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# How the Great Chain of Being Fell Apart: Diversity in natural history 1758-1859

# La rupture de la « grande chaîne des êtres » : la diversité en histoire naturelle, de 1758 à 1859

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# HOW THE GREAT CHAIN OF BEING FELL APART: DIVERSITY IN NATURAL HISTORY 1758–1859

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Abstract

*In the historiography of the life sciences, the period around 1800 plays a crucial role as a watershed moment that saw the transition from natural history, which was focused on the description and classification of organisms, to the history of nature, which studied the temporal development of life on earth. In this essay, I will argue that this period saw crucial changes in the practices and institutions devoted to collecting information on plants and animals, changes that led to the demise of the ancient idea that nature's products could be arranged on a scale of perfection from the lowest, most deprived forms of life to the highest, most complex and autonomous beings – a "Great Chain of Being," as the historian of ideas Arthur O. Lovejoy put it. Instead, the diversity of life forms was increasingly perceived as fragmented and contingent, thus creating the conditions for the temporalization of life. The following essay attempts to outline some of the major conceptual developments in the history of natural history – the old-fashioned name for what today is hailed as "biodiversity research" – in the wake of the thorough reform to the way organisms were named and classified that was initiated by the Swedish naturalist Carl Linnaeus (1707–1778). The paper presents first thoughts on this subject, and it is hence structured in a rather aphoristic manner. Section i presents some reflections on the concept of diversity and formulates the claim that diversity, as we know it today, includes the curious idea that it is something that can be measured or quantified. Sections ii to v then make some very general and sometimes perhaps overly apodictic claims about what I think happened in natural history around 1800. What follows (sections vi to ix) is a detailed case study drawn from this period in support of these claims. The last section (x) offers some tentative conclusions.*

Keywords: natural history; species; biodiversity; local floras; collection

## i

Diversity does not equal difference, nor does it simply consist in a great mass of differences. Two further conditions have to be fulfilled when we speak of diversity. First, diversity has to possess structure. In modern biology, ever since the Swedish naturalist Carl Linnaeus (1707–1778), this structure is believed to consist in the nested hierarchy of species, genera, families, orders, and classes, the so-called Linnean hierarchy of taxonomic ranks. Each species belongs to one genus and one genus only. This, in fact, is expressed in the construction of binomial names like *Homo sapiens*, where *Homo* designates the genus and *sapiens* is the specific epithet, the two forming the species name. Moving up through the ranks, every genus belongs to one family and one family only, and so on and so on. Or, to put it differently, no two

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genera overlap by including the same species, no two families overlap by including the same genera, etc., etc. Logically speaking, the Linnean hierarchy is generated by relations of equivalence: one genus of a family "counts as much" as any other of the same family. Second, diversity has a lower limit. Diversity does not peter out in endless difference while we descend the Linnean hierarchy; there exists something like a smallest unit of diversity, usually the species, or, depending on research context, other units such as geographic subspecies, genetic varieties, or haplotypes. Both conditions together account for something quite fundamental about modern ideas of diversity, namely that diversity is something that can be compared, measured, and even quantified. We speak of "highly diverse" plant families like the *Solanacea* (nightshades), we assess the species diversity in a pond to judge the water quality, and we count the number of species represented in a collection or museum to raise funds. Diversity, in the modern era, is not so much something we contemplate philosophically, or look in awe at, but rather something we take account of, administer, and process for particular purposes.

## ii

There is no denying that a lot changed in natural history from Linnaeus to Darwin – the dates in my title reflect the publication of the tenth edition of Linnaeus's *Systema Naturae* and the first edition of Charles Darwin's *Origin of Species* – and there is equally no doubt that these changes had a lot to do with the historicization of key concepts of the discipline, such as species, reproduction, distribution, and adaptation. All of these concepts underwent a shift from designating a state of affairs to designating a process in time and space.[1] New concepts that appear in the life sciences around 1800, like heredity or organisation, likewise reflect this epochal shift (see Jacob 1970; Müller-Wille and Rheinberger 2012). What drove these conceptual changes on the whole, however, remains one of the big mysteries of the history of the life sciences. I will suggest in this essay that one of the main factors was the increasing articulation of the subject matter of natural history as something that was not only named and ordered but, crucially, counted as well, and that this articulation went along with a redefinition of the role of the naturalist from an interpreter to a "Sachwalter," or trustee, of nature.[2]

## iii

The changes in natural history from Linnaeus to Darwin have been aptly captured by the phrase "from natural history to the history of nature" (Lyon and Sloan 1981).[3] They are usually associated with profound changes in Western mentalities. The classic expression of this point of view comes from Michel Foucault, in *The Order of Things* (1974 [1966]), and is worth being quoted at length:

> At the institutional level, the inevitable correlatives of this patterning [of nature, by taxonomy; the original has "découpage"] were botanical gardens and natural history collections. And their importance, for Classical culture, does not lie in what they make it [sic] possible to see, but in what they hide and in what, by this process of obliteration, they allow to emerge: they screen off anatomy and function, they conceal the organism, in order to raise up before the eyes of those who await the truth the visible relief of forms, with their elements, their mode of distribution, and their measurements. They are books furnished with structures, the space in which characteristics combine, and in which classifications are physically displayed. One day, towards the end of the eighteenth century, Cuvier was to topple the glass jars of the Museum, smash them open, and dissect all the forms of animal visibility that the Classical age had preserved in them. This iconoclastic gesture [...] does not reveal a new curiosity directed towards a secret that no one had the interest or courage to uncover, or the possibility of uncovering, before. It is rather, and much more seriously, a mutation in the natural dimension of Western culture [mutation dans l'espace naturel de la culture occidentale]: the end of history in the sense in which it was understood by Tournefort, Linnaeus, Buffon, and Adanson [...]. And it was also to be

> the beginning of what, by substituting anatomy for classification, organism for structure, internal subordination for visible character, the series for tabulation, was to make possible the precipitation into the old flat world of animals and plants, engraved in black and white, of a whole profound mass of time to which men were to give the renewed name of history (Foucault 1974 [1966]:137–138).

This is Foucault, the archaeologist of discourse, not the genealogist; he refers to the institutional correlates of classical natural history, but these, and the historical forces that shaped them, were not the subject of *The Order of Things*. Wolf Lepenies went a long way in his *Das Ende der Naturgeschichte* to add a genealogical component to Foucault's account, arguing that it was growing "pressure from experience (*Erfahrungsdruck*)" – associated with the political and industrial revolutions that marked the beginning of modernity – that exhausted the capacity of the spatially organized systems of natural history to retain their claim to systematicity (Lepenies 1976:16). Although some of Lepenies observations are lucid – for example, his reference to the tendency, observable in both Buffon and Linnaeus, to publish natural history findings in the form of supplements (Lepenies 1976:163) – one wonders why mere quantitative growth of knowledge should necessitate a temporalisation of its subject matter. Just like Foucault, Lepenies pays too little attention to the actual practices of naturalists to understand how precisely history entered the life sciences at the close of the eighteenth century.

There are a number of less prominent, but equally perceptive historians of the life sciences who have emphasized continuity, rather than rupture, in the transition period from Linnaeus to Darwin. They have attempted to delineate how the very subject matter of natural history, its object and objects, evolved over this crucial period, and how it was shaped by the incessant, and perhaps obsessive, activity of collecting specimens as well as naming, describing, and classifying species. A number of important lessons can be drawn from this literature, even though it sometimes appears somewhat positivistic (it is difficult not to be a positivist with respect to natural history: here knowledge does indeed grow by accumulation, and every bit of knowledge retains its value for the future, at least in principle).

First of all, one should mention philosophically inclined historians of biology like Philip R. Sloan who have emphasized the achievements of mid- and late eighteenth-century naturalists like Buffon and Blumenbach. These two men reformulated the concept of species by portraying them not as timeless forms that living matter takes on, but as *temporally and spatially distributed* groups of individuals that engage in the reproduction of their own kind (Sloan 1979; see also Glass 1959; Lenoir 1980). Second, Peter F. Stevens, in *The Development of Systematics*, coins the lovely phrase of "continuity in practice" to highlight that one of the chief problems of late eighteenth- and early nineteenth-century naturalists was the problem *of keeping track of* past discoveries while their discipline undeniably *progressed* in the exploration of natural species, genera, and orders (Stevens 1994; see also Daston 2004; McOuat 1996). And third, James L. Larson, in his *Interpreting Nature*, retraces how natural history *fragmented* into specialised areas – such as entomology, biogeography, or the study of hybrids – in the late eighteenth century, each with its own specialised personnel and methodologies, and argues that it was precisely this fragmentation that turned natural history into an *autonomous* and, perhaps more importantly, *secular* pursuit that dissociated itself both from its physico-theological past and from its status as a handmaiden of natural philosophy (Larson 1994).

## iv

It is tempting to regard the historical twist that the likes of Buffon gave to species concepts as a new, unifying principle of botany and zoology. But once one takes Stevens' and Larson's points into consideration, it becomes obvious that this is not what these concepts achieved. Species can only appear as physical systems extended in time and space once they are explored as such. Or, to put it differently, in following species around geographically or tracking them stratigraphically, one already presupposes their distinctness. In practice, this meant that naturalists had to rely on species concepts that spelled out certain criteria, like constant characteristics, common descent, or the production of fertile offspring, by which species could be distinguished in local settings. Ernst Mayr (1957) called such operational species concepts "non-dimensional" because they only allow us to say something about relations between particular individuals or specimens, rather than anything about the "nature" or "essence" of species.

The most confusing aspect of this is that while naturalists generally aspired to capture the "nature" of species through this strategy, there was no guarantee that nature would not come up with its own kind of aberrations and idiosyncrasies. Once Linnaeus, for example, had defined species by genealogical descent and constancy of characteristics, it did not take long until he stumbled across varieties that were clearly related by descent, yet differed by constant characteristics, that is characteristics that did not depend on environmental factors but rather were passed on from generation to generation without change (Müller-Wille and Orel 2007). The question of whether truth or falsehood, essentiality or accidentiality, lay in the eye of the beholder or were actually right at the heart of nature aberrations thus became a notorious problem in natural history.

The early modern metaphor of a "book of nature" – a second revelation organized in chapters following the scale of being and lying open to those who were prepared, or equipped, to read it – was replaced by metaphors that aptly reflected the new, relational nature of species definitions: the metaphor of nature as an archive organized by series and strata, and the metaphor of nature as a terrain to be charted by map- and netlike representations.[4] These metaphors emphasize the decentred, fragmentary, and indeed a-logical nature of (known) nature, and palpably document how Arthur O. Lovejoy's "Great Chain of Being," stretching the poles of perfection and privation in a hierarchical arrangement of all forms of life, lay shattered in pieces at the end of the eighteenth century.[5] With respect to time, discontinuities and catastrophes punctuated the geological record; with respect to space, diverse life forms occupied what seemed to be identical places in the economy of nature (Jacob 1970, ch. 3). The transformation of natural history into the history of nature not only implied temporalization; it also implied new ways of reading truth into nature, of being conscious of the incompleteness and indeed untrustworthiness of its "records." Building the maps and archives of natural history was a piecemeal endeavour that only received a sense of purpose through its orientation towards the future usefulness of completed works.

## v

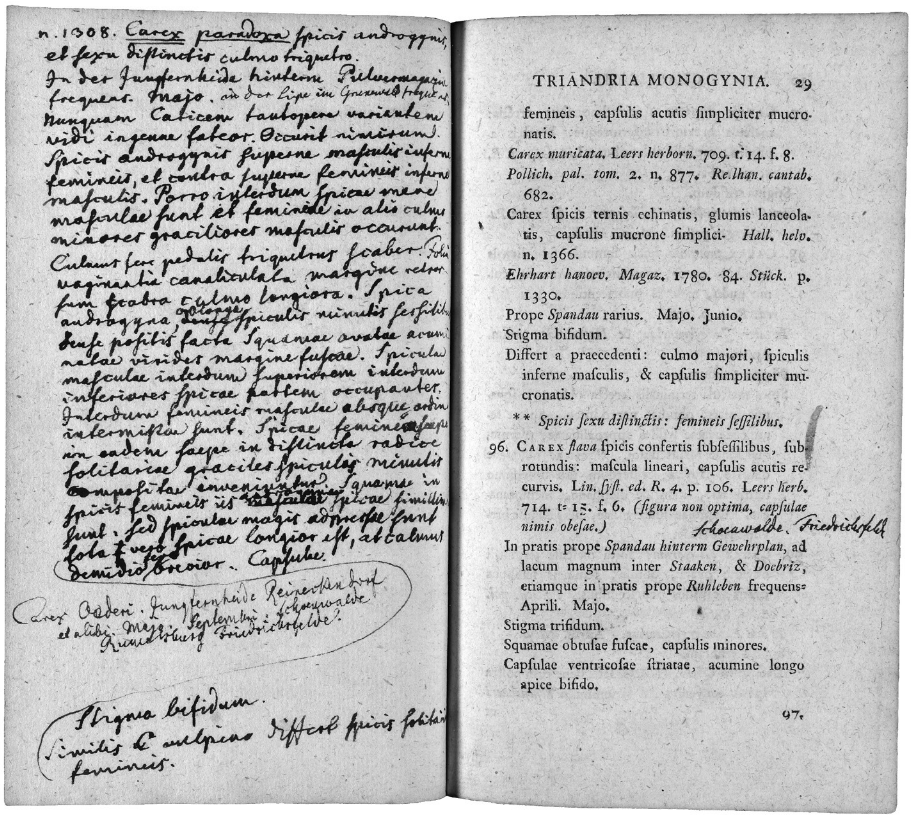
In parallel to the conceptual developments discussed in the preceding section, late eighteenth and nineteenth-century natural history saw institutional changes of an equally bewildering nature that are perhaps best described as the gradual build-up of both centrifugal and centripetal forces.[6] The fragmentation of natural history was reflected in a massive broadening of its practitioner base – including a large number of university-trained professionals, physicians in particular, but increasingly non-university trained people, men and women alike (Secord 1994). They were engaged in collection and correspondence, but also organized themselves from the bottom up in naturalist, and more often than not, agricultural, and economic associations which often had their own publication outlets. Rising levels of literacy, as well as the spread of cheap print, were key factors here, as was the increasing demand for experts to fill positions in state bureaucracies and the administrations of commercial and industrial enterprises (Meyer and Popplow 2004). Alongside this, natural history exchanges came to revolve around a new set of central nodes. While in the mid-eighteenth century these exchanges revolved around certain influential individuals – Linnaeus, Georges-Louis Leclerc Comte de Buffon (1707–1788), and Albrecht von Haller (1708–1777) – central institutions that were there to stay took over this role by the early nineteenth century – the Musée d'histoire naturelle in Paris, the British Museum in London, Berlin University with its gardens and collections in Prussia, the St. Petersburg Academy in Russia. This not only enabled an unprecedented quantitative growth of collections, but also provided the condition for physically organising them by internal departments and workflows that did not reflect the idiosyncrasies of a single person's mind. Instead, these institutions offered an increasing number of hierarchically organized positions of keepers and amanuenses that adjudicated and administered the collections. The following sections will zoom in on that world by looking at the case of natural history in Berlin around 1800.

## vi

"In der Jungfernheide hinterm Pulvermagazin frequens" (*Frequently in the Jungfernheide behind the storehouse for explosives*) is one of the many notes contained in a personal, heavily annotated copy of Karl Ludwig Willdenow's (1765–1812) *Florae Berolinensis Prodromus* (1787) that I have analysed in great detail elsewhere in collaboration with Katrin Böhme (Böhme and Müller-Wille 2013). The notes document botanical excursions that Willdenow undertook in and around Berlin, and are of a dry and laconic character, usually just pinning down exactly where, and in what numbers, a certain plant species was encountered. Willdenow had been trained as an apothecary, had taken over his father's pharmacy "Unter den Linden" in 1790 after completion of medical studies at the University of Halle, and was working there until 1798 when he was called on to fill the Chair for Natural History at the Berlin *Collegium medico-chirurgicum* (Schlechtendal 1814). Inventories, orders, receipts, and double entry book-keeping belonged to the literary world of apothecaries at least since the Renaissance, and elements of these record keeping practices found their way into learned natural history.[7] Willdenow's *Prodromus* – the Latin term means *harbinger* – should therefore not be seen as a finished piece of literature but as a tool for daily use in data collection, preservation, and retrieval. These practices continue to this day with local flora and "check lists" that not only train and discipline the gaze of amateur and professional naturalists, but also ready that gaze for unexpected discoveries (Law and Lynch 1988). In order to see how this works, it is worthwhile to look at two examples.[8]

## vii

To see how Willdenow's personal copy of *Florae Berolinensis Prodromus* functioned as an information processing tool, I will turn to *Carex paradoxa*, a species from the grass-family *Cyperaceae*, known as *Schwarzschopf-Segge* in German, which Willdenow had first described and named. It was one of the many new species for which Willdenow provided a lengthy, handwritten morphological description on one of the interleafed pages of his *Prodromus* (Figure 1). The description begins by citing the new running number ("n. 1308"), the species name *Carex paradoxa*, using double underlining for the genus and single underlining for the species epithet, a short diagnosis ("spicis androgynis et sexu distinctis culmo triquetro"), and finally the location where the species had been observed ("In der Jungfernheide hinterm Pulvermagazin frequens") which was later supplemented by a further location ("in der Lipe im Grunewald frequens"). What follows in a long paragraph is the detailed description of the morphological features. The format of this new entry follows the printed text down to the placement of paragraph and typographic details, such as the emphasis of the species name by underlining (the printed text has small caps for the genus name and italics for the epithet).


n. 1308. Carex paradoxa spicis androgynis, et sexu distinctis culmo triquetro.

TRIANDRIA MONOGYNIA. 29

femineis, capſulis acutis ſimpliciter mucronatis.

*Carex muricata.* Leers *herborn.* 709. t. 14. f. 8.
*Pollich. pal. tom.* 2. n. 877. *Relhan. cantab.* 682.

Carex ſpicis ternis echinatis, glumis lanceolatis, capſulis mucrone ſimplici. *Hall. helv.* n. 1366.

*Ehrhart hanoev. Magaz.* 1780. 84. *Stück.* p. 1330.

Prope *Spandau* rarius. Majo. Junio.

Stigma bifidum.

Differt a praecedenti: culmo majori, ſpiculis inferne maſculis, & capſulis ſimpliciter mucronatis.

** *Spicis ſexu diſtinctis: femineis ſeſſilibus.*

96. CAREX *flava* ſpicis confertis ſubſeſſilibus, ſubrotundis: maſcula lineari, capſulis acutis recurvis. *Lin. ſyſt. ed. R.* 4. p. 106. *Leers herb.* 714. t. 15. f. 6. *(figura non optima, capſulae nimis obeſae.)* Schocawalde. Friedrichsfeld

In pratis prope *Spandau hinterm Gewehrplan*, ad lacum magnum inter *Staaken*, & *Doebriz*, etiamque in pratis prope *Ruhleben* frequens. Aprili. Majo.

Stigma trifidum.

Squamae obtuſae fuſcae, capſulis minores.

Capſulae ventricoſae ſtriatae, acumine longo apice bifido.

97.

Figure 1. Handwritten description of the species *Carex paradoxa* in Karl Ludwig Willdenow's personal copy of *Florae Berolinensis Prodromus* (1787). SBB, Abteilung Historische Drucke, with kind permission by the Staatsbibliothek zu Berlin – Preußischer Kulturbesitz.

All in all, seven specimens of *Carex paradoxa* have been preserved in Willdenow's herbarium. Willdenow himself had originally kept his specimens in envelopes. After his death, they were transferred and rearranged onto loose herbarium sheets by Franz Leonhard Schlechtendal (1794-1866), who also preserved handwritten notes from Willdenow in the process (Hiepko 1972, vii). One of these notes – fixed to the blue folder that contains the seven herbarium sheets of *Carex paradoxa* – reads "Car. flav. 1368 ß". The slip on which the note was written has a small rip so that one can assume that it was originally fixed to the specimen. In Willdenow's personal *Prodromus* copy, the handwritten description for *Carex paradoxa* is inserted right next to *Carex flava* in the printed text. "1368" is probably just an erroneous reference to the number that *Carex paradoxa* received in Willdenow's personal copy ("1308"). In any case, the notes also make reference to the two locations where this species was found (Grunewald and Jungfernheide). All this indicates that Willdenow was in the habit of first collecting a specimen while in the field, and only later produced descriptions and carried out exact taxonomic assignments.

The running number "1308" comes from the continuation of the species numeration in the printed text found in the handwritten index of newly observed species at the end of the volume ("Conspectus vegetabilium nuperrime heic observatorium [sic]"). The list continues up to the number 1378, thus adding another 135 species to the 1243 species already described in the *Prodromus*. For each species listed, Willdenow also added the page number where the species in question was inserted, and where his manuscript notes on that species could be found. The order in which the species follow each other in the "Conspectus" is not dictated by the classification system Willdenow adopted. Rather, the order reflects how Willdenow came across species not previously observed during his excursions. This explains, for example, why *Carex paradoxa* is inserted as no. 1308 between species no. 95 (*Carex Leersi*) and no. 96 (*Carex flava*).

## viii

The species diagnosis that Willdenow provides for *Carex paradoxa* is remarkable, and also explains its exact position within the volume. *Carex* is a very diverse genus (the *Prodromus* alone lists 31 species), and Willdenow therefore divided it up into two groups, sedges with monoeciuos spikes ("spicis androgynis") and sedges with dioecious spikes ("spicis sexu distinctis"). The species diagnosis of *Carex paradoxa*, however, claims that this species, in addition to possessing a triangular stalk ("culmo triquetro"), is characterised by having both monoecious and dioecious spikes ("spicis androgynis et sexu distinctis"). Now, *Carex Leersi* is the last of the monoecious sedges, whereas *Carex flava* is the first of the dioecious sedges. *Carex paradoxa* – or the "strange sedge" (*seltsame Segge*), as Willdenow calls it in German in the fourth edition of Linnaeus's *Species plantarum* that he was editing (Linné 1805, Bd. 4, 243) – thus takes an ambivalent position with respect to the sexual characteristics that Willdenow employed, following Linaneus and Thunberg, to distinguish plants taxonomically, and this position was reflected with great exactness both by its positioning between *Carex Leersi* and *Carex flava*, and by choosing the epithet *paradoxa* to name it.

In other words, this means that *Carex paradoxa* undermined the distinctions of Linnaeus's sexual system that provided the unifying paradigm for Linnaean natural history (Stafleu 1971). "I admit freely," Willdenow says right at the beginning of his handwritten description of *Carex paradoxa*, "that I have never seen a sedge that varies so widely." This is probably also why Willdenow collected seven specimens all in all of *Carex paradoxa*. In 1794, Willdenow lectured in front of the Prussian Academy of Sciences on wild sedge species growing around Berlin (sedges provide important raw material for thatching and producing fibres), and the published version of this lecture also contained a revised and expanded description of *Carex paradoxa*. In a separate section of that description, marked as an "observation," he emphasized once more that the sexual characteristics of this species were very inconstant ("unbeständig"). Yet he retained his division of sedges according to sexual criteria, simply adapting the system by creating a new category of sedges "that have several kinds of spikes where male and female flowers mix" (Willdenow 1799:37).

This looks like a classic ad hoc solution to an anomaly, but it is worth looking at the preface to the *Prodromus* (1787) which among other things discusses taxonomic principles. In it, Willdenow explicitly states that the sexual system was unable to reproduce "the quasi netlike relationships between individual creations (*Singula Creata nexu quasi retiformi*)". But the Linnaean system was equipped with the "sigill of humanity (*sigillum humantiatis*)," that is, it provided a common frame of reference formed by convention. Ironically, it is cases such as *Carex paradoxa* that demonstrate that it was exactly that frame of reference against which the netlike relationships among organisms, as well as the variability of apparently essential characters, became visible. In a botanical textbook Willdenow even went so far as to claim, that "nothing [is] more inconstant than sex" (Willdenow 1792:214). Almost 75 years later, Charles Darwin published a monograph on *The Effects of Cross and Self Fertilisation in the Vegetable Kingdom* (1876) in which he tried to explain this "inconstancy". First notes by Darwin on this subject, contained in a notebook entitled "Questions and Experiments" (1839-1844), also mention *Carex* as a case in point.

## ix

The apparently rigid and mechanical application of the Linnaean system, as the previous section demonstrates, was actually quite able to reveal a host of complex taxonomic relationships and to point at far-reaching research questions regarding the variability of seemingly essential properties of organisms. Something similar can be said about the numbering of species, even if this practice seems to have no intrinsic relation to the subject matter of natural history, but seems rather to serve entirely practical purposes. On an interleafed page at the end of Willdenow's personal copy of *Prodromus* there appears a handwritten calculation that presents the numerical ratio of phanerogam to cryptogam species by subtracting the number of phanerogam species from the total number of species listed in the *Prodromus*. This calculation is the only instance of an annotation written in another hand than Willdenow's. Through a comparison with other documents, it was possible to establish that the calculation was done by Carl Sigismund Kunth (1788-1850), a clerk at the Königliche Seehandlungsinstitut, who had been introduced to botany by Willdenow. Kunth published his own *Flora Berolinensis* in 1813 – shortly after Willdenow's death – in two volumes, one covering phanerogams, the other cryptogams. In the same year, Kunth moved to Paris where he stayed until 1829, working on Alexander von Humboldt's botanical collections from South America (Wunschmann 1883).

Kunth almost certainly calculated the ratio of phanerogams to cryptogams to estimate whether this created a good division to publish his *Flora* in two volumes. There are similar calculations by Willdenow in the latter's personal copy of the *Prodromus*. But it is worth thinking twice about this. Alexander von Humboldt and Willdenow got to know each other in 1788 and together developed ideas about floral regions and "centres of creation (*Schöpfungscentren*)" that were first published by Willdenow in his *Grundriss der Kräuterkunde* in 1792 (Jahn 1966). In these biogeographic speculations, proportions like the one Kunth calculated played a central role. Thus, Willdenow quoted the fact that the number of *Carex*-species decreases continuously in relation to other species if one moves from the pole to the equator as an example of the "particular rules" that govern the "distribution of plants across the globe" (Willdenow 1792:366). Humboldt's *Essai sur la géographie des plantes*, published in 1805 with Aimé Bonpland, contains similar qualitative statements, but in 1817, Humboldt would publish *De distributione geographica plantarum*, which advocated the idea that exact numerical ratios should serve as the foundation of a "botanical arithmetics" (*Arithmetica botanica*) (Humboldt 1817:18; see Browne 1983:58-64). Not only did he discuss the ratio of phanerogams to cryptogams in this context, but also how the portion of sedges within grasses overall grows systematically as one moves to the North (Humboldt 1817: 28–30, 202). Kunth's contribution to these results is emphasized again and again.

## X

The two examples presented in the above sections suggest the following, four tentative conclusions with respect to the general theme of collection and the movement from natural history to the history of nature around 1800.

The first conclusion is that many of the practices and conventions Willdenow used when collecting plants had been in the making for a very long time in natural history. For example, it was commonplace, at least since the seventeenth century, to note the exact place and date for observations of particular species, especially in the genre that Willdenow contributed to, namely regional flora.[9] A remarkable moment occurs, however, when Schlechtendal rearranged Willdenow's herbarium after it had been acquired by the Prussian state. Schlechtendal did not use the material left from Willdenow to create his own vision of the vegetable kingdom. Rather, by preserving every note that might give a hint to where and when exactly Willdenow had collected a specimen, he rooted the herbarium in time and space, and turned observations into historical events leaving archival traces. Species were grounded in such observations and, to some extent, were even co-extensive with them. Looking at living nature through Willdenow's herbarium, or rather, what Schlechtendal had made of it, turns nature into an archive in a literal sense: an archive of traces due to events dispersed across geographic space and unfolding in time.

A second conclusion relates to the modern concept of biodiversity. Both in the printed *Prodromus*, and in his annotations, Willdenow followed the conventions of Linnaean taxonomy and nomenclature. There is a long tradition, beginning with Buffon, of criticizing these as "artificial" elements that just serve pragmatic goals. This, however, is precisely the point of these conventions. They gave the great mass of facts that naturalists collected a structure that had no intrinsic relation to the content of natural history and thus could articulate that content independently of any prior theoretical knowledge. In this manner, and supported by crucial changes in the institutional and social landscape of natural history, avenues opened up for the objectification and quantification of natural history. Just like records in a well-kept archive, species became units that were added to or eliminated from collections, kept track of in lists and catalogues, and counted and distributed in ever new ways. It was these kinds of practices that marked the beginning of the era of modern ideas of biodiversity. In this context, diversity first and foremost means to be able to count and evaluate taxonomic units like genera and species as endangered, widespread, alien, etc. The history of this aspect of the modern concept of biodiversity reaches back to the late eighteenth century.

The third conclusion brings us back to the protagonists of natural history. In the case of Willdenow, and even more so in those of Schlechtendal and Kunth, one can observe that naturalists increasingly retreated from their role as authors. Although Willdenow published a text book and a whole series of articles in the Academy's journal, his main work appeared under a different name: from 1797 he worked on the "fourth edition" of Linnaeus's *Species plantarum* which appeared in six volumes under Willdenow's (partially posthumous) editorship until 1825 and was subsequently continued by Willdenow's successor, Johann Heinrich Friedrich Link (1767–1851). The acquisition of Willdenow's collection by the Prussian state was explicitly tied to the continuation of that project by the Chancellor Hardenberg.[10] With Willdenow, Schlechtendal, Kunth, and Link, we see new scientific personae emerge in natural history that identified part of their working life, at least, with the care for collections and production of catalogues, rather than with "original research."

My final conclusion pertains to the emotive associations that often accompany contemporary appeals to the value of diversity. It seems to me that the fundamental assumption that underwrote the old idea that organisms can be fitted on a scale of perfection and occupy corresponding "natural places" in the world is that it makes sense to say that it is "natural" for an organism to have this or that feature, to show this or that behaviour, to grow or live in this or that place. It is in this sense, for example, that Aristotle found it perfectly justified to address seals as "monsters" – as mammals inhabiting the sea; they were literally out of place (Sober 1984:170). Transforming natural history into an activity that was not only geared towards observation as such, but primarily towards the collection of records of observations, created (and presupposed) a detachment from such impulses, a kind of alienation from nature, a view from above, a statistical gaze. And diversity, as we understand it today, is primarily a product of that disinterested gaze. The object of natural history ceased to be nature, and its counterpoint, a monstrosity. The object of natural history began to be the diversity of collectives of individual organisms, the events these organisms were subjected to, and, ultimately, their expansions, retreats, and successions.

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## NOTES

1 See the corresponding entries "Anpassung," "Art," "Fortpflanzung," and "Biogeografie" in Töpfer (2012).

2 "Sachwalter," in German, designates any third party to a contract that is trusted by at least one of the contracting parties for the expertise he/she possesses for conducting the business involved in the contract. It is only insufficiently translated by a variety of terms – including "solicitor," "procurator," and "trustee."

3 The title goes back to a distinction drawn by Immanuel Kant in his essay "On the Different Human Races" (1775): "We commonly make no distinction between 'the description of nature' and 'natural history'. However, it is obvious that knowledge of the things of nature as they are now will always leave us wishing for knowledge of how they once were and by what series of changes they went through to come to their present place and condition. Natural history, of which we presently have very little, would teach us about the changes in the earth's form, including the changes that the earth's creatures (plants and animals) have sustained as a result of

natural migrations, and about the deviations from the prototype of the lineal root genus that have originated as a consequence of these migrations. Natural history would presumably lead us back from the great number of seemingly different species to races of the same genus and transform the presently overly detailed artificial system for the description of nature into a physical system for the understanding" (quoted from Bernasconi and Lott 2000:13). In "On the Use of Teleological Principles in Philosophy" (1788), Kant spoke of "Naturforschung des Ursprungs" as natural history in its proper, temporal meaning.

4 On the rise of map metaphors, see Rheinberger (1986), Barsanti (1992); on series and strata, see Sarasin (2009).

5 This is how Arthur O. Lovejoy put it himself: the Great Chain of Being "broke down [...] largely from its own weight" (1936:245).

6 For a recent attempt to capture this for the relevant period in the German speaking world, see Phillips (2012).

7 On apothecaries and natural history, see Valentina (2012).

8 For a more detailed account of the two examples, see Böhme and Müller-Wille (2013).

9 On the early history of local and regional flora, see Cooper (2007).

10 See Böhme and Müller-Wille (2013) for details.

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