PROCEEDINGS OF SCIENCE

Linking research and science communication by cooperating with school classes

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In the course of the Citizen Science project 'The hidden world of bacteria' a research group worked together with school classes trying to meet both requirements, for scientific publication of project results and for successful knowledge and science communication. The aim of the project was to isolate interesting bacteria strains from inland waters and to describe them as new taxa. A further aim was to illustrate the invisible world of bacteria in surface waters and to promote the understanding for their role in the environment. Students from six school classes took water samples and handled them in workshops. Overall nearly 100 bacteria strains were isolated and half of them genome sequenced. Four peer reviewed articles taxonomically describing new genera and species were already published in an international journal in the time frame of the project. The students were involved in the whole process from taking samples to publishing the results and significantly contributed to the success of the project. Beside this they got an insight into the hidden world of bacteria and how scientific research works.

5th Austrian Citizen Science Conference 2019 (ACSC2019)
26-28, June, 2019
Obergurgl, Austria

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PoS(ACSC2019)010

1.Introduction

Citizen Science projects pursue various goals. On the one hand, the aim is to benefit from the contribution of the Citizen Scientists to research work. On the other hand, the ambition of such projects is to impart specific knowledge and to improve the understanding of the public for research and science. One big challenge of Citizen Science projects is not to lose sight on the objective to produce publishable findings. A study in 2016 [1] analyzed 490 Citizen Science projects and found that only 78 had an output in form of peer reviewed publications. In the Citizen Science project 'The hidden world of bacteria' we worked together with school classes and tried to meet both requirements, for productive research as well as for successful knowledge and science communication.

2. Aim and procedure of the project

In the public it is widely unknown that our direct surrounding, for example the flowerpot on the window bench or the nearby lake, contains many not scientifically described species. According to differing estimations at least millions of bacterial species exist [2], but only a very small fraction of them are scientifically described. Based on these facts the research goal of the project was to isolate interesting bacterial strains from inland waters with the assistance of students from schools. Some of these bacterial isolates should be described as new genera and new species. In addition, genome sequences were obtained from part of the isolated bacterial strains. These sequences are of great importance to link taxonomic research with the investigation of microbial diversity and ecology. An important aim of the project was to give the students an insight into the invisible world of bacteria in inland waters and to promote the understanding for their role in the environment. Linking these concerns, the concept was to involve school students from the very first step up to publishing the results. During the project fifteen to seventeen years old students from six classes took samples from different waters. They showed high creativity and brought samples from creeks, rivers, lakes, ponds, puddles, but also from rain butts and water cans. Every class handled their samples during workshops in the classroom and got first bacteria cultures. The project team continued the work in the lab and isolated by purification nearly 100 bacterial strains. During four weeks lasting internships nine students worked with the project team in the lab to characterize the strains phenotypically. With the help of a taxonomic supervisor and according to taxonomic rules 25 students created Latin derived names for the new genera and species. Descriptions of some of the newly discovered genera and species were published in a peer reviewed journal. So, every class could contribute from taking samples to the publication of the new taxa.

3. Science communication activities

To introduce the students to the topic, theoretical units complemented the hands-on activities during the workshops. Three videos were designed and used during the workshops and in school lessons. One video shows the way from taking samples to the description of a new species to illustrate the steps in which the students were not directly involved. Another one gives insights into the ecosystem lake by using microscopic images and computer animations (YouTube: Sparkling Bacteria). The core of the project was a website (www.sparklingbacteria.com) where

all information and teaching material were available. Each class had their own page, where they could follow the project progress for their samples and later for their isolated bacterial strains.

4. Research outcome

The initial goal, that every class should participate at the isolation of one interesting bacterium, was exceeded. Of 92 isolated bacterial strains 44 were genome sequenced. 20 were additionally characterized and deposited at two culture collections, so that all necessary data and requirements for scientific description were available. On the basis of these data ten publications were planned. Four peer reviewed publications describing new genera and species were already released in an international journal in the time frame (28 month) of the project [3-6]. One of these new genera named *Aquirufa* [4], which derived from Latin 'water' and 'red', was of huge scientific interest. It turned out that *Aquirufa* is a widespread and abundant bacterial taxon in small waters and of interesting ecology. So, the project team together with two students from the school classes tried to obtain further isolates. Overall representatives of six *Aquirufa* species could be obtained and 17 genome sequences for later analyses were generated. The two other newly described genera *Fluviispira* [3] and *Rariglobus* [6] were also of great scientific significance. They concern rare groups of bacteria with only a few cultivated and described members. Therefore, regarding the scientific outcome, the project was highly successful. The diverse und unusual samples from waters brought by the students enabled the isolation of many interesting and unknown bacterial strains. Besides that, the involvement of 125 students as Citizen Scientists led to a great number of samples and precultures and enhanced the probability to get interesting bacterial isolates.

5. Conclusion

In conclusion the project was very beneficial for both sides. The design of the project made it possible to involve the students from the first beginning up to the publication of the results. Regarding their specific contributions, many students were mentioned in the acknowledgements of the publications. An essential role played the teachers of the classes. They helped to organize the workshops and samplings and ensured that the school classes were up to date about the project progress. Their mediation between the students as Citizen Scientists and the project team enabled the collaboration. The released and planned publications showed that the scientific aim was reached. From the participating students and the involved teachers, the project team got very positive feedbacks. For instance, the opinion of a student: 'I was not aware that bacteria play an essential role in waters, they are the building block of life. I liked the practical work (in the classroom) very much.' A view from a teacher: 'The students really got an insight into the secret world of science.'

Funding information: The project 'The hidden world of bacteria: Exploring the diversity of bacteria in Austrian inland waters: isolation and description of new species.' (SPA 06/065) was supported by 'Sparkling Science' a program of the Austrian Federal Ministry of Education, Science and Research (BMBWF). Summer internships were supported by the program 'Talente' of the Austrian Research Promotion Agency (FFG).

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