? *Verhandlungen der Gesellschaft für Ökologie* 45, 319–320. doi: NODOI PMID:NOPMID

Checking snails – pupils as snail watchers

Katharina Jaksch[1], Gabriele Baumgartner[2], Elisabeth Haring[1], Helmut Sattmann[3]

[1]Central Research Laboratories, Natural History Museum Vienna, Vienna, Austria
[2]GRg 13, Vienna, Austria
[3]Zoological Department, Natural History Museum Vienna, Vienna, Austria
katharina.jaksch@nhm-wien.ac.at

Introduction: The Craven Door Snail (*Clausilia dubia*) is a rock-dwelling clausiliid and known for its variable external appearance. Accordingly, different morphological forms and subspecies have been described, but the biological background of those supposed taxa is uncertain (Nordsieck, 2002; Jaksch, 2012). So far, only few data are available on the biology of this species (e.g., Nordsieck, 2005; Maltz and Sulikowska-Drozd, 2008) and only few data exist on close relatives (e.g., Maltz and Sulikowska-Drozd, 2012; Sulikowska-Drozd and Maltz, 2012; Szybiak et al., 2015). Therefore, all information on the life cycle of *C. dubia* is of high scientific interest. Furthermore, taxonomically relevant differences in size, shell shape, and ribbing might be genetically and/or environmentally linked. We hypothesise that if there is some environmental influence on shell traits, this might become apparent under altered conditions. To test this, we planned as the first experiment to rear and breed different morphological forms under the same laboratory conditions. Since for this experiment, plenty of snails have to be observed, pupils were involved as Citizen Scientists.

This project was started in 2014 in cooperation with secondary school students of the GRg 13 Wenzgasse, Vienna, and the Natural History Museum of Vienna (NHMW) (Figure 1). Besides conducting all the necessary work, the students also raised their own questions, made careful observations, and recorded important information. This included not only shell characters but also observations of reproduction biology like clutch size, hatching time, duration of development, and life span. After 2 years of rearing and breeding, first fundamental results on reproductive biology can be reported.

Methods: Subadult snails (estimated age: 4 months) were collected from different populations in the Schneeberg region (Lower Austria). Students of the 6th and 7th grade (12–13 years old) received ~200 door snails kept in small terrariums. The students were instructed regarding the conditions under which the animals should be kept by the scientists of the NHMW and by their biology teacher, who supervised the onsite procedures in the school. Regularly, several times per week, the boxes were cleaned, snails were fed (with lettuce and carrots), and any conspicuities were documented. Each time, all boxes were inspected for eggs and/or clutches. Eggs per clutch were counted, protocolled, and transferred into separate breeding boxes. The time until hatching, the hatching itself, and finally the growing of the hatchlings were monitored, described, and documented by reports and images.

Results: Altogether 420 eggs were yielded from the generation caught in the wild. Of the F1 generation, 228 snails were successfully reared to adult stage. At the first glance, the offspring did not differ from parental snails in size, shell shape, and ribbing, but detailed measurements will be necessary to statistically test any differences. Besides the establishment of feasible settings for successful breeding of *C. dubia*, new data about the species' biology were gathered by the students: The eggs are partly calcified with visible calcium carbonate crystals on the surface (Figure 2). Size of egg clutches ranged from 2 to 8 eggs (average 3.8). Eggs were laid during the whole period of observance (September to September), and it takes 11–19 days until hatching. In all these parameters (size of clutches, seasonality, and duration until hatching), slight differences between populations/morphotypes were observed. Yet, due to the still small sample size, statistical significance has not been tested. Time from hatching until reaching adult stage (as determined by a certain size and form of the aperture) was 252 days on average. The parental generation of the studied snails reached an age up to 3 years.

Discussion: This was the first attempt to obtain data on door snail taxonomy and biology with substantial involvement of pupils, and this pilot study can be regarded as very successful. First results about basic biological data of *C. dubia* have been gathered by the students. It has to be underlined that information on the biology of this species was scarce. Maltz and Sulikowska-Drozd (2008) described the knowledge on life cycles of *C. dubia* as "unknown" in the field and "fragmentary" from laboratory observations. They reported that the species was oviparous and egg sizes were determined. According to our results, clutch sizes are relatively small compared with other clausiliid species. Incubation time until hatching is within the range of other clausiliids, but longer than in *C. pumila*. Development seems to be relatively slow compared with other species (Maltz and Sulikowska-Drozd, 2008). Welter-Schultes (2012) mentioned that epiphytic lichens and algae are the main food of *C. dubia*. This kind of nutrition was not available in our experiment, but it is noteworthy that we could successfully rear the animals with lettuce and carrots, which indicates that the food spectrum might be wider in nature.

This pilot study provided us with some key data on reproduction, although it has to be considered that the laboratory conditions surely deviate to a certain degree from natural ones. At first appearance, the results did not show any environmental influence on shell characters, but this question has to be evaluated in upcoming experiments analysing more snails and using also individuals of the F2 generation. Also, observations on egg and clutch sizes as well as hatching behaviour will be statistically analysed when more data are available. In addition, food preferences will be tested in further experiments.

Conclusion: The success of this study was due to the strong commitment of the pupils. This was demonstrated in a joint public presentation of the young scientists together with the researchers of the NHMW and documented in a survey article of the supervisors of the project (Jaksch and Baumgartner, 2015). A great benefit was the particular experience of the biology teacher in breeding of snails. Recently, we have adapted the methodological approach according to our experience gained in this pilot study. We plan to extend the experiments including more students and snails. In addition to the ongoing breeding experiment, snail pairs will be handed out to students who will monitor them at home. In general, all observations will be documented in more detail.

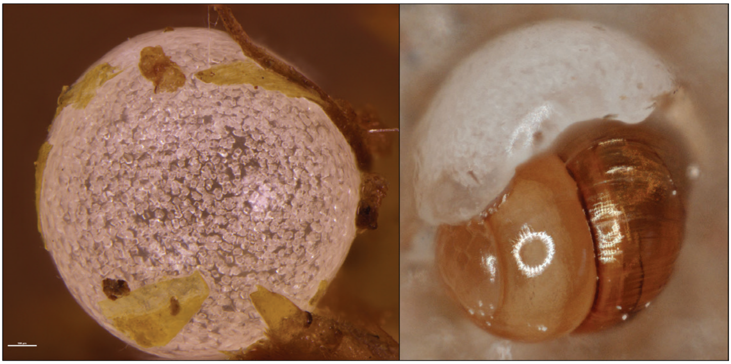

FIGURE 1: *Clausia dubia* egg and hatchling; photos: O. Macek / K. Jaksch

FIGURE 2: Pupils of GRg Wenzgasse involved in the snail study; photo: G. Baumgartner

Keywords: rearing, reproduction biology, shell characters, citizen scientist data, *Clausilia dubia*

Acknowledgements

We are grateful to all pupils involved in this project for their commitment and to the director of the GRg 13, Andreas Paseka, for his backing. We also thank Julia Schindelar and Oliver Macek for preparing and arranging facilities for snail keeping.

REFERENCES

Jaksch, K. (2012). Phylogeographie und Unterartklassifikation von *Clausilia dubia* Draparnaud, 1805 im östlichen Österreich (Gastropoda: Pulmonata: Clausiliidae). Diploma thesis, University Vienna, Vienna.

Jaksch, K., and Baumgartner, G. (2015). *Citizen Scientists – Schülerinnen und Schüler werden zu Schneckenforschern. Das Naturhistorische*. Vienna: Universum Magazin, 8–9.

Maltz, T. K., and Sulikowska-Drozd, A. (2008). Life cycles of clausiliids of Poland – knowns and unknowns. *Ann. Zool.* 58, 857–880. doi: 10.3161/000345408X396783 PMID:NOPMID

Maltz, T. K., and Sulikowska-Drozd, A. (2012). Life history of *Alinda biplicata* (Montagu, 1803) (Gastropoda: Pulmonata: Clausiliidae) based on five-year laboratory observations. *Ann. Zool.* 62, 789–807. doi: 10.3161/000345412X659803 PMID:NOPMID

Nordsieck, H. (2002). The subspieces classification of *Clausilia dubia* DRAPARNAUD (Gastropoda: Stylommatophora: Clausiliidae), a critical revision. *Mitt. Dtsch. Malakozool. Ges.* 68, 37–44. doi: NODOI PMID:NOPMID

Nordsieck, H. (2005). Mating biology of Clausiliidae. *Mitt. Dtsch. Malakozool. Ges.* 73/74, 29–34. doi: NODOI PMID:NOPMID

Sulikowska-Drozd, A., and Maltz, T. K. (2012). Reproduction of *Balea (Pseudalinda) stabilis* (L. PFEIFFER, 1847) (Gastropoda: Pulmonata: Clausiliidae) kept under laboratory conditions. *Folia Malacol.* 20, 73–79. doi: 10.2478/v10125-012-0007-1 PMID:NOPMID

Szybiak, K., Gabała, E., and Leśniewska, M. (2015). Reproduction and shell growth in two clausillids with different reproductive strategies. *Biologia* 70, 2015. doi: 10.1515/biolog-2015-0076 PMID:NOPMID

Welter-Schultes, F. (2012). *European Non-Marine Molluscs: A Guide for Species Identification*. Göttingen: Planet Poster Edition.

The CAPTOR project: joint efforts reducing ozone pollution

Sylvana Kroop, Teresa Schäfer, Barbara Kieslinger

Technology and Knowledge, Zentrum für Soziale Innovation, Vienna, Austria
kroop@zsi.at

Air pollution has become a major global concern. In 2012, nearly half a million people in Europe alone have died of premature deaths due to elevated levels of particulate matter in the air. Furthermore, it puts considerable damage to agriculture as well as our natural environment (EEA, 2015). Environmental organizations have long been trying to increase the awareness for air pollution, especially with regards to elevated ozone levels. But, the readiness and power of European citizens to take actions themselves is limited. With the recent emerging of a new generation of low-cost sensors for air quality measurement new opportunities arise. CAPTOR is a European citizen science project which builds on these recent developments and explores new concepts to reduce ozone pollution. This extended abstract describes the CAPTOR approach.

CAPTOR – Collective Awareness Platform for Tropospheric Ozone Pollution: CAPTOR is a Horizon 2020 project which started in January 2016 with eight partners from three countries across Europe (Captor Partners, 2016). The overall aim is to create a sustainable collective awareness platform on the topic of tropospheric ozone pollution as a joint effort of environmental activists, air quality researchers, concerned citizens, and local decision makers. CAPTOR's activities focus on regions in Austria, Italy, and Spain where citizens will be involved by handling air quality measuring tools at their homes and in community places, such as schools. Researchers' efforts will essentially focus on increasing the quantity and the quality of data collected by citizens as well as providing open access to all research data outcomes and raising awareness. In local community platforms (LCPs) that are offered in the regions respective languages communication will take place on a local level, involving discussions around daily concerns of citizens and inform about events, reports, pictures, and experiences from these activities (Captor, 2016).

Tropospheric Ozone Pollution: Generally, when speaking about ozone, we have to differentiate between stratospheric and tropospheric ozone. While stratospheric ozone ("good" ozone) blocks the sun's ultraviolet (UV) rays and prevents them from reaching the earth's surface, tropospheric (ground-level) ozone (O_3) ("bad" ozone) is an air pollutant that damages human health, vegetation, and ecosystems (Ccacoalition, 2016; EEA, 2016).

Ozone is sometimes referred to as a "forgotten pollutant," given that it is formed in rural areas through chemical reactions from precursor gases emitted mainly in urban environments (Figure 1). Therefore, the polluters (the urban population) often do not suffer from the effects of the degraded air quality generated by their emissions to the same extent as the rural population who has limited influence on the emissions that degrade the air they breathe.

Low cost sensors – the opportunity to create Citizen Science projects: Traditionally, air quality has been monitored using expensive reference equipment located at a number of monitoring sites hosted by meteorological stations. In recent years, sensor technology related to air quality has made significant and rapid progress (Castell et al., 2013). Sensors are available for much lower cost, they are of small size, low weight, and open hardware based. It is, therefore, possible to deploy such sensors in a much larger number than reference monitoring stations, measuring urban air quality at unprecedented spatial detail (Kumar et al., 2015), and in locations where monitoring with traditional facilities is not possible. However, the use of low-cost sensors for air quality research is still in its infancy and needs, e.g., further proof of accuracy and reliability.

Citizens who agree to participate in the project as CAPTOR sensor hosts do not need previous experience as they will be guided by a team of experts. Sensors are provided by the project and also installed and uninstalled by project members (Figure 2). In the course of the project, we expect the partnership between the different stakeholders to grow and volunteers and communities taking full ownership of the low cost measuring stations and the collected data.

The Captor Pilots – a Citizen Science bottom-up approach: In CAPTOR project, there are three national pilots which will take place in European regions heavily affected by tropospheric ozone (O_3). The red dots on the map in Figure 3 show where measured data of O_3 are above the target value of the European Union.

The pilot regions are situated in:

- Barcelonès-Vallès Oriental-Osona (Catalonia, Spain);
- Pianura Padana (Po Valley, Italy);
- Burgenland, Steiermark and Niederösterreich (Austria).

Citizens in these regions will be ask to provide a place for a sensor for three periods of measurement in Spain (summer of 2016, 2017, and 2018) and two periods of measurement in Austria and Italy (summer 2017 and 2018).

The citizens' sensors will collect data for tropospheric ozone, which are key to improve scientific and citizen knowledge about the problem, as well as to mobilize citizens and local decision makers to find solutions. The data will be public and the project will inform sensor hosts about the quality of the air and the proposals to change the situation in an understandable manner. The purpose of CAPTOR is to stimulate mutual learning between the involved stakeholders of local communities, citizens, NGOs, and scientists who are all equal partners in the project.

CAPTOR's expected impact: The CAPTOR project is based on the assumption that the combination of citizen science, collaborative networks, and environmental grassroots social activism helps to raise awareness and find solutions to the air pollution problem, having a high potential impact on fields such as education, social innovation, science, environment, politics, and industry.

More specifically, the impact that we expect at societal level will be measurable in a series of relevant indicators, such as changes in attitude and in life-style, citizen's increased awareness, sense of ownership and responsibility for air quality, influence on policies. In a carefully drafted socio-ecological impact, assessment strategy evidence will be collected to provide indications of measurable impact, successful elements, and possible barriers and obstacles encountered in the citizen science approach of CAPTOR.

FIGURE 1: Ground-level Ozone and Summer Smog (pic: LfU, 2015).

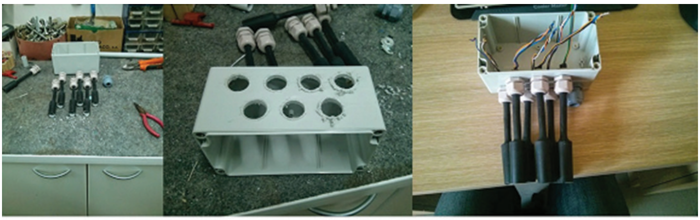

FIGURE 2: Sensors provided by the CAPTOR project to citizens.

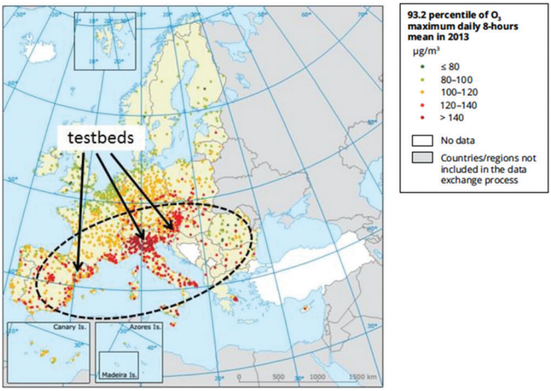

FIGURE 3: Captor Pilots in areas with elevated tropospheric ozone (O_3) levels (map: EEA, 2015).

Keywords: air pollution, ozone, citizen science, low cost sensors, environmental activists, Horizon 2020 project, CAPTOR pilots, Collective Awareness Platform, CAPS project

Acknowledgements

This project is funded by the European Union's Horizon 2020 Programme under the Grant Agreement No. 688110. Thanks to all consortium members who collaboratively created the CAPTOR concept described in this extended abstract. It is complementing the provided poster which was presented at ECSA2016 in Lunz am See, Austria. Special thanks for the voluntary efforts of Florian Heigl and Daniel Dörler to establish and maintain the Austrian Citizen Science network and platform (citizen-science.at).

REFERENCES

Captor, L. C. P. (2016). *Access to Local Community Platforms*. Available at: https://www.captor-project.eu/index.php/en/local-activities/

Captor Partners. (2016). Available at: https://www.captor-project.eu/index.php/en/project/partners/

Castell, N., Viana, M., Minguillón, M. C., Guerreiro, C., and Querol, X. (2013). *Real-World Application of New Sensor Technologies for Air Quality Monitoring*. Copenhagen: European Environment Agency (EEA).

Ccacoalition. (2016). Climate and Clean Air Coalition: Available at: http://www.ccacoalition.org/en/slcps/tropospheric-ozone

EEA. (2015). *Air Quality in Europe – 2015 Report*. Copenhagen, Denmark: European Environment Agency.

EEA. (2016). *Air Pollution by Ozone*. Available at: http://www.eea.europa.eu/themes/air/ozone

Kumar, P., Morawska, L., Martani, C., Biskos, G., Neophytou, M., Di Sabatino, S., et al. (2015). The rise of low cost sensing for managing air pollution in cities. *Environ. Int.* 75, 199–205. doi: 10.1016/j.envint.2014.11.019 PMID:NOPMID

LfU. (2015). *Bodennahes Ozon und Sommersmog*. Bayerisches Landesamt für Umwelt 2015.

Factors influencing data quality in citizen science roadkill projects

Florian Heigl, Johann G. Zaller

Citizen Science Working Group, Institute of Zoology, University of Natural Resources and Life Sciences Vienna, Vienna, Austria

florian.heigl@boku.ac.at

Introduction: Roads are an essential part of Central European landscapes and, therefore, have a major impact on flora and fauna (Herry et al., 2012; van der Ree et al., 2015). The most direct negative effect of roads on animals is roadkill, i.e., the collision of animals with vehicles, leading to the decrease of populations of several animal groups (Erritzoe et al., 2003; Coffin, 2007; Fahrig and Rytwinski, 2009; Beebee, 2013). In several countries, reporting systems for observations of road-killed animals have been established (Shilling et al., 2015). Some of these projects use a citizen science approach to get an overview of the type, number, and distribution of road-killed animals. Citizen science is perhaps the only feasible method to cover a broad geographic range over a long time span (Vercayie and Herremans, 2015). Regardless which reporting method is used, collecting reliable data of road-killed animals over a wide area and over a long time span can be very challenging since many biases exist that could influence mortality estimates on roads (Bager and da Rosa, 2011; Santos et al., 2011; Teixeira et al., 2013; Paul et al., 2014; Guinard et al., 2015; Lewandowski and Specht, 2015). The aim of this study is to identify factors influencing data quality in citizen science-based roadkill projects. Here, data quality is defined as a measure of the difference between data and the reality they represent, whereas data quality is high when data fit their intended uses (Shi et al., 2002).

Materials and Methods: We searched for publications publicized between 1900 and March 2016 in the scientific databases ISI Web of Knowledge and Scopus using the following search term combination: "data quality" AND/OR "citizen science" OR "public participation" AND/OR "roadkill" OR "animal vehicle collision" OR "road mortality" OR "wildlife vehicle collision" (Table 1). In the second step, we ensured that the list of references contained no duplicates. For our presentation at the Austrian Citizen Science Conference 2016, we selected key publications and combined the information with our experiences from Project Roadkill (www.roadkill.at).

Results and Discussion: The initial search yielded a total of 837 articles, books, book sections, and conference proceedings published between 1960 and 2016 uniquely listed either in Web of Science or Scopus (Table 1). Overall, using citizen science to monitor road-killed animals seems to be a relatively new approach. Information on factors influencing data quality is quite scarce and is scattered among remote research areas. Four articles concentrated on roadkill and data quality. Based on the literature found and our 3-year experience in Project Roadkill (Heigl and Zaller, 2014), we built four category groups by which data quality in citizen science roadkill projects could be influenced: environmental conditions, collection method, material, and participants (Table 2).

Environment: Landscape and road characteristics influence the detectability of road-killed animals. Winding roads, densely vegetated roadside strips, or even newly bituminized roads can make it difficult to see roadkills and therefore underestimate numbers of roadkills. Additionally, weather conditions influence migration behavior of many animal groups. Amphibian migration is timed by temperature (Kromp-Kolb and Gerersdorfer, 2003; Parmesan, 2007). Reptiles are using roads for thermoregulation and are therefore time dependently distributed on roads (Jochimsen et al., 2004). Fog, rain, or bright sunshine can make it difficult to detect roadkills and weather is also one of the factors influencing the persistence of road-killed animals on streets. Most carcasses are gone within 1 day, depending not only on weather but also on animal group, traffic volume, and scavengers (Santos et al., 2011). From our Project Roadkill, we know that a reporting bias exists in favor of eye-catching species. Additionally, working with different animal species in one project can be very challenging, since some species are hard to distinguish when road killed, e.g., the group of true frogs (Pelophylax), rodents (Muroidea), or some passerine birds (Sylviidae).

Collection Method: Roadkill data are either collected via standardized monitoring or opportunistic data gathering (roving records). Standardized monitoring is more accepted in the scientific community, but it is more time consuming and more difficult to find participants (Vercayie and Herremans, 2015). Roving records contain "presence only" data and often comprise big amounts of data collected over a wide geographic range. The only study in road ecology comparing these two approaches concludes that opportunistic data can indeed be robust and reliable as long as the search and report effort is documented (Paul et al., 2014).

Material: Dependent on the target audience, road-killed animals can be reported via Smartphone apps, pen/paper method, social media platforms, SMS message, Email, or online forms (Olson et al., 2014; Shilling et al., 2015). Study design and communication tools determine data quality more than volunteer involvement per se (Schmeller et al., 2009). Focusing on communication and providing high quality and user targeted communication tools (e.g., education material and reporting platforms) raises the chance to get high quality data. Or as Chu et al. (2012) put it "Keeping users happy is important because of the value of long-term data from the same localities."

Participants: The main challenges in citizen science roadkill projects are correct species identification and spatial distribution (Vercayie and Herremans, 2015). Species identification can be improved by high-quality educational training and a long-term commitment of participants. Spatial biases can be accounted for in statistical analyses or with specific sampling campaigns into areas where few data are reported. Moreover, based on personal experience and communication with participants, we found that participants are often distracted when driving on roads, resulting in overlooking small road-killed animals. Kind of travelling (car, bike, and foot) and speed of travel also matters, searching on foot is much more effective than by car (Slater, 2002), but it is obvious, that there is a trade-off between accuracy and spatial coverage.

Conclusion: Data quality in citizen science roadkill projects is influenced by many factors that need to be addressed in order to gather robust roadkill data. Taking these limitations into account, citizen science is an adequate method for covering wide geographic ranges and raising public awareness on accident risks and conservation.

TABLE 1: Number of references per topic, search terms, and age of the oldest included reference extracted from Web of Science and Scopus (search date March 29, 2016).

Topic	Terms	No. of references	Years
Roadkill	Roadkill or animal vehicle collision or road mortality or wildlife vehicle collision	1201	56
Data Quality in Citizen Science	Data quality and citizen science	115	8
Citizen Science Roadkill Projects	Citizen science or public participation and roadkill or animal vehicle collision	4	2
Data Quality in Roadkill Projects	Data quality and roadkill or animal vehicle collision or road mortality or wildlife vehicle collision	4	3
Total		1324	
Without duplicates		837	

TABLE 2: Identified main factors influencing data quality in citizen science projects regarding roadkill.

Environment	Method	Material	Participants
Landscape/road	Standardized monitoring	Reporting platform	A priori knowledge
Characteristics	Roving records	Education material	Awareness
Climate/weather		Communication tools	Spatial bias
Animal species			Type and speed of travel

Keywords: public engagement, remote sensing, public participation, road mortality, wildlife vehicle collision, wildlife observation systems, digital reporting platforms

Acknowledgements

Great thanks to our participants in Project Roadkill for investing time and reporting data. We are grateful to P. Hummer and R. Holzapfel who developed the new project platform, A. Bruckner who supported the development of the first online platform as head of the Institute of Zoology at the Univ. of Nat. Res. and Life Sciences Vienna, B. Dauth for his huge support, J. Freinschlag for the design of the Logo, H. Hellmeier for the illustrations, and T. Posegga who developed the first website.

REFERENCES

Bager, A., and da Rosa, C. A. (2011). Influence of sampling effort on the estimated richness of road-killed vertebrate wildlife. *Environ. Manage.* 47, 851–858. doi: 10.1007/s00267-011-9656-x PMID:21404074

Beebee, T. J. C. (2013). Effects of road mortality and mitigation measures on amphibian populations. *Conserv. Biol.* 27, 657–668. doi: 10.1111/cobi.12063 PMID:23647090

Chu, M., Leonard, P., and Stevenson, F. (2012). "Growing the base for citizen science," in *Citizen Science: Public Participation in Environmental Research*, eds J. L. Dickinson, and R. Bonney (New York: Cornell University Press), 69–81.

Coffin, A. W. (2007). From roadkill to road ecology: a review of the ecological effects of roads. *J. Transp. Geogr.* 15, 396–406. doi: 10.1016/j.jtrangeo.2006.11.006 PMID:NOPMID

Erritzoe, J., Mazgajski, T. D., and Rejt, Ł. (2003). Bird casualties on European roads – a review. *Acta Ornithol.* 38, 77–93. doi: 10.3161/068.038.0204 PMID:NOPMID

Fahrig, L., and Rytwinski, T. (2009). Effects of roads on animal abundance: an empirical review and synthesis. *Ecol. Soc.* 14. Available at: http://www.ecologyandsociety.org/vol14/iss1/art21/

Guinard, E., Prodon, R., and Barbraud, C. (2015). "Case study: a robust method to obtain defendable data on wildlife mortality," in *Handbook of Road Ecology*, eds R. van der Ree, D. J. Smith, and C. Grilo (West Sussex, UK: John Wiley & Sons), 96–100.

Heigl, F., and Zaller, J. G. (2014). Using a citizen science approach in higher education: a case study reporting roadkills in Austria. *Hum. Comput.* 1. Available at: http://hcjournal.org/ojs/index.php?journal=jhc&page=article&op=view&path%5B%5D=10

Kromp-Kolb, H., and Gerersdorfer, T. (2003). *Auswirkungen von Klimaänderungen auf die Tierwelt – derzeitiger Wissensstand, fokussiert auf den Alpenraum und Österreich*. Vienna: Institut für Meteorologie und Physik Universität für Bodenkultur Wien.

Herry, M., Sedlacek, N., and Steinacher, I. (2012). *Transport in Figures – Austria Edition 2011*. Vienna: Federal Ministry for Transport, Innovation and Technology (bmvit).

Jochimsen, D. M., Peterson, C., Andrews, K. M., and Whitfiled Gibbons, J. (2004). *A Literature Review of the Effects of Roads on Amphibians and Reptiles and the Measures Used to Minimize Those Effects*. Pocatello, Idaho: Idaho Fish and Game Department USDA Forest Service.

Lewandowski, E., and Specht, H. (2015). Influence of volunteer and project characteristics on data quality of biological surveys. *Conserv. Biol.* 29, 713–723. doi: 10.1111/cobi.12481 PMID:25800171

Olson, D. D., Bissonette, J. A., Cramer, P. C., Green, A. D., Davis, S. T., Jackson, P. J., et al. (2014). Monitoring wildlife-vehicle collisions in the information age: how smartphones can improve data collection. *PLoS ONE* 9:e98613. doi: 10.1371/journal.pone.0098613 PMID:24897502

Parmesan, C. (2007). Influences of species, latitudes and methodologies on estimates of phenological response to global warming. *Glob. Change Biol.* 13, 1860–1872. doi: 10.1111/j.1365-2486.2007.01404.x PMID:NOPMID

Paul, K., Quinn, M. S., Huijser, M. P., Graham, J., and Broberg, L. (2014). An evaluation of a citizen science data collection program for recording wildlife observations along a highway. *J. Environ. Manage.* 139, 180–187. doi: 10.1016/j.jenvman.2014.02.018 PMID:24705097

Santos, S. M., Carvalho, F., and Mira, A. (2011). How long do the dead survive on the road? Carcass persistence probability and implications for road-kill monitoring surveys. *PLoS ONE* 6:e25383. doi: 10.1371/journal.pone.0025383 PMID:21980437

Schmeller, D. S., Henry, P.-Y., Julliard, R., Gruber, B., Clobert, J., Dziock, F., et al. (2009). Advantages of volunteer-based biodiversity monitoring in Europe. *Conserv. Biol.* 23, 307–316. doi: 10.1111/j.1523-1739.2008.01125.x PMID:19183201

Shi, W., Shi, W., and Shi, S. (2002). *Spatial Data Quality*. London; New York: Routledge Chapman Hall.

Shilling, F. M., Perkins, S. E., and Collinson, W. (2015). "Wildlife/roadkill observation and reporting systems," in *Handbook of Road Ecology*, eds R. van der Ree, D. J. Smith, and C. Grilo (West Sussex, UK: John Wiley & Sons), 492–501.

Slater, F. M. (2002). An assessment of wildlife road casualties of wildlife road casualties – the potential discrepancy between numbers counted and numbers killed. *Web Ecol.* 3, 33–42. doi: 10.5194/we-3-33-2002 PMID:NOPMID

Teixeira, F. Z., Pfeifer Coelho, A. V., Esperandio, I. B., and Kindel, A. (2013). Vertebrate road mortality estimates: effects of sampling methods and carcass removal. *Biol. Conserv.* 157, 317–323. doi: 10.1016/j.biocon.2012.09.006 PMID:NOPMID

van der Ree, R., Smith, D. J., and Grilo, C. (2015). "The ecological effects of linear infrastructure and traffic: changes and opportunities of rapid global growth," in *Handbook of Road Ecology*, eds R. van der Ree, D. J. Smith, and C. Grilo (West Sussex, UK: John Wiley & Sons), 1–9.

Vercayie, D., and Herremans, M. (2015). Citizen science and smartphones take roadkill monitoring to the next level. *Nat. Conserv.* 11, 29–40. doi: 10.3897/natureconservation.11.4439 PMID:NOPMID

Data quality in citizen science projects: challenges and solutions

Gabriele Weigelhofer, Eva-Maria Pölz,

WasserCluster Lunz GmbH, Lunz am See, Austria
gabriele.weigelhofer@wkl.ac.at

Introduction: Data quality is one of the greatest challenges in Citizen Science (CS) projects. Insufficient data quality originates from the attempt to reduce the effort in data acquisition through the use of trained volunteers. Yet, the involvement of volunteers adds a chaotic component to the study design as neither the sample size nor the temporal and spatial distribution of the collected data can be determined a-priori. Variability among volunteers in knowledge, skills, and motivation, and over-simplification of tasks reduce data quality further. Data quality, however, determines the acceptance of results by both the scientific community and the stakeholders in environmental management. Thus, strategies are needed to identify potential sources of errors in the research design and to control data quality in CS projects. The current paper is the result of a workshop during the 2nd Austrian Citizen Science Conference. It identifies categories of data quality problems and offers solutions for different types of ecological CS projects.

Types of data quality problems: Data quality problems were grouped into four categories: (1) the scientific value of the data, (2) the objective bias, (3) the subjective bias, and (4) the quality control. The scientific value of the data addresses questions of sample size, completeness of data sets, and the explanatory power of simplified data required for scientific analyses (Table 1). Hence, this category questions whether a scientific project is suited for CS in principle. The objective bias arises from the individuality of the volunteers, their personal skills, knowledge, and attitude towards the project, or the amount of time they are willing to afford (Table 2). In global projects, cultural differences among participants may present additional challenges. The subjective bias originates more from the specific research subject rather than the individual observer, but may be interlinked with the objective bias (Table 3). Seasonal and daily fluctuations in studied parameters, such as species occurrence or water chemistry, may create a temporal bias. Different accessibility to locations (e.g., shoreline of lakes vs. free-water zone) or probability of animal–volunteer encounters may create spatial patterns unexpected in a-priori planned study designs. The quality control, at last, includes tools for identifying and correcting errors (Table 4). This category is partly linked to the first three categories, but additionally addresses errors which may also occur in traditional research projects, such as errors in data entry or wrong identification of rare and unexpected species.

Problems in data quality differ among the different types of ecological CS projects: (a) monitoring of species: volunteers are trained in species identification and record species occurrence and frequency. Specific problems are wrong identifications, especially of rare species (over-motivation), and under-estimation of abundant species (under-motivation). The research tasks usually require high skills and high motivation of volunteers. (b) Animal sightings: volunteers report animal encounters. Specific problems are the temporal and spatial bias of animal–volunteer encounters and the lack of absence data. Volunteer skills are usually of less importance due to the simplicity of the tasks. (c) Environmental observations (e.g., phenology): volunteers report observations in environmental changes. Specific problems are the high amount of data needed and the spatial bias. (d) Environmental quality analyses (e.g., water, air): volunteers measure environmental quality parameters. Specific problems are the accuracy of simplified methods versus established analytical methods, sources of pollution during sampling, and the subjective bias.

Potential solutions and strategies: Tables 1–4 list reasons and solutions for various data quality problems in ecological CS projects based on the workshop discussions. Data quality problems and solutions, especially regarding the objective bias, have been addressed by numerous authors. The use of registered participants with certificates and the ongoing training of volunteers are seen as prerequisites for successful CS projects (e.g., Gouveia et al., 2004; Cohn, 2008; Dickinson et al., 2010). Many authors also stress the importance of external communication experts and pilot-tests to optimize working protocols (Bonney et al., 2009). Descriptions of automatic filters in online data forms, which should prevent wrong data entry or incomplete data sets, are provided by, e.g., Bonney et al. (2009) and Bonter and Cooper (2012).

Before developing a CS project, scientists need to check the suitability of the research question for CS and the required sample size for scientific analyses (e.g., Conrad and Hilchey, 2011). These questions are especially critical for projects dealing with animal sightings, as, e.g., the lack of absence data prevents the scientific analyses of the data. In environmental quality projects, simplification of tasks and adaptations of methods may reduce the scientific output markedly. In such projects, simplified methods have to be validated via comparisons with established methods (e.g., Au et al., 2000; Fore et al., 2001). Besides, spatial and temporal patterns of the required data have to be considered before the project start and need to be addressed in working protocols to reduce the subjective bias.

Conclusion: Many CS projects are by far more labor intensive than expected in order to guarantee the data quality required for scientific analyses. Much of the work goes into the recruitment, proper training, and continuous motivation of the volunteers. The preparation phase is especially important in CS projects. A-priori defined no-go criteria, such as minimum sample size or sampling sites required for scientific analyses, prevent the collection of large amounts of data which are neither publishable nor usable for other purposes (e.g., for environmental management). Data quality assurance requires a different approach of CS projects to the research design than traditional research. After the development of the research design, scientists need to reconsider the whole concept from the perspective of possible data quality problems created through the use of volunteers. In this step, scientists need to question which quality problems can be handled within the proposed research design and which problems may afford adaptations of the research concept. At last, scientists need to critically review whether such adaptations may threaten the scientific output of the project. CS can, thus, provide scientifically sound data if potential problems and restrictions are considered in advance and addressed through the application of adequate quality control tools.

TABLE 1: Data quality problems, reasons, and solutions regarding the scientific value of the data.

Scientific value of data		
Problems	**Reasons**	**Solutions**
Insufficient amount of data	Low number of participants	Address specific groups Use different media for PR Stress local importance of research Offer incentives (games, competitions)
Incomplete data sets	Unclear description of tasks	Work with communication experts Translate protocols to another language and back again Use multiple media for protocols Optimize protocols after pilot-testing with untrained people Train citizens in data generation Define data set ("cases")
	High complexity of tasks	Reduce complexity of tasks Assign more complex tasks to small, better trained groups
	Long duration of data collection, high drop-off rates	Optimize duration of data collection Create personal links Create community and stewardship Give immediate feed-back
	Incomplete data entry	Allow upload only when all fields are filled

Scientific value of data		
Problems	**Reasons**	**Solutions**
Low explanatory power	Over-simplification of data, missing hypotheses	Define hypotheses before study design Check if desired data requirements can be met by CS project
Low data accuracy	Qualitative data less accurate than quantitative data	Transfer qualitative data into quantitative data (check via pilot-tests)

TABLE 2: Data quality problems, reasons, and solutions regarding the objective bias.

Objective bias		
Problems	**Reasons**	**Solutions**
Different know-how and skills of volunteers	Insufficient training of volunteers High complexity of tasks	Check skills and reliability of participants, e.g., via games (certificates) Use only registered participants Offer facilities to re-train participants Decrease complexity of tasks
Under-motivation	In groups: not all may take data collection seriously	Stress importance of findings for society (personal link)
Decreasing motivation	High effort in data collection, long duration	Increase responsibility via personal links ("my" study location)
Over-motivated observers (false positive)	Volunteers want to find something Preconceptions of participants Competitions may decrease data quality for the sake of data quantity	Stress importance of randomized sampling in sampling protocols Be careful if using competitions, ranks, and prizes Address preconceptions in training
Absence data (in observational data bases)	Observers report only positive sightings, not negative ones	Include absence data by, e.g., shifting focus from animal sightings to monitoring of habitats

Objective bias		
Problems	**Reasons**	**Solutions**
		Insist on regular observations (e.g., same spot 5 times over a week) Include "background data" to avoid "no data" reports, e.g., weather condition, habitat description, etc.
Spatial bias	Personal preferences in field sampling	Assign sampling locations Include comments in the data entry form for deviations from sampling design Require geo-coded time stamped data
Temporal bias	Personal preferences in timing of sampling	Define time of sampling, duration, and eventually environmental conditions (e.g., weather) Include comments in the data entry form for deviations from sampling design

TABLE 3: Data quality problems, reasons, and solutions regarding the subjective bias.

Subjective bias		
Problems	**Reasons**	**Solutions**
Spatial bias	Exclusive recording of positive data	Include negative data/absence data (see Table 2)
	Different accessibility of sites	Adjust research question
	Different probability of animal–volunteer encounter	Adjust research question
No representative temporal, spatial, and demographic samples	Low number of volunteers	See Table 1 for motivation of participants Adjust research question
Temporal bias	Unsuitable weather conditions	Address weather conditions in protocol

TABLE 4: Data quality problems and solutions regarding the quality control.

Quality control	
Problems	**Solutions**
No reference data	Use reference date from different spatial scales Provide reference data
No robust data evaluation Strategies	Include data evaluation in data collection (e.g., species identification counts only when pictures are added) Use automatic internal quality check and cross-validation for data evaluation (e.g., correlated water quality parameters) Use replicates (repeated observations, repeated samples)
Errors in data processing	Prefer raw data to processed data
Errors due to simplification or not standardized sampling	Include standardized samples (e.g., standard rows for water quality) Compare and evaluate standard methods with simplified methods Compare deviations in sample storage with standard procedure
Wrong identifications of species, low quality of provided pictures	Use automatic filters of "expected" data and continuously adjust them Give immediate feed-back and require double-check and proof Review by experts Use expertise of internet community (e.g., forum)

Keywords: quality control, data quality, citizen science, subjective bias, objective bias

Acknowledgements

The conference was funded by the Austrian Ministry of Science, Education, and Research and the Ludwig-Boltzmann-Gesellschaft. We thank the workshop participants R. Brodschneider, M. Cieslinski, B. Heinisch-Obermoser, S. Kainzinger, S. Kroop, G. Leimüller, S. Loiselle, I. Maggini, A. Maringer, K. Premke, S. Pysarczuk, K. Raab-Oertel, B. Rotter, J. Rüdisser, T. Schauppenlehner, F. Schublach, U. Steiner, M. Theurl, T. Walter, K. Wölfel, and R. Zink for their contributions.

REFERENCES

Au, J., Bagchi, P., Chen, B., Martinez, R., Dudley, S. A., and Sorger, G. J. (2000). Methodology for public monitoring of total coliforms, *Escherichia coli* and toxicity in waterways by Canadian high school students. *J. Environ. Manage.* 58, 213–230. doi: 10.1006/jema.2000.0323 PMID:NOPMID

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., et al. (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *Bioscience* 59, 977–984. doi: 10.1525/bio.2009.59.11.9 PMID:NOPMID

Bonter, D., and Cooper, C. B. (2012). Data validation in citizen science: a case study from Project FeederWatch. *Front. Ecol. Environ.* 10:305–307. doi: 10.1890/110273 PMID:NOPMID

Cohn, J. P. (2008). Citizen science: can volunteers do real research? *Bioscience* 58, 192–197. doi: 10.1641/B580303 PMID:NOPMID

Conrad, C. C., and Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: issues and opportunities. *Environ. Monit. Assess.* 176, 273–291. doi: 10.1007/s10661-010-1582-5 PMID:20640506

Dickinson, J. L., Zuckerberg, B., and Bonter, D. N. (2010). Citizen science as an ecological research tool: challenges and benefits. *Annu. Rev. Ecol. Evol. Syst.* 41, 149–172. doi: 10.1146/annurev-ecolsys-102209-144636 PMID:NOPMID

Fore, L. S., Paulsen, K., and O'Laughlin, K. (2001). Assessing the performance of volunteers in monitoring streams. *Freshwat. Biol.* 46, 109–123. doi: 10.1111/j.1365-2427.2001.00640.x PMID:NOPMID

Gouveia, C., Fonseca, A., Camara, A., and Ferreira, F. (2004). Promoting the use of environmental data collected by concerned citizens through information and communication technologies. *J. Environ. Manage.* 71, 135–154. doi: 10.1016/j.jenvman.2004.01.009 PMID:15135948

Artistic knowledge production for another planet? Participation as cultural practice and scientific approach for quality enhancement in citizen science

Pamela Bartar[1,2]

[1]Fakultät für Informatik, CSLEARN – Educational Technologies, University of Vienna, Vienna, Austria
[2]Communications, Cross-Project Activities Including IT Services, ZSI GmbH, Vienna, Austria
bartar@connectingculture.at

Position statement and introductional context: Discussions on quality in citizen science seem to be determined by a kind of "institutional corset" and by mechanisms of excellence in the scientific community [Finke (2014), p. 46 et seq.; Biggs and Karlsson (2011), p. 405 et seq.]. With the help of best practice guidelines, citizen science experts try to enhance quality for a better "standing" within community and public (Heigl and Dörler, 2015, p.2). Corresponding to this discussion, I want to contribute to the management and assessment of quality in citizen science (and participatory research in general). Citizen science is defined as a kind of "flexible concept that can be applied within diverse situations and disciplines" (European Citizen Science Association, 2016) also including participation as one of the key fundaments. According to this nature, an effort is taken to unify definitions from the arts and research in order to make the ubiquitous term of participation more applicable for further discussion. Underlying assumptions are influenced by thesis of the ARIS project (Art, Research, Innovation and Society; Bast et al., 2015), which highlights the impact of creativity, the arts, and artistic knowledge production for science and society equally [also by considerations such as "Mode 3"; ibid.: Carayannis and Campbell (2015), p. 38 et seq.]. Output of this arrangement is an argument and model on quality in citizen science with focus on societal, communicative, and relational dimensions. The selection of perspectives and examples is cursorily, the concept fragmented, but – so the hope of the author – inspiring.

Artistic knowledge production and citizen science: No doubt, our presence is very much characterized by different needs, interests, and quirks of a diverse world as well as strong and ongoing transitions. Having in mind to develop a socially innovative and inclusive (knowledge) society, it is a must to search for approaches which can match diversity as a fruitful resource. This fact is reflected by a slowly increasing number of projects encouraged to cross disciplines and formats on science by artistic strategies.

"Jeder Mensch ist ein Künstler. Damit sage ich nichts über die Qualität. Ich sage nur etwas über die prinzipielle Möglichkeit, die in jedem Menschen vorliegt …" (Beuys, 1995) (Figure 1).

Starting to disclose his artistic philosophy in the 1960s, Josef Beuys insisted on the idea that all of us are creative and can form a "Social Sculpture" ["Soziale Skulptur"; Lange (2002),

p. 276] – his societal vision promoting democracy and participation by opening up the concept of art to an interdisciplinary practice and collective authorship of social innovations. With regard to citizen science context, a handful of authors [e.g., Schäfer and Kieslinger (2016)] started to discuss the approach in the context of creativity, social innovation, and society agenda. While citizen science as umbrella term puts the focus on collaboration of scientists and amateurs, creative experts, such as artists and artistic researchers, are not included in most definitions (Figure 2).

Some authors suggest to use the term public participation in scientific research (PPSR) for the range of diverse projects categorizing them by the intensity and quality of participation [Shirk et al. (2012), p. 3 et seq]. Using this definition, projects including aspects of artistic knowledge production can be identified especially in the context of co-creation and collaboration, according to the preliminary results of a heuristic monitoring of following examples.

While collaborative projects are meant to be designed by researchers and refined by further participants from the public, co-creation means a high involvement of non-researcher from the start.

In practice, there are only a few projects so far, which involve artists or artistic strategies of knowledge production profoundly into their research design. One of the exceptions was the Collective Music Experiment (CME), a musical project on collective problem solving implemented in the framework of the EU project Socientize. It was successfully presented at the International Sonar+D Festival in Barcelona in 2014 (Sanz, 2016). Another ongoing project is Eyewire, based on a game in neuroscience to map neurons in collaboration with the Seung Lab at Princeton. The project DIYSECT uses an artistic approach for a kind of critical mapping of DYIbio and Bioart in the U.S. by creating a documentary series in the internet. In the next future, further transdisciplinary projects can be expected by the initiative START, funded by the European Commission to boost synergies between artists, creative people, and technologists.

Snapshot on a process-orientated model on quality: What happens, if researchers, artists, and other experts of daily life participate in a CS project? How can we define and assure quality in this context? How to manage many diverse talents and opinions and how to steer conflicts? Answers will be various and depend on different settings and proponents. In common is a focus on quality of participation as central approach in the design, implementation, and assessment of projects. Further problems need to be managed on a regular basis, for example, in context of the creation of design, team and community building, the flow of creativity, science communication, efforts of transfer as well as education and learning. The graphic below conveys an overview on challenges and leverages within a CS project including strategies of creativity and/or artistic knowledge production (Figure 3).

Preliminary conclusion: Co-creation and collective authorship versus the tradition of genius, disciplinary borders are catchwords in both the worlds, science and the arts. At presence, most of the scientists, universities, and research councils rely on bibliometric tools to measure, while innovative approaches such as artistic knowledge production and quality concerns aligned by questions on participation and empowerment are marginal issues but could offer further input to the discourse and reputation of citizen science.

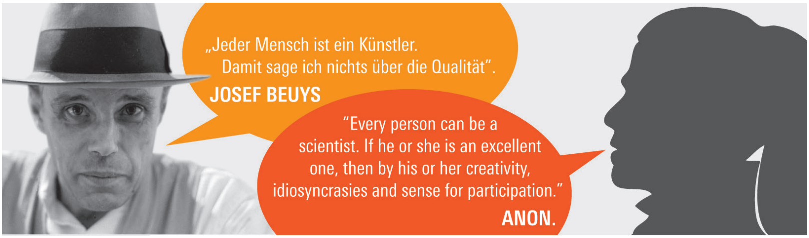

FIGURE 1: A thought on scientific and artistic knowledge production for citizen science, based on Beuys (1995).

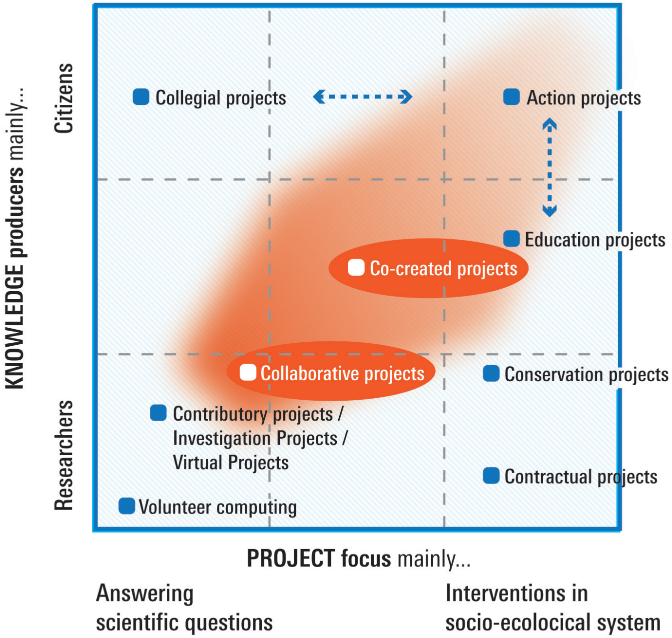

FIGURE 2: Artistic knowledge production and participation in citizen science based on types of citizen science projects integrating typologies from Boney et al. (2009), Shirk et al. (2012), and Wiggins and Crowston (2011) compiled by Schäfer and Kieslinger (2016).

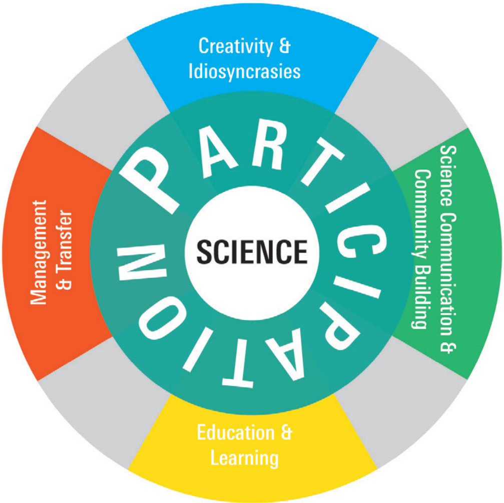

FIGURE 3: Management of quality in citizen science projects.

Keywords: excellence, quality, citizen science, participation, public participation in scientific research, artistic knowledge production, Art Research Innovation and Society

REFERENCES

Bast, G., Carayannis, E. G., and Campbell, D. F. J. (eds) (2015). *Arts, Research, Innovation and Society*. Springer: New York, Heidelberg, Dordrecht, London.

Beuys, J. (1995). *Sprechen über Deutschland: Rede, gehalten am 20. November 1985 in den Münchner Kammerspielen. FIU-Verlag: Wangen im Allgäu.*

Biggs, M., and Karlsson, H. (2011). "Evaluating quality in artistic research," in *The Routledge Companion to Research in the Arts*, eds M. Biggs and H. Karlsson (Routlegde: London, New York).

Bonney, R., Cooper, C. B., Dickinson, J., et al. (2009). Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience* 59, 977–984. doi: 10.1525/bio.2009.59.11.9

Carayannis, E. G., and Campbell, D. F. J. (2015). "Art and artistic research in quadruple and quintuple helix innovation systems," in *Arts, Research, Innovation and Society*, eds G. Bast, E. G. Carayannis, and D. F. J. Campbell (Springer: New York, Heidelberg, Dordrecht, London), 29–51.

European Citizen Science Association. (2016). *10 Principles on Citizen Science*. Available at: http://ecsa.citizen-science.net/documents

Finke, P. (2014). *Citizen Science. Das unterschätzte Wissen der Laien*. OEKOM Verlag: München.

Heigl, F., and Dörler, D. (2015). *Qualitätskriterienkatalog für Citizen Science Projekte in den Naturwissenschaften. Im Auftrag des Bundesministeriums für Wissenschaft, Forschung und Wirtschaft*. Universität für Bodenkultur: Wien, Wien.

Lange, B. (2002). "Soziale Plastik," in *DuMonts Begriffslexikon zur zeitgenössischen Kunst*, ed. H. Butin (DUMONT: Köln), 276.

Sanz, F. S. (2016). *Entrelazando la ciencia ciudadana y el arte*. Available at: http://blogthinkbig.com/entrelazando-la-ciencia-ciudadana-y-el-arte/

Schäfer, T., and Kieslinger, B. (2016). Supporting emerging forms of citizen science: how to cite a plea for diversity, creativity and social innovation. *JCOM* 15, Y02. doi: NODOI PMID:NOPMID

Shirk, J. L., Ballard, H. L., Wilderman, C. C., Phillips, T., Wiggins, A., Jordan, R., et al. (2012). Public participation in scientific research: a framework for deliberate design. *Ecol Soc* 17, 29. doi: NODOI PMID:NOPMID

Projects

http://collectivemusicexperiment.euhttp://www.socientize.eu/; http://eyewire.org; http://www.diysect.com; https://ec.europa.eu/digital-single-market/en/ict-art-starts-platform

Further sources

Glauner, M. (2016). *Get Involved! Partizipation als künstlerische Strategie, deren Modi Interaktion, Kooperation und Kollaboration und die Erfahrung eines "Mittendrin-und-draußen"*. In: Kunstforum international Bd. 240.

Löbach-Hinweiser, B. (2014). *Kunst und Wissenschaft. Band 1 – Zum Verhältnis zwischen den Disziplinen*. Cremlingen.

Löbach-Hinweiser, B. (2014). *Kunst und Wissenschaft. Band 3 – Experimente in den verschiedenen Gesellschaftsfeldern*. Cremlingen.

Miessen, M. (2012). *Albtraum Partizipation*. Berlin.

Spohn, A. (2015). *Handlung, Teilnahme Beteiligung. Partizipation zwischen Politik und Kunst*. In: Kunstforum international Bd. 231.

Sanz, F. S., Holocher-Ertl, T., Kieslinger, B., Garcia, F. S., and Silva, C. G. (2014). *White Paper on Citizen Science in Europe*. The Socientize Consortium (ed.). Available at: http://www.citizen-science.at