https://buergeruni.hhu-blog.de/index.php/2025/01/15/nun-sind-es-die-jackson-5-buergerwissenschaftsprojekt-hat-nun-fuenf-stars-der-pflanzenforschung/

Now it's the Jackson 5: Citizen science project now has five stars of plant research

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The citizen science project PUKI invites interested citizens to look out for five inconspicuous but highly interesting plant species!

Two years ago, we introduced a megastar of plant science in this blog: the **thale cress** (*Arabidopsis thaliana*)[1]. However, a star doesn't like to be alone: four other stars of plant research have now joined.

We named our citizen science project **PUKI**: this stands for **Pflanze** • **Umwelt** • **Klima** • **Interaktion [Plant** • **Environment** • **Climate** • **Interaction]**. At PUKI, interested people can participate as citizen scientists to research how plants adapt to a rapidly changing environment. We all know the buzzwords: climate crisis, urbanization, soil pollution, etc. What is behind all of this is the fact that our environment is changing ever faster due to human activity[2].

Plants are the basis of every ecosystem. That is why it is essential to understand how plants can adapt to these partly dramatic changes. Hence the **I for interaction** in PUKI: How does the change in the environment affect the plants? And how do the plants in turn change their environment?

Although it is beech, oak and spruce trees that are dying in large numbers in German forests due to the climate crisis[3], it is of course not possible to carry out laboratory research on trees, because then you would have to wait a few decades for the results. That is why research often selects models that are easy to handle in the laboratory: the laboratory rat for bodily functions, for example, or the fruit fly for genetics. And in plant research, it is often the thale cress, because it has numerous advantages: it is small, grows very quickly, is undemanding, and is well suited to experimentation due to its relatively small genome (the genetic material).

You can do an experiment yourself: Just enter "Arabidopsis thaliana" into *Google Scholar*[4] and press the Enter key. The result is "about 979.000 results" – that means there are now almost a million scientific papers that somehow refer to the thale cress! If you were to read one of these papers a day, it would take 2740 years to read all of them. Our scientific knowledge is now so incredibly vast that no one can grasp even a fraction of it. Unfortunately, this often makes it so difficult to communicate science to the public at all.

But we still want to try it with PUKI: Our website already contains a lot of information about the plants and the research that our project is pursuing (www.puki.hhu.de). Feel free to take a look!

Which brings us back to the **P** for **plants**: As mentioned before, we have gained four more megastars that we would like to briefly introduce to you here, namely the hairy bittercress (*Cardamine hirsuta*), the shepherd's purse (*Capsella bursa-pastoris*), the perennial wall-rocket (*Diplotaxis tenuifolia*) and the turnip rape or field mustard (*Brassica rapa*) (Figure 1). All of these plant species belong to the cruciferous family (Brassicaceae) and are so-called "pioneer plants" that can quickly colonize disturbed soils due to their very short life cycle. This rapid growth also makes them so suitable for research.

Figure 1: The five plant species being studied in the PUKI citizen science project (from left to right: thale cress, hairy bittercress, the shepherd's purse, perennial wall-rocket, turnip rape). Citizens can participate in the research by finding the plants, measuring them, and taking small samples (Fotos von B. A. Walther, T. Blank, E. Hamann).

Because of their undemanding nature, all five species can be found in almost all of Germany and in many habitats, especially also in cities. For example, we found three of the species within a few meters of each other on a sidewalk in both Mönchengladbach and Düsseldorf (Figure 2). And because they are neither threatened nor protected due to their abundance, they are ideal plants for citizen science, as citizens can take plant samples without causing any harm or breaking any law.

Figure 2: The target plants often grow in the cracks between paving stones: here the thale cress (1), the hairy bittercress (2) and the shepherd's purse (3) within a few meters of each other (Himmelgeist, 21 April 2023; photo by B. A. Walther). Close-ups of some of these plants can be seen in Figure 3.

So let's first introduce you to the **hairy bittercress**. It has only 16.900 hits on *Google Scholar*, but that is still an astonishingly large amount of scientific literature. Most similar to thale cress, it differs most in its pinnate leaves and the position and coloration of its pods (Figure 3). These pods are actually something special: the ripe pods literally "explode" when touched, thereby hurling the seeds over long distances. This mechanism is being intensively studied in order to understand biomechanical principles. The hairy bittercress shows a high genetic diversity, especially with regard to the different leaf shapes during its life cycle. This property is used in our research group[5] to decipher the genetic mechanisms of leaf development in response to temperature differences.

Figure 3: Although the thale cress (1), the hairy bittercress (2) and the shepherd's purse (3) look similar, a closer look reveals significant differences that make species identification easier (see the identification aids on our website[6]; photos by B. A. Walther).

The **shepherd's purse** got its peculiar name because the short pods (called siliques) are shaped like the bags of former shepherds. Their shape is also one of the best identifying features. It is also a fascinating plant with numerous scientifically interesting properties, and accordingly has 28.800 hits on *Google Scholar*. It is used as a model plant for genetic diversity and adaptability to different environments because it is one of the most widespread plants in the world, occurring in almost all climates, except in extremely cold or dry areas. On top of that, it flowers all year round, which further proves its extreme adaptability. In recent years, research has shown one of the possible mechanisms for this adaptability. Many people are sure to know the sundew, which nourishes itself in our moors by also catching insects. Experiments showed that nematodes living in the soil were attracted to the seeds of the shepherd's purse, but were then killed by touching them[7]. The nutrients released by the decomposition of the worms increased the germination rates of the seeds and the development of the plant, especially in nutrient-poor soils. Shepherd's purse is therefore a carnivorous plant like the sundew!

The **perennial wall-rocket** and the turnip rape (see below) have yellow flowers in contrast to the white flowers of the other three species (Figure 4). Another good

identifying feature is the distinctively shaped leaves, which many people know from the supermarket: namely as wild rocket salad[8]. The perennial wall-rocket is a popular salad and spice plant because it has a characteristic, hot and spicy aroma, which is created by mustard oil glycosides, and because it is rich in antioxidants, vitamins (especially vitamin C and K), minerals (such as calcium and potassium) and secondary plant substances. It only has 8.600 hits on *Google Scholar*, but the perennial wall-rocket is, for example, a model plant for studies on the stress physiology of plants because it is highly resistant to salty soils, drought and pollutants. That is why it also grows well along motorways, where a lot of salt is spread and many heavy metals pollute the soil. As a plant originating from the Mediterranean region, it is excellently adapted to dry, barren soils, because the deep taproot enables it to absorb water and nutrients even in dry conditions. And also fitting its Mediterranean character: It needs a lot of sun!

Figure 4: The perennial wall-rocket Schmalblättrige Doppelsame likes to grow in pavement cracks, but also in numerous other habitats (see examples on our website[9]; photos by B. A. Walther).

The **turnip rape** has 213.000 hits on *Google Scholar* because it is an agriculturally important and one of the oldest domesticated plant species, having been cultivated since the Neolithic period 4000 years ago[10]. Numerous subspecies have been bred from the naturally occurring plant and are grown as oil, vegetable and fodder crops, for example turnip, Chinese cabbage and komatsuna (see Wikipedia for more examples). The turnip rape is also closely related to other economically important plants such as cabbage (*Brassica oleracea*), rapeseed (*Brassica napus*) and mustard (*Brassica juncea*). Therefore, it serves as a model for genetic studies within the *Brassica* genus, particularly on evolution and domestication. Turnip rape has the ability to absorb heavy metals such as arsenic, lead and cadmium from contaminated soils and can therefore be planted to

clean up contaminated soils[11]. Like the perennial wall-rocket, turnip rape also shows a remarkable tolerance to environmental stressors such as cold, salt and drought. These properties are being intensively studied in order to gain insights for the breeding of resilient crops. For example, Professor Elena Hamann from our research group[5] is studying how turnip rape can adapt to fluctuations in rainfall and severe drought[12].

All five are thus fascinating plant species, and in order not to go beyond the scope of this article, I will only briefly mention that these species also have numerous medicinal uses, some of which date back to the Middle Ages and antiquity[13].

And why is research on these five plant species so important? Because plants are struggling with ever greater environmental changes, we need to understand how they can adapt (or not). On the one hand, this is **basic research**, i.e. a better understanding of how plants and ecosystems deal with extreme conditions. On the other hand, there will also be **practical applications**, for example in agriculture and forestry, in nature conservation and renaturation projects, and in the creation of green cities. Which tree species can replace the disappearing beech, oak and spruce trees? What characteristics do cultivated plants need to cope with higher temperatures, less water and longer droughts? And how can you get involved in our research? Everything is explained in detail on our website, but here is a brief summary of the essentials. We work with the ***Flora Incognita*** app (https://floraincognita.com/). This app allows you to identify almost all plant species in Germany very quickly and reliably (Figure 5).

Figure 5: With *Flora Incognita*, almost all plant species in Germany can be identified quickly and reliably (photo by B. A. Walther, screenshot of *Flora Incognita* with kind permission of P. Mäder).

Of course, it is fun to identify the plants without technical help[6], but in combination with *Flora Incognita* you have additional information and tips. On *Flora Incognita* you can then open an additional function[14] with which you can enter data about the plants you have found, e.g. the length of the plant, the number of pods, the habitat and the incidence of light. This data helps us to better understand the adaptations of the plant to the respective location. If you then also collect and send in a plant and soil sample (Figure 6), we can carry out genetic studies and soil analyses that generate a lot of interesting and relevant data. Your participation therefore contributes directly to important research into plant adaptations to a rapidly changing environment!

Figure 6: On the left, the length of a shepherd's purse is measured, and on the right, a plant sample of the thale cress is bagged (photos by B. A. Walther).

You can also help by commenting on and improving our data protocols, recruiting more participants, organizing and managing collections, or helping with outreach and education. Please send all questions and suggestions to: **Bruno Walther**, Heinrich-Heine-Universität Düsseldorf, Gebäude 26.14, Raum 01.067, Universitätsstr. 1, 40225 Düsseldorf, Tel: 0211-81-13427, Email: Bruno.Walther@hhu.de

Further information can be found here:

[1]https://buergeruni.hhu-blog.de/index.php/2022/11/21/eine-kleine-pflanze-wird-zum-star-fuer-buergerwissenschaft/

[2]https://www.ardalpha.de/wissen/umwelt/nachhaltigkeit/anthropozaen-erdzeitalter-geologie-mensch-100.html, https://docupedia.de/zg/Tanner_anthropozaen_v1_de_2022

[3]https://www.forstpraxis.de/klimaszenarien-im-buchenwald-duestere-prognosen-sind-wahrscheinlich-23416, https://www.deutschlandfunkkultur.de/folgen-des-klimawandels-fichte-ohne-zukunft-100.html

[4]https://scholar.google.com/

[5]https://trr341.uni-koeln.de/

[6]https://www.puki.hhu.de/fileadmin/redaktion/Fakultaeten/Mathematisch-Naturwissenschaftliche_Fakultaet/Biologie/puki/Artbestimmung_Kurzversion.pdf, https://www.puki.hhu.de/fileadmin/redaktion/Fakultaeten/Mathematisch-Naturwissenschaftliche_Fakultaet/Biologie/puki/Artbestimmung_Langversion.pdf

[7]https://www.nature.com/articles/s41598-018-28564-x.pdf

[8]Two types of plants are usually sold as rocket salad: usually the perennial wall-rocket or the arugula (*Eruca vesicaria* subsp. *sativa*). Sometimes it can also be the annual wall-rocket (*Diplotaxis muralis*) (https://de.wikipedia.org/wiki/Rucola). Compared to the arugula, the perennial wall-rocket has narrower leaves and a more intense aroma, which is preferred by lovers of spicy flavors.

[9]https://www.puki.hhu.de/fileadmin/redaktion/Fakultaeten/Mathematisch-Naturwissenschaftliche_Fakultaet/Biologie/puki/Habitate_der_Zielpflanzen.pdf

[10]https://www.yumda.com/de/news/1171363/moegen-sie-ihr-gruenzeug-nicht.html, https://doi.org/10.1093/molbev/msab108

[11]https://doi.org/10.1016/j.ecoenv.2019.109961

[12]https://now.fordham.edu/science/plants-adapt-to-climate-change-but-theres-a-catch/, https://doi.org/10.1111/evo.13631, https://doi.org/10.1111/evo.14413

[13]https://de.wikipedia.org/wiki/Gew%C3%B6hnliches_Hirtent%C3%A4schel

[14]https://www.puki.hhu.de/fileadmin/redaktion/Fakultaeten/Mathematisch-Naturwissenschaftliche_Fakultaet/Biologie/puki/Anweisung_fuer_PUKI-Zusatzfunktion_01.pdf