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SOME ODDITIES ON THE EARLY ORIGINS AND INSPIRATIONS OF MENDEL'S EXPERIMENTS AND THE 'REDISCOVERY' OF THE MENDELIAN LAWS IN 1900

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ABSTRACT – Contemporary fragments from newspapers and books around the time of Gregor J. Mendel's famous experiments and lectures in Brno (Brünn) provide new evidence on the early beginnings of his experiments and experimental design. The fragments show that his early efforts were strongly focussed on plant breeding of varieties and at the time particularly discussed in the context of acclimatization experiments. Further newly found sources highlight that Mendel's 22 pea varieties might have been already presented to the public at exhibitions at the early beginning of his experiments in 1855. While Mendel was convinced that those experiments had economical relevance, contemporaries anonymously expressed doubts on this point. Criticism on his analysis in Brno also continued after the conclusion and presentation of his experiments. Johann Nepomuk Bayer (1802–1870), a railway expeditor and botanist for example doubted Mendel's concept of dominant and recessive traits and published a sharp comment in his final book on results of his own field trip. This previously unknown early citation of Mendel's article from 1866 is a particular oddity in the history of Genetics, because there is a huge likelihood that it might be a missing link in the early citation network of Mendel's work in the 19th century that eventually ensured that it could be rediscovered in 1900. The citation though also raises the question if this remark was only the tip of the iceberg in a longer and continuing discourse between the two researchers.

When we started to work on our upcoming new critically commented edition Mendel's scientific paper "*Versuche über Pflanzen-Hybriden*" we were confronted, as likely many editors before, with several open questions on the early origins of Gregor J. Mendel's experiments.[1] On these beginnings practically nothing is known with certainty beside the fact that already in the 1840s there was a small garden in the abbey that was maintained by the monks and later especially by Mendel's close friend František Matouš Klácel (1808–1882).[2] In 1848, during the revolution, Klácel had to leave Brno for longer periods

of time and thus he ordered the younger friar Gregor to further care for his garden.[3] It is not unlikely that peas and beans were grown there already at that time, yet not within a specific research program.[4] Different authors have tried to reconstruct the timeline of Mendel's hybridization experiments with peas and experiments during the last century.[5] However, those re-calculations are limited to some extent on Mendel's articles and the few snippets of information that can be extracted from the few surviving letters of Gregor J. Mendel and they are particularly thin in information. According to those recalculations, it is most commonly assumed that in 1854 or 1855 Mendel started to grow 34 different pea varieties. During this time, he wrote a first small article on the pea weevil *Bruchus pisi* and performed some pre-experiments with different pea varieties. In the following year 1856 Mendel then selected 22 pea varieties for further investigation on which he also performed first crossings of individuals differing in regard of one essential pair of traits (see also Figure 1).[6] In the autumn of 1856, he thus could have obtained the first uniform generation (F1) of seeds. Those crossing experiments were then continued over several generations as described by Mendel in his 1866 paper for seven years until the pea experiments were mostly terminated in 1863.[7] According to Cetl (1973) most experiments with other plant species were performed from 1864 onwards.

NEW INSIGHTS ON THE EARLY BEGINNINGS OF MENDEL'S PEA EXPERIMENTS

New primary sources from the time of the experiments now provide some further insights to the early origins of Mendel's pea experiments. First, we found another reference to "*22 pea varieties*" in a newspaper article from Brno that was published in 1855. The 22 varieties there were listed in the context of a report from an Industrial- and Agricultural exhibition in Paris at the time.[8] The varieties of peas as those of other plant species such

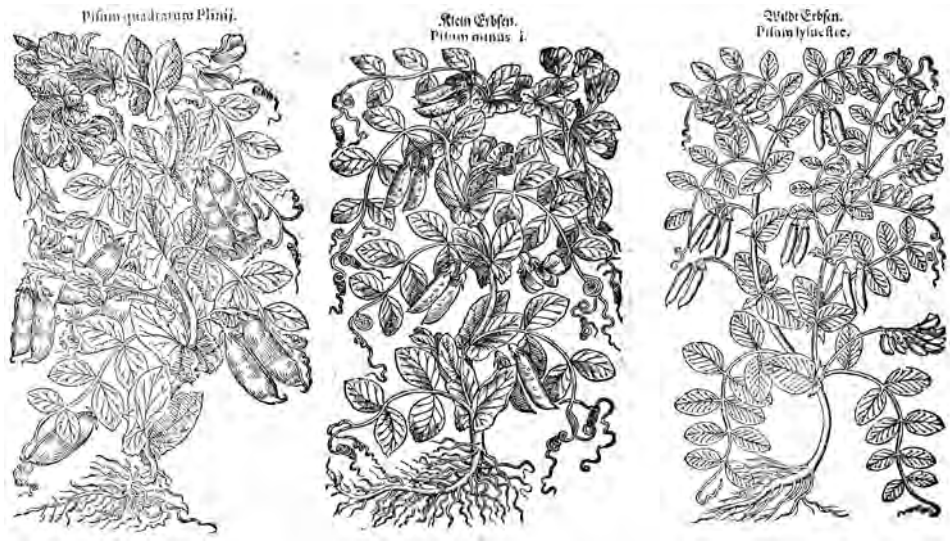


Fig. 1: Some of traits and pairs of traits in peas that Mendel investigated have been long known as a taxonomical markers. The difference of pea plants with normal height and those of dwarfed pea plants for example was already shown in the 16th century herbal of Jacobus Theodorus Tabernaemontanus (1525–1590).

as maize had been prepared by the local Chamber of Commerce in Brno on request of the Austrian Imperial Ministry of Trade to provide the exhibition with agricultural products from Moravia. Due to the direct relation of this article to Brno and Moravia, it seems almost certain that those 22 pea varieties must have been the same ones that were studied by Gregor J. Mendel as it is the only other time exactly 22 varieties were discussed in the 19th century literature corpus before 1866. It is also likely they were previously presented in another agricultural exhibition in Brno shortly before. For the reconstruction this has several consequences. First of all, the 12 additional varieties must have been already discarded in 1855 and not, as discussed currently by Van Dijk et al. 2022 in 1856. In fact, it would be plausible, too, that the first crossing experiments might have been initiated in the same year. Second, considering also the passive construct in phrasing in Mendel's original paper when he described the pre-experimental stage, it can no longer be safely assumed that this first pre-processing was executed by Mendel himself. As Mendel is actually not mentioned in the newspaper article, it is well possible that the collection of peas then was a joint project of the Moravian Chamber of Commerce, the Moravian and Silesian Agricultural Society and the local Business Society[9], especially as Mendel was a member at the time in both societies. A possible explanation is that Mendel at the time was investigating different pea charges of different origins for his article on *Bruchus pisi*[10] and afterwards became access to the different varieties of peas. If one agrees with the conclusion that those 22 varieties were the same as those used by Gregor J. Mendel in his experiments, further details given in the small article are of great importance in extracting evidence on the pea varieties he had actually used. The small news-paper article explicitly cites individual traits such as colour, size, quality and time of ripening of "*early, late, yellow, green, grey, sugar- and sweet-peas*".[11] Especially the traits of flowering- and ripening-time are quite remarkable, and they raise the question if it was one of the original traits Mendel might have been potentially interested in. The latter reading differs from other reconstructions of Mendel's experiments. Mendel himself mentions differences in flowering time as an eight trait only in a passing remark in his paper from 1866 and in his letters to Carl W. Nägeli (1817–1891) in which he mentioned that this was the sole experiment on pea traits that was continued at least until 1864.

PLANT BREEDING AND ACCLIMATIZATION EXPERIMENTS AS POSSIBLE INFLUENCES FOR MENDEL'S EXPERIMENTS

Both in the popular and scientific literature on Mendel, he is often depicted as an "*isolated*" figure[12] who carefully and stubbornly worked to untangle the mysterious arithmetic rules of heredity. However, biographers of Gregor J. Mendel knew for a long time, that he was deeply embedded and interacting within an extensive social network.[13] It will probably remain forever a mystery what he exactly had in mind when he started his experiments. Mendel's biography, however, highlights, that his work was influenced and inspired by numerous different sources. In his paper from 1866 he already intensely cited a few of the most well-known links to earlier hybridization studies including those from Gärtner (1849) and then recent studies on willow hybrids (Wichura 1865).

Another early influence for Mendel's hybridization experiments might have come from his interest in plant breeding. Two recently discovered contemporary newspaper articles from 1861 mentioned Mendel's crossing experiments directly and highlight that he had a specific vegetable breeding focus in mind.[14] Unfortunately, the articles, published 4 years before he first presented results of his hybridization experiments at two sessions of the Natural History Society (*Naturforschender Verein*; hereinafter NHS) in Brno, and

provide very few additional details on his experimental design. They though highlight that he did not only perform experiments on beans and peas at the time, but also grew other vegetables such as New Zealand spinach, cucumbers and potatoes. The newspaper articles are very illustrative, as they provide proof that Mendel's experiments were already critically discussed while they were still undertaken. Furthermore, the criticism embedded in one of the articles also underlines that Mendel was particularly interested in economically relevant topics, which is in line with a similar focus in his two early articles on two insects.[15] The most remarkable information contained in the two rediscovered newspaper-articles, however, is the fact, that they were considered as acclimatization experiment, a term not well defined, yet popular as kind of a catch phrase during the time.[16] Especially Mendel's work with an additional eighth trait flowering time in peas would fall well within a closer type of experiment. In general, it is though difficult to assess what Mendel and others in Brno at the time understood under 'acclimatization experiments'. The term acclimatization itself can be occasionally found in the botanical literature of the first decades of the 19th century. It was most commonly used for the acclimatization of foreign tree species and when discussing geographical distributions of plants.[17] However, during the mid-19th century there was a slow transition towards a different perspective seeing acclimatisation rather as a generational than geographical problem.[18] This understanding might have originated partially from plant acclimatisation experiments, in which foreign seeds were used for cultivation.[19] However, during the mid-1850s and early 1860s, also driven by colonialization and scientific botanical expeditions, it soon became a buzzword which reached a first hight in the short time span in the first half of the 1860s. In the Austrian, Bohemian, and Moravian context it was though originally used quite earlier. Franz Diebl (1770–1858), who was then Professor for agriculture at the Philosophical institute in Brno and later one of Mendel's teachers, for example described in 1840 an excursion to the Moravian towns of Blansko and Raitz. Visiting the Moravian towns of Blansko and Raitz and the local farms of Reichenbach he described several unusual plant cultivations including "acclimatisation experiments" with rice and/or "peruvian rice" whereby some of them where the germination process was even supported by an early steam driven heating grid.[20] Moravia therefore can be considered as an early centre for acclimatization-experiments linked to the Moravian- and Silesian Agricultural Society. Comparably there were also other cultivation experiments in the 1840s in which by use of chemicals changes in germination time were examined. Acclimatization experiments in its most basic form thus simply could mean cultivation experiments with foreign seeds samples, but there was also an interest in more complex considerations that discussed climatic conditions of seed origins or complex experiments with "controlled climate". From this perspective it is an interesting question when and why and to which extent Gregor Mendel considered his cultivation experiments as kind of acclimatization experiment. As he was cultivating over the years several kinds of foreign plant species, including probable pea varieties from differing European origins, his crossing experiments and other plant species described in the mentioned two newspaper articles would have clearly met the original very broad definition of acclimatization experiments. What is much more difficult though is to define when those kinds of experiments have started. One possibility is that Gregor Mendel indeed considered all of his experiments as such kind of cultivations as acclimatization experiments. What would support this hypothesis is the construction of the glass houses during the mid-1850s (see Figure 2 & 3). Alternatively it is possible that acclimatization-experiments as used in the newspaper articles only concerned the specific cultivation of plant species that were discussed. If this is true it seems a logical assumption that particularly his experiments with New Zealand spinach

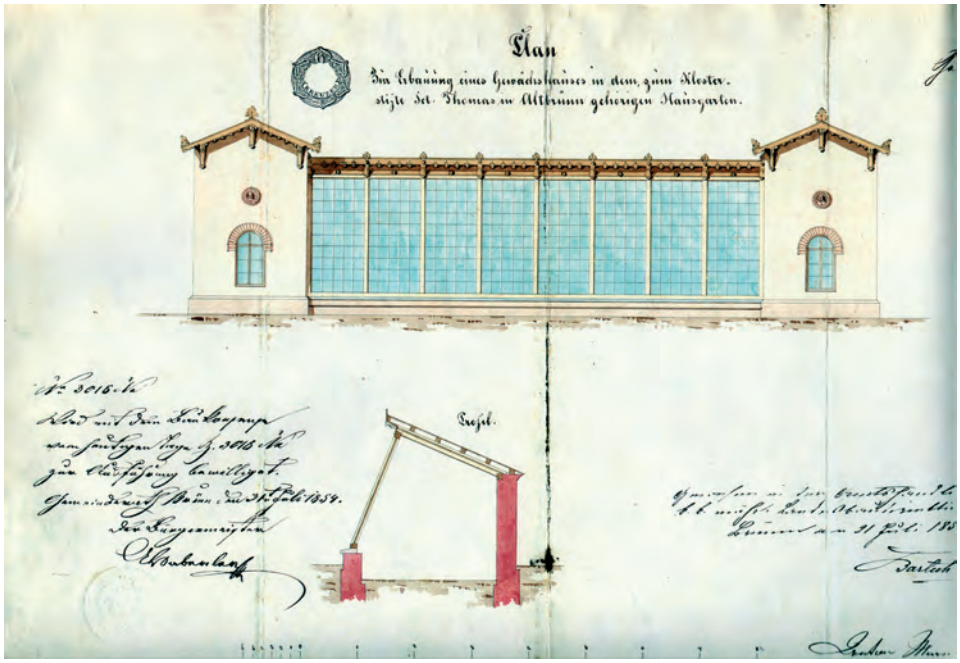


Fig. 2: Depiction of the glasshouse in the monastry in the 1850s.

Fig. 3: Photograph of the glasshouse in the monastry together with the monks around 1900.

likely may not have started before 1860s. The reason is that even though New Zealand spinach as mentioned in the newspaper articles was first imported and cultivated much earlier into Europe, Mendel might have obtained his seeds from the Austrian Novara expedition[21] which had just returned from its circumnavigation of the globe on which it had also visited New-Zealand.[22] Mendel thus might have obtained this kind of seeds indirectly from Vienna or from the Agricultural Society. One historical fact, that would support this kind of reading is that rare foreign seeds that had been collected on the Novara expedition were indeed distributed by the Imperial Ministry of Finance and for example given to the Economical Society in Bohemia.[23] The named society was especially asked to perform cultivation and acclimatization experiments with the acquired seeds.[24] In any case, some of the plant species discussed in the two newspaper articles were not previously not known to have been investigated by Mendel. They thus seem to have been addition to his later crossing experiments with other plant species that he discussed in some detail in his letters to the botanist Carl Wilhelm Nägeli.[25] It yet remains unclear if all his acclimatization experiments, then necessarily included crossing studies.

Gregor Mendel's interest in acclimatization experiments did not cease with his plant experiments anyhow. Even though from the early 1870s he had less time for such time-consuming studies after he became abbot of the monastery, he performed several studies in bees, whereby he also worked an probably crossed several foreign bee species. This experiments also were described by contemporary authors as acclimatization studies then.[26]

Knowledge of those Mendelian studies on bees is particularly limited, as he never published full accounts of those experiments.[27] Some information though can be gained from descriptions of other authors such as those of Anton Tomaschek who collaborated with Gregor Mendel directly and published an extended account on the acclimatization of a tropical stingless bee species that by chance had come into Mendel's possession.[28] Surprisingly the relation between Anton Tomaschek and Gregor Mendel has rarely been discussed and as far as we know never outside the context of Mendel's agricultural studies. This relation however is quite important in regard if Mendel's studies had any direct contemporary followers. It has been generally assumed that this was not the case. Historic newspapers however show that Tomaschek also was quite interested in similar scientific topics as those that interested Mendel. He briefly worked in Vienna as an assistant at the Meteorological Institute before he became eventually a teacher in Brno himself. His main studies then became the investigation of climatic influences on plant growth and the seasonal development of vegetation. Obviously inspired by earlier works Tomaschek worked on a model system to describe species dependent constants of thermal time.[29] For at least some of those analyses it can be shown that he used meteorological data that had been provided by Gregor Mendel.[30] Contemporary sources so far however do not provide any further prove for cooperations with Mendel before. However, it is quite interesting to note that Tomaschek himself continued to work with peas and other legumes and especially asked the Agricultural Ministry in 1874 during the World Exhibition held in Brno for foreign seeds that could be used in "*acclimatization experiments*".[31] In May 1874 such seeds were indeed send by the Ministry to the imperial Moravian and Silesian Society of Agriculture and those seeds were distributed among the societies members.[32] Some of those seeds were also given to Tomaschek. From this perspective a further collaboration between Mendel and Tomaschek seem to be very possible especially before the background on their shared interest in meteorology, phenology, acclimatization and plant development. Unfortunately, Tomaschek's own experiments with legumes seem to have been not fully published.

Beside this there is also a second tradition of acclimatization in Brno, which needs to be mentioned, as it was first used in a key lecture at an international conference by one of Gregor Mendel's mentors – Friedrich Anton Kolenati (1812–1864) in the post-revolutionary year 1849. Kolenati, in his lecture at the «Versammlung Deutscher Naturforscher und Ärzte» discussed rather the human aspects of acclimatization for people emigrating to foreign countries. While the later was certainly not a main influence on Mendel's experiments, the topic of emigration in the late 1840 and early 1850s was obviously an important topic among the friars at the monastery and particularly for his close friend Matouš Klácel, who later in 1869 himself emigrated to the US and already before supported and motivated several Moravian emigrants. The unusual lecture held by Kolenati, however, provides an interesting crosslink to the earliest time of Mendel's experiments when he just took over the oversight of the monastery garden.

THE FOUNDATION OF NATURAL HISTORY SOCIETIES AND THEIR POTENTIAL INFLUENCE ON MENDEL

One particular route of influence on the early phase of Mendel's experiments, though, is rarely if ever mentioned: The impact of the revolution and the Prague natural history society called *Lotos*. This is quite understandable, as Gregor J. Mendel himself was, as far as we are aware, not a member of the society. Nevertheless, the society was a quite important building block in the development of scientific societies in the Habsburg Empire. The *Lotos* society was founded in 1848 as a student fraternity by Prague scientist F. A. Kolenati, who later would become a teacher in Brno and a mentor of Gregor J. Mendel and at least once supported him with an expertise to gain a teaching position.[33] During the first years the society met irregularly, and lectures were presented, however, not much is known of those early years as the society did not publish an own journal. This only changed in 1851 when Johann Nepomuk Bayer (1802–1870), a railway expeditor from Prague, became the first editor in chief.[34, 35] The society soon became a new centre of expertise, and lectures were briefly afterwards also presented in print as well. One of those lectures marked a turning point for the further establishment of scientific societies in the Habsburg Empire. In a lecture the then director of the Prague university observatory Karl Kreil (1798–1862) discussed his ideas for the foundation of new Natural History Societies.[36] Kreil's ideas at the time were rather radical in such as he was suggesting that liberalizing scientific societies was a way to broaden access to knowledge and science for new parts of the society while improving the amount of knowledge that could be generated in a short amount of time. What makes the text so interesting in a modern context, however, was his specific view on the possibility of such societies regarding the special fields of meteorology and climatology. In his lecture Kreil, more or less, presented the idea of a Citizen Science, in which individual scientists and hobbyist could work together on larger topics collectively acquiring data. The ideas presented then did not directly turn into projects and they had been probably discussed by Kreil already earlier in Brno during his stay during the revolutionary years of 1848/1849. The idea was not an immediate success, but it laid kind of a starting point. In July 1851 Kreil was called to Vienna, where he became director of the newly found Central Institute for Meteorology and Earth Magnetism.[37] The goal was to establish a national institute that would organize a network of measurement stations throughout the country. In Brno the idea of a Natural History Society did not manifest immediately, but as a first start the Moravian and Silesian Agricultural Society was partially reformed allowing new members to participate. Over the years individual sections were formed and the section of Natural Sciences became the

founding stone of discussions to establish an independent NHS in Brno, which eventually was founded in 1861 after years of discussions. The NHS subsequently became the place where Gregor J. Mendel presented the results of his plant-hybridization experiments in two lectures in February and March 1865. Meanwhile in the mid-1850s, however, the NHS was the place where discussions on new ideas were presented. At that time the idea of meteorological weather stations became imminent in Brno again after it was repeatedly promoted by Alexander J. A. Zawadzki (1798–1868), a teacher at the *Oberrealschule*, where Mendel was working. Subsequently it was decided to collate measurements that had been already made over several years in Brno.[38] Mendel eventually would collate results from Moravia and in this followed a tradition of his colleague Antonin Alt, who already had collated earlier meteorological measurements. Mendel himself, around the time when he started his experimental pea crossings, also seems to have published his first meteorological work, which has only been discovered recently.[39] The meteorological compilations of Moravia and Brno though were only published after the NHS was officially founded in Brno with Mendel.

GREGOR MENDEL AND HIS RELATION TO JOHANN NEPOMUK BAYER

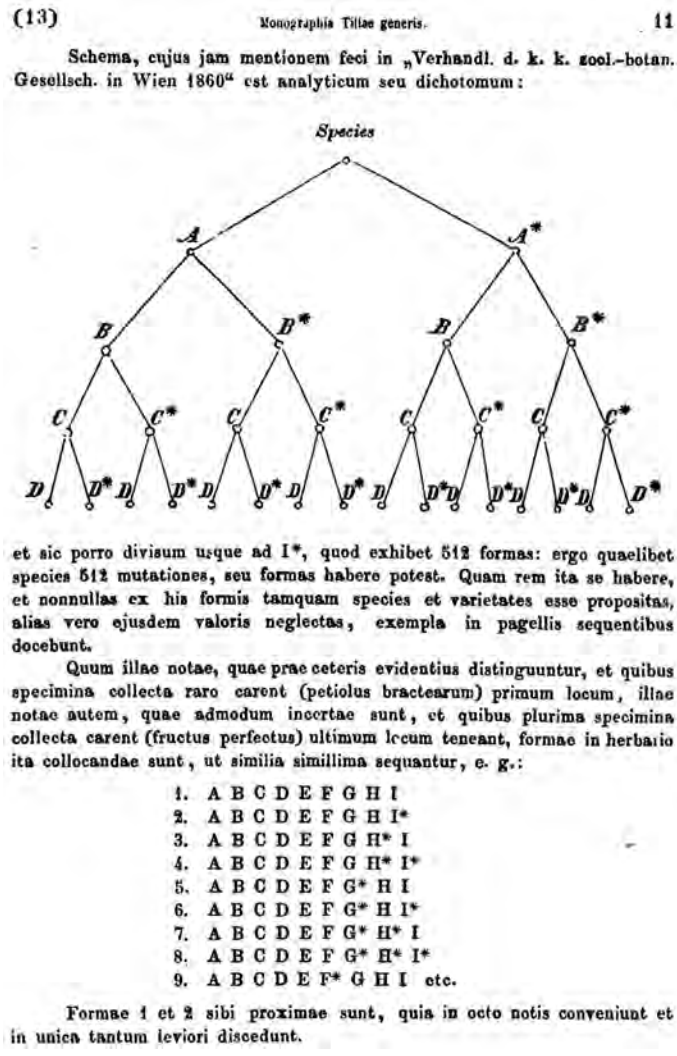
To our best knowledge the potential relationship between J. N. Bayer and Gregor J. Mendel so far has never been discussed in detail. As they were both members of the NHS in Brno and the Botanical and Zoological Society in Vienna and before in the Agricultural Society in Brno it is though obvious that they must have known each other for more than two decades. It is even possible that both men knew each other before. Mendel's friend the Augustinian friar F. M. Klácel and J. N. Bayer were both founding members of the Lotos society and Bayer himself was living in the mid-1840s for some time in Brno where he participated in many botanical excursions. When J. N. Bayer was called from Prague to Vienna in 1851, Friedrich Graf von Berchtold (1781–876) became his successor as the editor in chief of the journal Lotos.[40] Bayer though went for some time to work in Vienna and later Pesth but remained in contact with the NHS in Brno in general and with his members. It is known for example, that Mendel's friend Alexander Makowsky (1833–1908) visited Bayer there to participate in botanical excursions.[41] Bayer's focus though changed to actively work in the Botanical and Zoological Society in Vienna, where he several times was nominated for important positions. Perhaps most notably around 1861 he became responsible to reorganize and sort the society library. Furthermore, Bayer at the time organized funding support for the Society in Vienna by the ministry for botanical excursions by subsidies for train tickets. A similar funding was also provided to the NHS in Brno and was most likely also organized by Bayer. During this time, Bayer also lectured on his main work on the genus Tilia, which he presented on the 4th December 1861 at a session in Vienna. The latter work, published unusual for the time completely in Latin, introduced a new artificial taxonomic system for the genus, for which he used a letter system. While the system was quite different from the one used by Mendel for the presentation of his studies only a few years later, it shared a similarity. Bayer thereby, as Mendel later, selected individual dichotomous traits, that he found to be most important in regard to classification (see Figure 4). Based on the nine different observed traits and their dichotomous counterparts the nine letter system thus could describe 512 varieties[42], which Bayer then called "*mutationes*". While it is quite possible that Mendel took direct inspiration from Bayer in this regard, there is no direct proof for this. Nevertheless, it is most likely that Mendel at least read the paper published in the Vienna society in which he then was an active member. What is interesting though is the fact, that Bayer in his paper

explicitly already mentioned the influence of Charles Darwin (1809–1882) on his ideas. In his published article he argued as follows:

"*If from a series of transitive forms only one sample, borders it meets the eyes of the unknown, and the appearance is recognized as good; but the lakes were filled and the whole series being made, the species fall apart. While these things are so, it does not follow that forms and variations should be neglected: the science of labour and study does not stop at the end.*

If forms were born infinite in number, and without order and law, every species would be a false image. And when, according to cl. Darwin all forms are born from the variation of the partial shapes of one organism, their number is defined, and they are subject to order and law: therefore also to order they can be reduced.

Those parts, therefore, whose shape is more constant, are to be sought, and by the exchange of which a particular form is constituted. There are six parts of the linden tree, by



(13) Monographiae Tiliae generis. 11

Schema, cujus jam mentionem feci in „Verhandl. d. k. k. zool.-botan. Gesellsch. in Wien 1860" est analyticum seu dichotomum:

et sic porro divisum usque ad I*, quod exhibet 512 formas: ergo quaelibet species 512 mutationes, seu formas habere potest. Quam rem ita se habere, et nonnullas ex his formis tamquam species et varietates esse propositas, alias vero ejusdem valoris neglectas, exempla in pagellis sequentibus docebunt.

Quum illae notae, quae prae ceteris evidentius distinguuntur, et quibus specimina collecta raro carent (petiolus bractearum) primum locum, illae notae autem, quae admodum incertae sunt, et quibus plurima specimina collecta carent (fructus perfectus) ultimum locum teneant, formae in herbario ita collocandae sunt, ut similia simillima sequantur, e. g.:

1. A B C D E F G H I
2. A B C D E F G H I*
3. A B C D E F G H* I
4. A B C D E F G H* I*
5. A B C D E F G* H I
6. A B C D E F G* H I*
7. A B C D E F G* H* I
8. A B C D E F G* H* I*
9. A B C D E F* G H I etc.

Formae 1 et 2 sibi proximae sunt, quia in octo notis conveniunt et in unica tantum leviori discedunt.

Fig. 4: Letter system first introduced by J. N. Bayer in 1860 and eventually published in 1862 for the classification of Tilia varieties according to 9 main traits with the opposite traits (marked by asterisk) thus forming different traits describing the different genus whereby overall 512 varieties, which he called "*mutationes*" could be described.

which its species and forms are distinguished: Leaves, branches with petioles, bracts, flowers, style, fruits. In these six parts of each species are observed the peculiar properties, which can be considered as normal or fundamental [...]".[43]

The text thereby provides an interesting contemporary reading of Darwin's work, which might be similar to the one that influenced Mendel around 1862 in his own interpretation of Darwin's work.

In any case reports in the Proceedings (*Verhandlungen*) and session reports of the NHS in Brno make it clear that Bayer remained in contact with the NHS and also supported it with numerous books sent in as presents. The most interesting fact however is that J. N. Bayer apparently read Mendel's paper on his pea experiments from 1866. In his own work that he published shortly before his death he briefly mentioned and cited Mendel's paper, criticizing it for its concept of dominant and recessive plants:[44] Bayer there wrote "*The greatest mistrust deserve those, who claim to be able to differentiate from a hybrid the dominating seed- or pollen plant, or claim to be able to differentiate them from a herbarium specimen (Gr. Mendel, in the Proceedings of the Natural History Society in Brno, 1865, Vol. 4).*" It remains unknown if J. N. Bayer was also the one who criticized Mendel in the two recently found newspaper articles from Brno from 1862 in which Mendel's experiments were described as acclimatisation experiments.

ODDITIES IN THE 'REDISCOVERY'

Recent studies[45] have provided new insights in the early phase of the 'rediscovery' of Mendel's work in 1900 by Erich von Tschermak (1871–1962), Carl Correns (1864–1933) and Hugo de Vries (1848–1935). Beside the three rediscoverers and William Bateson (1861–1926), who heavily promoted Mendel and the Mendelian Laws in the English Literature after 1900, it was found that the 'rediscovery' did not occur as parallel as originally described while there were many more people involved who actively promoted Mendel's experiments shortly after 1900. Notably Erich von Tschermak's brother Armin (1870–1952) supported his brother intensely and discussed with him many aspects of Mendel's work.

As Mendel's work and the citations of his paper before and after 1900 have been long used as prominent examples for the usage of citation networks as proxies for the history of ideas[46], there had been some interest in the route how the rediscoverers eventually found Mendel's article in the Proceedings of the NHS in Brno. It has been long known the book "*Pflanzenmischlinge*" by Wilhelm Olbers Focke (1834–1922) played a prominent role in this transfer of knowledge.[47] Mendel's crossings and experiments are mentioned in this book at several occasions, including the systematic parts of the book on Hieracium, Pisum and Phaseolus. Focke there even mentioned the "constant numerical relations" and compared Mendel's experiments with those of Thomas A. Knight (1759–1838), which he otherwise found very similar. Thus, from the details, Focke apparently must have read Mendel's original article.

It though remained an ongoing mystery how W. O. Focke discovered Mendel's work himself. When asked after the rediscovery he could only remember that he was referred to Mendel's work by other literature from the 1870s.[48] Many authors have therefore believed, that even though slightly off in time Focke might have referred to a book by the botanist Herrmann Hoffmann (1819–1891)[49], which also mentioned Mendel's work on several pages.[50] More recently it was though highlighted that there were also other possible routes for example by early literature lists citing Mendel.[51] The newly found citation of Mendel's article by J.N. Bayer from 1869 though now provides a completely different plausible route.

Bayer interestingly mentions Mendel's work on hybridization at a very unusual place where he discusses hybrids in the Rubus family.[52] Focke, a particular specialist for this type of hybrids in Rubus thus might have looked up Mendel directly. If this is true, J. N. Bayer might have had an unusual and long overlooked influence on the reception of Mendel's work. First, and as a matter of fact, he is the only contemporary critic of Mendel's work with a direct relation to Brno and Prague who has become known by name. Second, his own work on Tilia in which he used an own letter system to describe individual discrete traits in Tilia might have been a direct influence of Mendel's paper of 1866. Third, ironically and despite his own scepticism on Mendel's work there might have never been a rediscovery at all without Bayer's publications.

REFERENCES

Anonymous (1859) Zur mähr. schles. Biographie. XIX. Franz Diebl. *Notizen-Blatt der historisch-statistischen Section der kais. kön. Mähr. schles. Gesellschaft zu Beförderung des Ackerbaues, der Natur- und Landeskunde* Nr. 8. Beilage der Mittheilungen 1858: 67–71.

Basch-Ritter R. (2008) Die Weltumsegelung der Novara 1857–1859. Österreich auf allen Meeren. Adeva. Graz.

Bayer J. N. (1862). Monographia *Tiliae generis*. *Verhandlungen der k. k. zool.-bot. Gesellschaft in Wien* 12: 3–62 (Separatabdruck).

Bayer J. N. (1869). Botanisches Excursionsbuch für das Erzherzogthum Oersterreich ob und unter der Enns. Wien.

Beránek V. & Orel V. (1988) New documents pertaining to Mendel's experiments with bees. *Folia Mendeliana* 23: 5–16.

Cetl I. (1973) Significance of Mendel's hybridizing experiments carried out after 1865. *Folia Mendeliana* 8: 213–221.

Cetl I. (1983) The chronology of Mendel's scientific activities. In: Orel V, Matalová A, (eds.) Gregor Mendel and the Foundation of Genetics. Proceedings of the Symposium "*The Past, Present and Future of Genetics*", Part 1, Kupařovice, Czechoslovakia, August 26–28, 1982, Brno Mendelianum, Moravian Museum: 289–297.

Cetl I. (2002/2003). Mendel's hybridization experiments with other plants than Pisum. *Folia Mendeliana* 37–38: 5–36.

Correns C. (1922) Etwas über Gregor Mendels Leben und Wirken. Naturwissenschaften 10: 623–631.

Correns C. (1924) Gesammelte Abhandlungen zur Vererbungswissenschaft aus periodischen Schriften 1899–1924. Springer-Verlag. Berlin.

Diebl F. (1840) Interessante Kulturversuche auf den Herrschaften in Raitz und Blansko. *Mittheilungen der k.k. Mährisch-Schlesischen Gesellschaft zur Beförderung des Ackerbaues, der Natur- und Landeskunde in Brünn* Nro. 13: 97–98.

Dvořáková Z. (1976). František Matouš Klácel. Melantrich. Prag.

Fischer R. A. [& Mendel G] (1965) Experiments in Plant Hybridisation. (ed. J.H. Bennett). Oliver and Boyd. Edinburgh.

Focke W. O. (1881). Die Pflanzenmischlinge. Gebrüder Bornträger. Berlin.

Gärtner C. F. (1849) Versuche und Beobachtungen über die Bastarderzeugung im Pflanzenreich. K. F. Hering & Comp. Stuttgart.

Garfield E. (1970). Citation indexing for studying science. *Nature* 227: 669–671.

Garfield E. (1979). Is citation analysis a legitimate evaluation tool? *Scientometrics* 1: 359–375.

Hoffmann H. (1869). Bestimmung des Werthes von Species und Varietät. Ein Beitrag zur Kritik der Darwin'schen Hypothese. Ricker'sche Buchhandlung. Gießen.

Hoßfeld U. & Simunek M. V. (2011). Frühe Geschichte der Genetik revidiert. Biospektrum 17: 712–713.

Hoßfeld U., Simunek M. V. & Mielewczik M. (2017). Die „Wiederentdeckung" der Mendelschen Gesetze im Kontext neuer Forschungen. *Nova Acta Leopoldina* N.F. 413: 135–153.

Iltis H. (1924). Johann Gregor Mendel – Leben, Werk und Wirkung. Springer. Berlin.

Kreil C. (1851). Ideen über naturforschende Vereine. *Lotos* 1: 81–91.

Lauer (1855). *Brünner Zeitung* 16. Mai 1855, S. 729–730.

Maiwald V. (1904). Geschichte der Botanik in Böhmen. Kaiserl. und königl. Hof-Buchdruckerei und Hof-Verlags-Buchhandlung Carl Fromme, Wien und Leipzig.

Makowsky A. (1855). Eine Excursion am Blocks- und Adlerberge bei Ofen. *Oesterreichisches Botanisches Wochenblatt* 5 (No. 27): 209–211.

Mendel G. (1854). Beschreibung des sog. Erbsenkäfers, Bruchus pisi. Mitgeteilt von V. Kollar. *Verh. Zool-Bot. Vereins in Wien* 4: 27–30.

Mendel G. (1866). Versuche über Pflanzen-Hybriden. *Verhandlungen des naturforschenden Vereins in Brünn* 4: 3–47.
Mielewczik M. (2017). Gregor Mendel as Entomologist. *Entomologie heute* 29: 121–129.
Mielewczik M., Francis D. P., Studer B., Simunek M. V., Hoßfeld U. (2017) Die Rezeption von Gregor Mendels Hybridisierungsversuchen im 19. Jahrhundert – Eine bio-bibliographische Studie. *Nova Acta Leopoldina* 413: 83–114.
Mielewczik M., Moll-Mielewczik J., Simunek M. V. & Hoßfeld U. (2022a). Gregor Mendel. Versuche über Pflanzen-Hybriden. Klassische Texte der Wissenschaft. Springer Spektrum, Heidelberg (in preparation).
Mielewczik M., Moll-Mielewczik J., Simunek M. V. & Hoßfeld U. (2022b). 200 Jahre Gregor Mendel. «Versuche über Pflanzen-Hybriden» – neue Einsichten. *Biospektrum* 28(5.22): 565.
Mielewczik M., Moll-Mielewczik J., Simunek M. V. & Hoßfeld U. (2022c). A previously unknown meteorological publication of Gregor Mendel from 1857. *Folia Mendeliana* (present issue).
Mielewczik M., Vollmann J., Moll-Mielewczik J., Simunek M. V. & Hoßfeld U. (2022d). Die Bedeutung der Erkenntnisse Gregor Mendels für die Pflanzenzüchtung. Gemeinschaft zur Förderung von Pflanzeninnovationen e.V. (GFPi), Geschäftsbericht 2022 (in press). See the extended version published online.
Olby R. C. & Gautrey P. (1968) Eleven references to Mendel before 1900. *Annals of Science* 24: 7–20.
Orel V. (1972) Mendel's elder friar and teacher, Matthew Klacel (1808–1882).
Orel V. (1996) Gregor Mendel: The First Geneticist. Oxford University Press.
Parent B., Millet E. J. & Tardieu F. (2019) The use of thermal time in plant studies has a sound theoretical basis provided that confounding effects are avoided. *Journal of Experimental Botany* 70(9): 2359–2370.
Peaslee M. H. & Orel V. (2007) The evolutionary ideas of F. M. Klacel, teacher of Gregor Mendel. *Biomed. Pap. Med. Fac. Univ. Palacky Olomouc Czech Repub.* 151(1): 151–156.
Pokorny A. (1864). Plantae Lignosae Imperii Austriaci. Österreichs Holzpflanzen. Eine genaue Berücksichtigung der Merkmale der Laubblätter gegründete Bearbeitung aller im österreichischen Kaiserstaate wild wachsenden oder häufig cultivirten Bäume, Sträucher und Halbsträucher. Druck und Verlag der k. k. Hof- und Staatsdruckerei, Wien.
Richter (1943). Johann Gregor Mendel wie er wirklich war. Neue Beiträge zur Biographie des berühmten Biologen aus Brünns Archiven. *Verhandlungen des naturforschenden Vereins in Brünn* 74: 1–262.
Soudek D. (1984). Gregor Mendel and the people around him (commemorative of the centennial of Mendel's death). *American Journal of Human Genetics*, 36(3): 495.
Simunek M. V., Hoßfeld U. & Wissemann V. (2011a) 'Rediscovery' revised – the co-operation of Erich and Armin von Tschermak-Seysenegg in the context of 'rediscovery' of Mendels laws in 1899–1901. Plant Biology 13: 835–841.
Simunek M. V., Thümmler F., Hoßfeld U. & Breidbach O. (Hrsg.) (2011b) The Mendelian Dioskuri. Correspondence of Armin with Erich von Tschermak-Seysenegg, 1898–1951. Studies in the History of Sciences and Humanities 27. Pavel Mervart. Prague-Červený.
Simunek M. V., Hoßfeld U., Thümmler F. & Sekerák J. (2011c) The Letters on G. J. Mendel. Correspondence of William Bateson, Hugo Iltis, and Erich von Tschermak-Seysenegg with Alois and Ferdinand Schindler, 1902–1935. Studies in the History of Sciences and Humanities 28. Pavel Mervart. Prague – Červený Kostelec.
Simunek M. V., Hoßfeld U. & Mielewczik M. (2017a) „Parallel" und „unabhängig" – Erich von Tschermak-Seyseneggs Darstellung der „Wiederentdeckung" der Mendelschen Gesetze. *Nova Acta Leopoldina* NF 413: 155–154.
Simunek M. V., Mielewczik M., Levit G. S. & Hossfeld U. (2017b) Armin von Tschermak Seysenegg (1870–1952): Physiologist and Co-'Rediscoverer'of Mendel's laws. *Theory in Biosciences* 136(1): 59–67.
Svojtka, M. (2016). Bayer, Johann Nepomuk (1802-1870). Österreichisches Biographisches Lexikon 1815–1950, Bd. 14 (Lfg. 5) 2. Überarbeitete Auflage Online.
Tomaschek A. (1878) Herr Prof. Tomaschek macht einige Mittheilungen über die Charaktere meteorologisch-phänologischer Epochen. *Verhandlungen des naturforschenden Vereins in Brünn* 16: 29–30.
Tomaschek A. (1879) Ein Schwarm der amerikanischen Bienenart *Trigona lineata* Lep. lebend in Europa. *Zoologischer Anzeiger* 2: 582–587.
Tomaschek A. (1880) Ein Schwarm der amerikanischen Bienenart *Trigona lineata* Lep. lebend in Europa. *Zoologischer Anzeiger* 3: 60–65.
Tschermak-Seysenegg E. v. (1937) Erinnerung an die Wiederentdeckung der Mendel'schen Vererbungsgesetze vor 37 Jahren. *Der Züchter* 9: 144–146.
Tschermak-Seysenegg E. v. (1941) Ein Leben für die Züchtung. Aus der Werkstatt eines alten Pflanzenzüchters. *Odal* 10: 768–769.
Tschermak-Seysenegg E. v. (1951a) Historischer Rückblick auf die Wiederentdeckung der Gregor Mendelschen Arbeit. *Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien* 92: 25–35.
Tschermak-Seysenegg E. v. (1951b) The rediscovery of Gregor Mendel's work: An historical retrospect. *Journal of Heredity* 42: 163–171.
Tschermak-Seysenegg E. v. (1956) Gregor Mendels Versuchstätigkeit und die Zeit der Wiederentdeckung seiner Vererbungsgesetze. In: Gedda, L. (Hrsg.): Novant'Anni delle Leggi Mendeliane; Instituto Gregorio Mendel. Rom: 113–117.

Tschermak-Seysenegg E. v. (1958) Leben und Wirken eines österreichischen Pflanzenzüchters. Beitrag zur Geschichte der Wiederentdeckung der Mendelschen Gesetze und ihre Anwendung für die Pflanzenzüchtung. Berlin-Hamburg: Verlag Paul Parey.
Tschermak-Seysenegg E. v. (1960) 60 Jahre Mendelismus. *Verhandlungen des Zoologisch-Botanischen Vereins in Wien* 100: 14–25.
Unger F. (1857). Botanische Steifzüge auf dem Gebiete der Culturgeschichte. I. Nahrungspflanzen des Menschen. Kais. Kön. Hof- und Staatsdruckerei, Wien.
Van Dijk P. J. & Ellis T. N. (2016). The full breadth of Mendel's genetics. Genetics, 204(4), 1327–1336.
Van Dijk P. J. & Ellis T. N. (2020). Mendel's journey to Paris and London: context and significance for the origin of genetics. Folia Mendeliana 56, 5–33.
Van Dijk P. J., Weissing F. J. & Ellis T. H. N. (2018). How Mendel's interest in inheritance grew out of plant improvement. *Genetics* 210, 347–355.
Van Dijk P. J., Jessop A. J. & Ellis T. H. N. (2022a). How did Mendel arrive at his discoveries? *Nature Genetics*
Weiling F. (1966) J. G. Mendels „Versuche über die Pflanzen-Hybriden" und ihre Würdigung in der Zeit bis zu ihrer Wiederentdeckung. *Der Züchter* 36: 273–282.
Wichura M. E. (1865) Die Bastardbefruchtung im Pflanzenreich erläutert an den Bastarden der Weiden. Verlag von E. Morgenstern. Breslau.
Zevenhuizen E (2008) Vast in het Spoor van Darwin. Biografie van Hugo de Vries. Uitgeverij Atlas. Amsterdam / Antwerpen.
Zlik O (1864) Ueber die Akklimatisation der Thiere und Pflanzen. Aus dem Programm für 1864 des k. k. evang. Gymnasiums in Teschen besonders abgedruckt. [Sonderdruck]

NOTES

1 Mendel 1866; Mielewczik et al. 2022a.
2 Orel 1972; Peaslee & Orel 2007.
3 Dvořáková 1976, S. 221; Peaslee & Orel 2007.
4 In his early biogrpahy, the botanist Heinrich Wawra von Fernsee (1831–1887), who was born in Brno remembered his early education in botany that he had obtained from Matous Klácel (Botanische Zeitschrift XVII, No. 1, p. 1–7). In this short reminiscence he told that Klácel at that time was "*considered in Brno as a Great Botanist*". Wawra in the 1850s became a doctor in the Austrian marine. He served on several expeditions to South America and thus gained the support of Archduke Maximilian, who would later become the emperor of Mexico. Those expeditions allowed Wawra to visit many foreign countries and continue to follow his botanical interests. In 1863 he eventually became the ship´s doctor on the frigate SMS Novara, which then had already had finished its circumnavigation of the globe and was destined to bring archduke Max, the new emperor.
5 Fisher 1965; Cetl 1973; 1983; 2002/2003; van Dijk et al. 2022.
6 van Dijk et al. 2022.
7 Ibid.
8 Lauer 1855.
9 Mährischer Gewerbeverein.
10 Mendel 1854.
11 Lauer 1855.
12 Van Dijk & Ellis 2022.
13 Iltis 1924; Mielewczik et al. 2022; Soudek 1984.
14 Van Dijk et al. 2018; 2022; Mielewczik et al. 2022a.
15 Mielewczik 2017.
16 Especially at the end of the 1850s and the early 1860s acclimatization as a research discipline received quite a lot of attention, which was probably driven by new waves of emigration into the colonies at that time. In parallel the first acclimatization societies were founded and in consequence numerous journals related to the topic were established. One of the first of such journals was the "Mittheilungen des Central-Instituts für Akklimatisation in Deutschland zu Berlin" which started in 1859 and was edited by v. Buvry. In 1863 it was renamed into "*Zeitschrift für Akklimatisation*" which appeared in 10 volumes until 1873.
17 See for example the use by Mendel's university teacher Franz Unger in his overview of horticultural plants (Unger 1857, p. 30).
18 See for example the letter of the botanist Franz Georg Phillip Buchenau (1831–1906), written shortly after the publication of Mendel's experiments on peas, on the 24th April 1867 to his colleague Anton Kerner

(1831–1898): "[...] *Dagegen scheint mir die unleugbar* [sic] *eingetretene größere Constanz der organischen Wesen auf der Erde (Constanz weniger in den neben einander auf der Oberfl. lebenden, als in den aufeinanderfolgenden Generationen) uns doch doch naturgemäß auf den Versuch der Abgrenzung hinzuweisen,* [...]", as reprinted in Kronfeld 1908, p. 299–300. Notably the letter was orginally published by Kerners biographer Ernst Moriz Kronfeld (1865–1942) at a peculiar position between a letter from Gregor Mendel to Anton Kerner and another letter from J. N. Bayer to Kerner, presumably already then to indicate the question if there had been discussions following Mendel's publication.

19 For a detailed account of acclimatisation experiments in Moravia see Zlik 1864.

20 Diebl 1840: «*In Raitz interessierte mich vorsonderlich eine im Frühlinge 1839 im Größern unternommene Reispflanzung. Unfern der Zuckerfabrik war ein Feld in Beete eingetheilt mittelst kleiner Dämme, zwischen welchen das Behufs der Reiskultur zugeleitete Wasser, über dessen Spiegel sich die Reispflanzen emporhoben, den Boden etwa 8 Zoll hoch überstaute. Ein Theil dieser Pflanzungen ist so eingerichtet, um das Wasser in den Beeten mittelst darin befindlicher eiserner Röhren durch Dämpfe, welche in einem in der Nähe befindlichen Kessel erzeugt wurden, erwärmen zu können. Zufolge erhaltener Auskünfte werden diese Kultur- und Akklimatisirungs-Versuche bereits im dritten Jahre beharrlich fortgesetzt.*» (Underlined by the authors).

21 The Novara expedition was the first circumnavigation of the globe by the Austrian Marine with its flagship SMS Novara. The expedition lasted from 1857–1859 and started in spring 1857 in Trieste. Sailing from there to Gibraltar, South America, passing the Cape of Good Hope it sailed into the Indian Ocean. Visiting many cities along the South Asian and Southeast Asian coast the expedition eventually arrived in Australia and New Zealand before the journey was continued crossing the Pacific, passing Cape Hoorn and returning via the Azores to Europe. The expedition had primarily a scientific focus and as such already in its planning was supported by other European Scientists, including Charles Darwin. For a detailed account on the expedition see for example Basch-ritter R. 2008.

22 The original newspaper articles (see the full translations in Van Dijk 2020) might give a small clue for this reading as the anonymous critique of Mendel´s work seems to have been well-informed on earlier expeditions. While the author of the second newspaper article criticizing Mendel´s work is not especially named, he must have been a local native closely linked to Old-Brno: "*Concerning the cultivation of New Zealand spinach Tetragonia expansa Murr; its cultivation and use as a vegetable is not new because it was already introduced from New Zealand into Europe in 1772. Mister Schebanek, head gardener of the city of Brünn, has cultivated it for several years in the small plots near the greenhouses, like we ourselves*." (Van Dijk 2020, p. 349).

23 See for example the newspaper report in the *Innsbrucker Nachrichten*, 10. April 1860, p. 5. Similar considerations following the Novara expedition can be found also in other places. Notably archduke Ferdinand Max was said to have acquired the island of Croma (Lacroma) opposite of the dalmatian port city of Ragusa to start acclimatization experiments with foreign crop plants such as Chinese sugar cane which had been collected during the Novara expedition (see for example a short report from Triest in the *Salzburger Zeitung*, 7. 10. 1859, Nr. 227, p. [2]).

24 Ibid.

25 See Correns 1924.

26 See for example Mielewczik 2017, Mielewczik et al. 2022a. For Mendel's experiments with bees see also Iltis 1924.

27 For Mendel's experiments of bees see also Iltis 1924; Beránek & Orel 1988; Mielewczik 2017.

28 Ibid.

29 The concept of thermal time, and related concepts such as growing degree days has long been remained an important question among agronomists and inside plant physiology. For an historical overview see Parent et al. 2019.

30 Tomaschek 1878. See also Mielewczik et al. 2022a.

31 See *Brünner Zeitung* 7. 11. 1874, p. 1023).

32 Ibid.

33 Richter 1943.

34 Johann Nepomuk Bayer (1802–1870) was born in Gross-Kroose in Austrian Silesia (today Velká Kraš, CZ). Bayer first completed his philosophical studies in Olomouc. Afterwards he went to Vienna where he visited technical and medical lectures though without obtaining a degree. In 1838 he became employed as an expeditor for the *Kaiser-Ferdinands-Nordbahn* railway. In 1845 he became the main-expeditor director for the railway and relocated to Prague. In 1851 he returned to Vienna. Biographical details of Bayer are given according to Maiwald 1904, p. 182; Svojtka 2016.

35 The role of J. N. Bayer as the editor in chief of Lotos so far seems to have been only noted in passing remarks in the literature Maiwald 1904, p. 129 & 182, particularly because he took over the position for a very short time. It is so directly evident from the editorial pages of the first volume of the Lotos journal.

36 Kreil 1851, p. 81–91. The lecture was held on the society meeting on the 4. April 1851. In a footnote Kreil however underlined that he had written down his lecture already 10 years earlier in March 1841.

37 Centralanstalt für Meteorologie und Erdmagnetismus.

38 See the article Mielewczik et al. 2022b in the present issue on an early unknown meteorological article of Gregor Mendel in the present issue of Folia Mendeliana.

39 Ibid.

40 Maiwald 1904, p. 180–181.

41 See Makowsky 1855.

42 In a contemporary German partial translation of Bayers work by Alois Pokorny (1864), the 512 varieties were changed to 256 forms or varieties.

43 Translations from Latin by the authors from Bayer 1862, p. 9: For comparison see the original: "*Si e serie formarum transitoriarum unicum solum specimen, confinibus ignotis, oculis obvenit, species bona agnoscitur; lacunis autem repletis et serie integra facta, species dilabuntur.*
Quae quum ita sint, non sequitur, formas et variationes esse negligendas: Scientia labori et Studio non sistit finem. Si formae nascerentur numero infinitae, et sine ordine et lege, quaelibet species falsa esset imago. Quum autem secundum cl. Darwin omnes formae e variatione figurarum partialium unius organismi nascuntur, earum numerus est definitus, suntque subjectae ordini et legi: ergo etiam in ordinem redigi possunt.
Quaerendae igitur sunt illae partes, quarum figura constantior est, et quarum permutatione forma quaedam peculiaris constituitur. Sex Tiliae partes sunt, quibus ejus species et formae discernuntur: Folia, ramuli cum petiolis, bracteae, flores, Stylus, fructus. In his sex partibus cujuslibet speciei observantur noyem proprietates, quae tanquam normales seu fundamentales considerari possunt, videlicet: »

44 Bayer 1869: „*Das grösste Misstrauen verdienen Jene, welche an einer Hybride sogar die dominirenden Samen- od. Pollenpflanze unterscheiden wollen, od. an einem Herbarexemplare zu erkennen glauben (Gr. Mendel, in den Verhndlgen* [sic] *des naturf. Vereins in Brünn, 1865, IV. Bd.)*". See also Mielewczik et al. 2022a, 2022b & 2022d.

45 Hoßfeld & Simunek 2011, Hoßfeld et al. 2017, Mielewczik et al. 2017, 2022a, Simunek et al. 2011a, 2011b, 2011c, 2017a, 2017b.

46 Garfield 1970 & 1979.

47 See the autobiographical accounts of the three "rediscoverers" in: Correns 1922, Tschermak-Seysenegg 1937, 1941, 1951a, 1951b, 1956, 1958, 1960. For De Vries see especially Olby & Gautrey 1968 and Zevenhuizen 2008.

48 Bayer 1869, p. 293. See also Mielewczik et al. 2022a & Mielewczik et al. 2022b.

49 Hoffmann 1869.

50 Punnett 1925, Tschermak-Seysenegg 1960, Weiling 1966.

51 Mielewczik et al. 2017.

52 Bayer 1869, p. 293.