From "Periodical Observations" to "Anthochronology" and "Phenology" – the scientific debate between Adolphe Quetelet and Charles Morren on the origin of the word "Phenology"

Gaston R. Demarée & This Rutishauser

International Journal of Biometeorology

ISSN 0020-7128

Int J Biometeorol
DOI 10.1007/
s00484-011-0442-5

Springer

Int J Biometeorol
DOI 10.1007/s00484-011-0442-5

ORIGINAL PAPER

From "Periodical Observations" to "Anthochronology" and "Phenology" – the scientific debate between Adolphe Quetelet and Charles Morren on the origin of the word "Phenology"

Gaston R. Demarée · This Rutishauser

Received: 10 November 2010 / Revised: 11 February 2011 / Accepted: 12 February 2011

Abstract Mankind has observed and documented life cycle stages of plants and animals for a long time. However, it was comparatively recently that the newly emerging science was given its name. The name of Charles Morren and the year 1853 are being cited, although not frequently. Exact information is hardly known among present-day phenologists, yet new evidence shows that the term "phenology" was already in use in 1849. In the early 1840s, physicist and astronomer Adolphe Quetelet set up an observational network named "*Observations of periodical Phenomena of the Animal and Vegetable Kingdom*" and issued instructions for it. Even though biologist Charles Morren welcomed Quetelet's initiative, differences between Morren and Quentlet regarding the instructions for the observations and the potential results soon arose and a debate started, which lasted for nearly 10 years. In the wake of these disagreements, Morren was compelled to create a new term to denote his ideas on "periodical phenomena". At first, he temporally used the word *anthochronology*, but in the end he coined the word *phenology*. The term was first used in a public lecture at the *Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique'* in Brussels on 16 December 1849, and simultaneously in the December 1849 issue of volume V of the *Annales de la Société royale d'Agriculture et de Botanique de Gand*. One had to wait until 1853 before the new name appeared in the title of one of Morren's publications. Based on evidence from archives and original publications, we trace the 10-year-long scientific debate between Morren and Quetelet. Morren states his biologist's view on the subject and extends the more climate-related definition of Quetelet of "periodical phenomena".

Keywords Phenology · History of phenology · Periodical observations · Anthochronology · Belgium

Introduction

> Stat sua cuique dies.
> Date is set for each and everyone.
> There is a day for everybody.
> Virgile, Aeneid, X.467
> (Morren 1843b, Fleurs éphémères, p. 335–340)

The science of phenology has, once again, seen a revival in the context of climate change impact research. Observations on the timing of life cycle events (Rosenzweig et al. 2007, 2008) have been prime evidence for impacts of climate change, not only for the twentieth century but also for many centuries before (Sparks and Carey 1995; Aono and Kazui 2008; Rutishauser 2009). Scholars in disciplines as diverse as medieval linguistics and global climate system modelling are now working in the field of phenology (e.g. Wegmann 2005; Randerson et al. 2009).

G. R. Demarée
Royal Meteorological Institute,
Brussels, Belgium
e-mail: gaston.demaree@oma.be

T. Rutishauser (✉)
Institute of Geography and Oescher Centre for Climate Change Research, University of Bern,
Bern, Switzerland
e-mail: rutis@giub.unibe.ch

T. Rutishauser
Centre for Ecological Research and Forestry Applications (CREAF-CEAB-CSIC), Universitat Autònoma de Barcelona,
Barcelona, Spain

Published online: 30 June 2011

Whether referring to the philosophical background that provided the environment for plant observations in the Age of Enlightenment, or the common term for seasonal changes of the green-cover of the land surface that are key for quantifying the carbon and hydrological cycle of the globe, scientists today are using "phenology" more and more often. Phenological methods and applications have changed over time, from the era of Greek philosophers to the twenty-first century (Keatley and Hudson 2010). In the Age of the Enlightenment, plant physiologists like Carl Linnaeus (1707–1778) looked for plant species that flower at the same time and carefully noted and precisely defined life-cycle stages (Linné 1788). And the human eye served as the instrument. Today, orbiting satellites and ground-based sensors observe and measure seasonal changes in radiative properties and atmospheric composition to derive phenological data. At the same time, observers in networks and private backyards continue the tradition of looking at plants, noting the date of an event in *Nature's Calendar,* as humans have for centuries and even millennia.

With this paper, we want to shed light on the time when the term "phenology" was introduced into the scientific literature, in Belgium in the late 1840s. Our study concentrates mainly on a Euro-centric perspective on the history of phenology; however, it is useful for phenologists from around the world. We first present a short summary of the background in European history of the philosophy, language and history that became the stage for the term "phenology". The antagonists, Adolphe Quetelet and Charles Morren, are then briefly introduced. In the following two sections, the scientific debate of the naming of the discipline between both scientists in the 1840s is developed. In the last section, we describe how the term "phenology" has made history ever since, becoming an important term in the twenty-first century climate change impact research at all spatial and temporal scales.

Setting the stage: origins of the art of phenology

The existence of unsystematic phenological observations is known from ancient China (e.g. Chen 2003, and references therein) and from ancient Greece and Rome (for a general overview, see Schnelle 1955; Schwartz 2003; Rutishauser 2009). For China, Yoshino (2004) reported routine observations and descriptions of phenological events and a phenological calendar of agricultural activities since the twenty-first century BC. Furthermore, special attention was paid to anomalous phenological events in the form of proverbs in order to identify climate anomalies. A phenological calendar of central China was compiled by Xia Xiao Zheng as early as in the eleventh century BC (Chen 2003). Probably the best known records of phenology contain the date of the Japanese cherry festival. The date of the festival is closely related to the full bloom of the cherry tree. Series with some temporal gaps starting in A.D. 705 and 812 were published by Arakawa (1955), Sekiguchi (1969) and Aono and Kazui (2008). In Eurasia, the Bible refers to observations of growth stages of the fig-tree and describes the progress of seasons: "Now learn this lesson from the fig-tree: As soon as its twigs get tender and its leaves come out, you know that summer is near" (Mark 13, 28; New International Version).

The word "phenology" has its etymologic roots in the ancient Greek 'phaenesthai', φαίνεσθαι which in English means 'to appear'. Aristotle (384–322 BC) discussed the terms 'nature' (physis, φ'υσιζ) and 'process' (kinesis, κ'ινησιζ). 'Nature' is defined as emergence and origin (genesis, γένεσιζ), a nascent and growing thing as opposed to art. Thus, nature implicitly contains the connotation of movement, appearance and disappearance. Following Plato and Timaeus, natural science implicitly seeks the 'causes' and not the symbolic meaning of phenomena (Wegmann 2005).

Aristotle's and Plato's work and their rediscovery in medieval Europe were essential for the emergence of a modern scientific perception of seasonal life-cycle stages. In particular, the views of Albertus Magnus (1193/1206–1280) were crucial to shaping the modern perception of phenological observations. He concluded, in the thirteenth century A.D., that experience from repeated observations is the best teacher for things such as natural processes (Wegmann 2005). Terms such as budding, flowering, and leaf fall appeared in European literature starting in the twelfth century. At this time, logical reasoning began to take over the symbolic, speculative interpretation of natural phenomena.

Then, at the beginning of the Age of Enlightenment (eighteenth century), the philosophical framework was laid for scientific and systematic phenological observations, recordings, studies and publishing in the modern sense of the term. This is illustrated by the wine vintage data in western Europe (Chuine et al. 2004; Maurer et al. 2009; Meier et al. 2007; Pfister 1975; Tagami 2008), apple tree observations by Gilles de Gouberville (1521–1578) in the Cotentin peninsula, France (Tollemer 1879) and by many other obervations. In the eighteenth century, during the Age of Enlightenment, carrying out observations, classifying and comparing these observations was part of the then general interest in the natural sciences. Interesting examples are given by Marsham's record in Norfolk, England (Sparks and Lines 2008) and the observations of Linnaeus in Uppsala and his ephemeral network of 1750–1752 in Sweden. Life-cycle observations of plants were also collected by the Economic Society of Bern (*Ökonomische Gesellschaft Bern*) from 1760 onwards. This society, which focused on collecting information on plant growth for

comparison with meteorological parameters, was, most probably, the first of its kind. Applications of phenological data were collected with the goal of increasing yield by better planning and improvements of agricultural practices (Pfister 1975; Burri and Rutishauser 2009; Rutishauser 2009; Možný et al. 2011). By the beginning of the nineteenth century, people had observed plants and their appearance for millennia; however, they did not use a common term to label these observations.

Adolphe Quetelet and the observation of the periodical phenomena

In July 1819, Adolphe Quetelet (1796–1874) (Fig. 1a) was the first to be awarded the degree of doctor in physical and mathematical sciences at the University of Ghent. He became professor of mathematics at the *Athenée de Bruxelles* in 1824 and of physics and astronomy at the *Musée des Sciences et des Lettres* in 1827. In the following year, Quetelet was appointed astronomer at the Royal Observatory of Brussels, founded in 1826. It took many more years—and a Belgian revolution—for the observatory to become operational. In November 1834, Quetelet became the Permanent Secretary of the Belgian royal Academy of Sciences—a position he kept until his death (Mailly 1875; Collard 1928). During his life, Quetelet was clearly a very powerful man in the scientific community and his influence was far-reaching.

Adolphe Quetelet had a very wide spectrum of scientific interests. From 1836 onwards, the idea to observe periodical phenomena of plants in Europe and in America arose at the Belgian Royal Academy of Sciences because of a proposition by Quetelet and his colleagues. It is possible that John Herschel's idea, in 1836, to carry out worldwide, hourly, meteorological *Méthodologique en Appui à l'Innovation en Agriculture Familiale* observations during the periods of solstices and equinoxes inspired Quetelet to propose observations of the vital phenomena occurring on the surface of the globe (Annales, T. V, Octobre 1849). Quetelet started, in the year 1839, observations on the flowering of plants in the garden of the old Observatory at Saint-Josse-Ten-Noode (Quetelet 1842b) (Fig. 2). In 1841, a large programme of plant observations comprising the flowering, leafing and leaf fall of the garden's plants began. In an account of a visit to England, dated 9 October 1841, Quetelet laid the foundations of the observations of the *periodical phenomena* of the plant and animal kingdom (Quetelet 1841). According to Quetelet, studying periodical phenomena would provide a better understanding of the nature and characteristics of the Belgian climate that make it different from neighbouring climates. However, scientists quickly discovered that they lacked a guide to carry out these observations in such a way that observations would be comparable across sites. Thus, Quetelet published under the auspices of the Academy *Instructions for the Observations of periodical Phenomena*; the first set of instructions on 13 January 1842 (Quetelet 1842a), the second one on 1 December 1843 (Quetelet 1843). While the first set of instructions used a highly specific classification scheme, the second set was more efficient because it classified plants in alphabetical order by their Latin names. In the Instructions of 1842, the botanist Barthélemy Charles Joseph Du Mortier (or Dumortier) (1797–1878) is quoted as having contributed to its writing. The Class of Sciences of the Belgian Royal Academy of Sciences allowed the printing of the second set of instructions in its session of 15 January 1842.

An overview of the observations on periodical phenomena was published as chapter IV of the book *Sur le Climat de la Belgique* (Quetelet 1849). This book contains a note on the *Instructions pour l'observation des phénomènes périodiques* concerning plants (Quetelet 1849, pp. 174–183). Later, a third set, dated 25 April 1853, was printed as

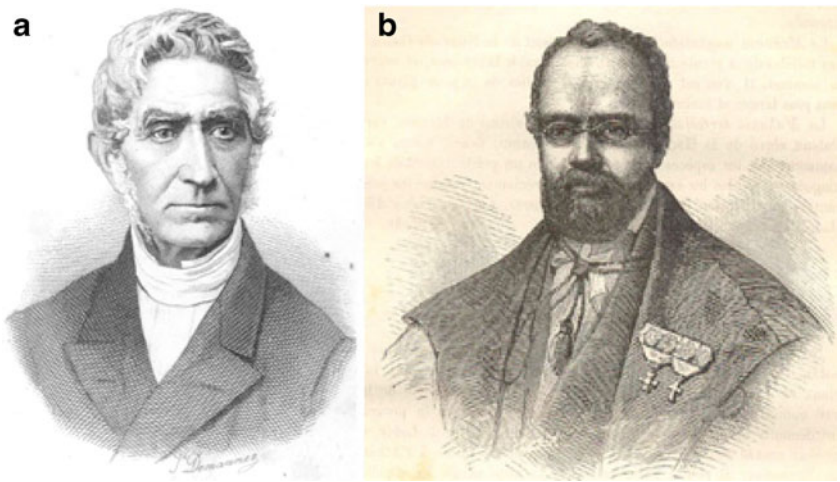


Fig. 1 **a** Adolphe Quetelet (1796–1874), Director of the Observatory of Brussels and founder of the international network of "Observations of the periodical phenomena". **b** Charles Morren (1807–1858), Professor of Botany at the University of Liège and father of "Phenology"

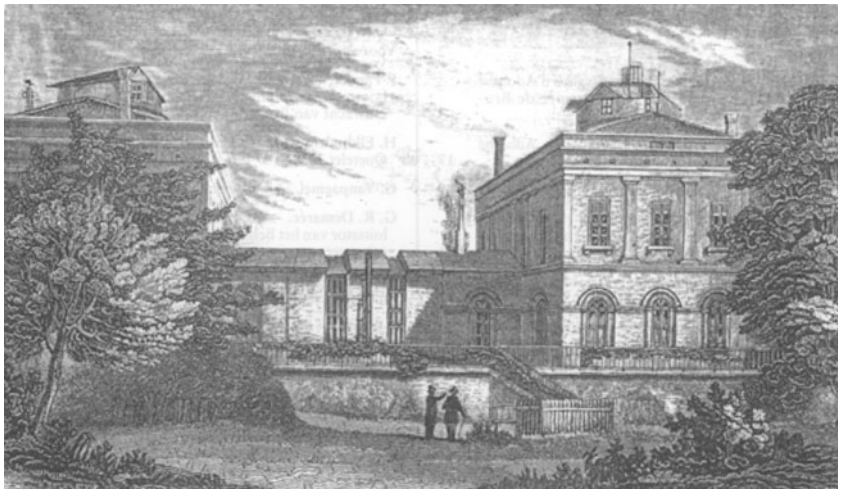


Fig. 2 Garden of the Royal Observatory of Brussels near the Schaerbeek Gate and site of the observations of plant periodical phenomena of Quetelet

a leaflet by the Belgian Royal Academy of Sciences containing detailed instructions for the observation of periodical phenomena (Quetelet 1853). Soon, the network created by Quetelet spread across Belgium and throughout Europe (Ihne and Hoffmann 1884; Schnelle 1955). The information collected by Quetelet was published in the Memoirs of the Belgian Royal Academy of Sciences under the headings *Observations botaniques, Observations zoologiques and Observations faites à des époques déterminées* as a part of the *Observations des phénomènes périodiques* for the years 1839–1872 (Demarée 2009).

Charles Morren, the "Father of phenology"

Charles-François-Antoine Morren (Fig. 1b)—born in Ghent (1807) and died in Liège (1858)—was one of Quetelet's students at the *Athénée* of Brussels. After leaving the *Athénée*, Morren went on to study natural sciences at the University of Ghent in 1825. In the wake of the Belgian revolution, he was asked to teach at several institutions in Ghent where he became a doctor (honoris causa) in medicine in 1835. He was nominated professor of botany at the University of Liège in 1835 and became corresponding Fellow of the Belgian Royal Academy of Sciences in 1835 and Fellow in 1837. Morren was an extraordinarily active scientist in various fields, published a considerable number of papers and founded several journals in botany, horticulture, agronomy and related fields, and he also made numerous communications to the Belgian Royal Academy of Sciences (Morren 1860; Le Roy 1869; Crépin 1903). While Morren contributed to the observations of periodical phenomena collected by Quetelet at the academy, his contributions were limited to the years 1841 and 1842 and were not continued afterwards. Was this possibly an early sign of his disagreement with Quetelet's proposal at that time?

In his search for finding a name for a new discipline, Morren turned to *annual natural periods* which was used by D'Hombres-Firmas (1776–1857) at Nîmes, France, to indicate the limit of periods in which the different stages of plants occur annually (D'Hombres-Firmas 1838). Similarly, Carl Joseph Kreutzer (1809–1866) used the term *anthochronology* (ἄνθος=flower) to describe the floral calendar of central Europe (Kreutzer 1840). Morren was critical that neither Kreutzer and Quetelet studied the laws of correlation that govern all periodical phenomena. He further noted that Kreutzer did not pay enough attention in the framework of the periodical phenomena to continuous flowerings, flowers flowering several months and monochronic flowerings (flowering at a very restricted period). Morren suggested that the term "anthochronology" be used in his correspondence with Quetelet on the periodical phenomena for the year 1842 (Morren 1842, mss.; Morren 1843a). These anthochronological observations deal with subdaily observations to construct a floral clock and with the periodicity of the sexual motilities of plants.

In December 1849, Charles Morren used the term"phenology" for the first time in a public lecture at the Belgian Royal Academy of Sciences at Brussels on this particular science (Morren 1849a). Recently, Demarée and Rutishauser (2009, including supplementary material) reported on the naissance of the term on the basis of archival material. Morren is rarely credited for the first use of the word "phenology" in the twentieth century literature (for exceptions, see Schnelle 1955; Cappel 1980; Grove 1988; Demarée 1996, 2009; Demarée and Chuine 2006). Even less credit is given to the exact reference where the term was mentioned in the title of a scientific publication by Morren (1853) except from Keatley and Hudson (2010), who arrived at the same conclusions referring to Morren (1849a). However, the term "phenology" was also proposed simultaneously by Morren in the December 1849 volume of a series of publications in the *Annales de la Société royale*

d'Agriculture et de Botanique de Gand (Annals of the Royal Society of Agriculture and Botany of Ghent).

The scientific debate between Quetelet proposing the name "periodical phenomena" and Morren proposing "phenology" lasted for 10 years. This discussion is described through the extant correspondence between both scientists and through their published material.

The scientific debate as seen from the correspondence between Quetelet and Morren

Charles Morren was informed on details of Quetelet's instructions on the observations of periodical phenomena, which were presented at the meeting of the Belgian royal Academy of Sciences, dated Brussels, 13 January 1842. In a letter he responded to Quetelet:

> "Liége, January 12th, 1842. What concerns the editing of the programme, I am more than ever embarrassed. […] Your ideas have changed and I cannot share your way of viewing in this matter. By limiting the observations to isolated facts, the larger goal is missed; the goal like Schübler[1] had conceived it. If I have succeeded at Lyon, at Florence, at Naples, etc. to make feel the importance of this work for the physiology, it is considering the phenomenon of the periodicity in its most general expression. At nearly all of my observations of flowering, I have indicated the fragrance, at all the colours; I had very remarkable results. But by limiting to only the flowering and even of only a few flowers determined by nothing precise and which will be selected after the caprice or the laziness of the observer, you can be sure that you will take away from your concept all that was utile. Our dear fellow members have not understood where your system will lead." (Wellens-De Donder 1964).

During the following years, Charles Morren sent a number of letters to Adolphe Quetelet. On 19 May 1842, Charles Morren sent his contributions of periodical phenomena to Quetelet and attached his zoological observations (Wellens-De Donder 1964).

In a following letter to Quetelet, and, in order to clarify some aspects in the Instructions, Morren specifies his definitions of flowering and of full flowering.

> "Brusssels, 12 August 1842. One understands by flowering the period at which the bud operates its first opening. […] One understands by full flowering the period at which the first leaves of the bud of the year have taken their full development." (Wellens-De Donder 1964).

Morren informs Quetelet, on 26 June 1843, that the book of poems [*Fleurs éphémères*] which contained an ode on periodical phenomena dedicated to Quetelet, had been printed (Wellens-De Donder 1964).

Morren addresses, on 27 September 1845, a letter to Quetelet on periodical phenomena in China. It turns out that George Tradescant Lay (c. 1800–1845), a British naturalist, missionary and diplomat, carried out observations of periodical phenomena at Fuzhou, China, in a similar way as was suggested by Quetelet. Morren's letter will be published in the Bulletin of the Belgian Royal Academy of Sciences (Wellens-De Donder 1964; Morren 1845, 1849b/1850).

Morren writes as a footnote in his letter to Quetelet, dated 29 June 1848: "It is today exactly, day by day, one hundred years ago that Linnaeus botanized with Berger, the father of the periodical observations." (Wellens-De Donder 1964).

Morren writes to Quetelet, on 29 June 1848, in order to be registered for a communication in the session of Saturday on the following subjects: (1) A letter to Mr. Quetelet on periodical phenomena; (2) List of the agricultural flowerings in the month of June [1848] (Wellens-De Donder 1964). In the end, Morren's presentation at the Academy meets with Quetelet's disapproval (see below).

The scientific debate between Quetelet and Morren as seen from published works

Following his disagreement with Quetelet, expressed in his letter dated 12 January 1842, Morren already writes in his *Fleurs éphémères*:

> "If an event, in the history of science in Belgium characterises our era, it will certainly be the idea of Mr. Quetelet on the observations of the periodical phenomena. […] Just like the study of the phenomena which link the animal and vegetal kingdoms on the terrestrial globe will conduct to the discovery of fixed relations, general laws, where today nothing seems to be ruled and where everything seems arbitrary and irregular. Certainty will replace the vagueness, […]. The goal which proposes the association of the observation of the periodical phenomena is to know the manifestation of life ruled by the time." (Morren 1843b, pp. 439–440)

[1] Gustav Schübler (1787–1834) was a German naturalist, and the founder of applied meteorology in Germany. In 1817 Schübler became professor of botany, natural history and agricultural chemistry at the University of Tübingen, Germany.

In 1848, Morren expresses again his disagreement with the name given by Quetelet:

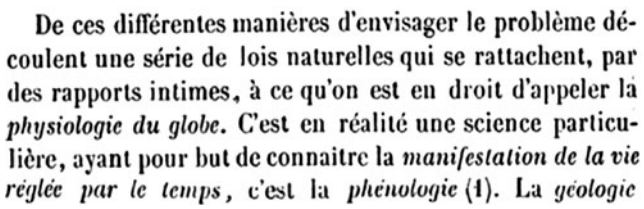
> "The ensemble of the returning phenomena constitutes of course for the plant kingdom *the manifestation of life ruled by the time*. That ensemble has been named in recent time 'periodical phenomena'. The name seems to us too vague because he is too general. […] Our goal must be to restrict this study to the essentials in these relations with the organized living beings. […] It is a very complex study but it is embodied in the *manifestation of life ruled by the time*." (Annales, t. IV, Janvier 1848, p. 1–8)

In his historical approach published in the Annales, Morren refers to Linnaeus' work (Linné 1788, p. 328), who suggested:

> "producing in every country, every year, a Floral Calendar based on the precise moment of leafing, flowering, fructification and leaf fall, and, by observing at the same time, one would know the diversity of the regions of the world. The climate will be well known by the botanist by the progress and the march of the year according to the time of development of the leaves and their fall, from which one will estimate the heat and the cold." (Annales, t. IV, Août 1848, p. 281).

On 1 July 1848, a letter was read at the academy in which Morren criticised Quetelet's instructions. Although the members voted that the letter would be published in the Bulletins, Quetelet submitted an observation to Morren on 7 July and Morren decided to withdraw his text for publication. However, the letter was published in *Fuchsia*, an anthology of Morren's work (Morren 1849c/1850, pp. 77–83). In this text, Morren reproaches Quetelet for having only issued the instructions on the observation of periodical phenomena but omitting the relationships that the observed data might have among them. Numerous research data published by Quetelet in the several years surrounding publication of the letter prove this spirit. Morren quoted Linnaeus' aphorisms of correlations between the periodical phenomena of vegetation and animal life. Furthermore, Morren suggested extending the list of Quetelet to agricultural plants. All this would contribute to establishing a Calendar of the Nature (Morren 1849c/1850, pp. 77–83).

Morren repeated his objections in more detail in the *Annales* in 1849 (Annales, t. V, Octobre & Novembre 1849). Quetelet had excluded observations of annual plants because the period of sowing could differ. Similarly, bi-annual plants were excluded except for autumn cereals, for which the periods of sowing and the appearance of ears were requested in the instructions. No observations of flowers, such as tulips or roses, or of fruit trees, were requested, which seriously diminished the horticultural interest. Morren rejects the astronomical year and suggests considering the biotic year as the period which flows between two successive returns of the vital phenomena of nature. According to this idea, Morren classifies plants in nine particular groups.

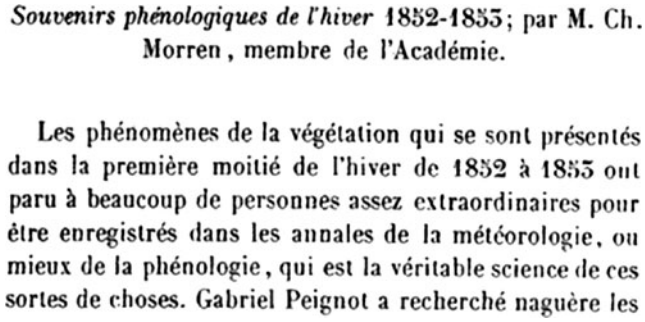


De ces différentes manières d'envisager le problème découlent une série de lois naturelles qui se rattachent, par des rapports intimes, à ce qu'on est en droit d'appeler la *physiologie du globe*. C'est en réalité une science particulière, ayant pour but de connaitre la *manifestation de la vie réglée par le temps*, c'est la *phénologie* (1). La *géologie*

Fig. 3 First elaborated definition of *'phénologie'* (phenology) by the Belgian botanist Charles Morren (1807–1858) following a public lecture at the Belgian Royal Academy at Brussels on December 16 1849 (Morren 1849a) and in a publication in the Annales, t. V, Décembre 1849, p. 450. Lines 4–6: "This is a particular science having the goal to understand the manifestations of life governed by time, it is called phenology."

Morren concludes that the plan proposed by the academy is deficient in its essential parts and, consequently, it did not, he believed, have all the utility that the observational system could have offered (Annales, t. V, Novembre 1849, p. 410). He offered another option in defining a new science for which he coined the term *phenology* at two different but simultaneous occasions in December 1849.

- From the December 1849 volume of the *Annales*: "… a question that important of the periodical phenomena of the vegetation. We view this study taken on the whole as a particular science to which we have given the name 'Phenology'". (Annales, t. V, Décembre 1849, p. 450).
- In a public lecture at the Belgian Royal Academy of Sciences in Brussels on 16 December 1849, Morren elaborated on this subject and used the term 'phenology'. He defined 'phenology' as follows (see Fig. 3): "It is in reality a specific science which has the goal to know the *manifestation of life ruled by the time*". (Morren 1849a; Morren 1851).



Souvenirs phénologiques de l'hiver 1852-1853; par M. Ch. Morren, membre de l'Académie.

Les phénomènes de la végétation qui se sont présentés dans la première moitié de l'hiver de 1852 à 1853 ont paru à beaucoup de personnes assez extraordinaires pour être enregistrés dans les annales de la météorologie, ou mieux de la phénologie, qui est la véritable science de ces sortes de choses. Gabriel Peignot a recherché naguère les

Fig. 4 First use of the term phenology in the title of a scientific paper by Belgian botanist Charles Morren in 1853. Lines 1–6: "A large number of persons observed extraordinary appearances of the vegetation during the first half of winter 1852 to 1853 noteworthy to be collected in the annuals of meteorology, or even better in the annuals of phenology, which is the science of theses sort of things."

Concluding remarks

The origin of the word "phenology" was retraced to December 1849 in which Charles Morren, a botanist at the University of Liège in Belgium, coined the term on two nearly simultaneous occasions. The use of this term was an answer by Morren to the invitation by Quetelet at the Belgian Royal Academy of Sciences in Brussels to carry out observations of periodical phenomena.

As early as 1842, Morren disagreed with Quetelet, starting a 10-year scientific debate. However, Morren, as a botanist and a plant physiologist, found that details and interactions were not specified in the instructions issued by Quetelet and criticised the cooperation set up by Quetelet. The discussion was a difficult and delicate one, as seen by the positions of both actors: the powerful Quetelet versus his former student Morren. The latter fact explains the precautions taken by Morren when discussing the point-of-view of Quetelet. The scientific discussion ended, more or less, in 1853 when Morren published a paper (Fig. 4) in the Bulletins of the Academy in which the new term "phenology" was used in its title (Morren 1852–74, 1853).

Morren's terminology was taken up temporarily by the Meteorological Institute in Vienna in 1858, and soon after the new term started to be used by several scientists in Latvia, in Italy (Puppi 2007), in Finland, in the U.K. and in the U.S.A. In Belgium, de Selys-Longchamps (1853) was one of the first to refer, in a footnote, to the new term. However, the old term "periodical phenomena" continued to be used, as is shown by the Smithsonian Institute (Smithsonian Miscellaneous Collections 1860).

The present day legacy of the debate is contradictory: the climate-oriented, Quetelet type of instructions have survived, while the more botany-oriented Morren type of instructions were probably never used. However, the term "phenology" has obtained worldwide general acceptance while the term "observations of periodical phenomena" today is more rarely used. Differences still remain today: environmental scientists more relate phenological data to the definition of Adolphe Quetelet while the view of Morren is more reflected by the plant modelling and biological science communities. The history of the term "phenology" sheds light on the understanding of "phenology" as a scientific discipline in the beginning of the twenty-first century.

Today, the term "phenology" is widely used by scientists from disciplines as diverse as medieval history and climate modelling. The term, in its scientific meaning, has regained momentum within climate change impact studies. In a time of global change and of understanding the impacts of climate change, the phenological observations on global, regional and very local scales are of the utmost important. In this context, the stress given by Morren to the observation of the manifestation of life as ruled by time becomes crucial to witnessing the impact of climatic change.

Acknowledgements The authors express their gratitude to the Library and Archives de l'Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique and to the Library of the National Botanical Garden at Meise for their precious help in consulting the relevant literature. The cooperation and contacts within the COST 725 project "Establishing a European Phenological Data Platform for Climatological Applications" is acknowledged. The authors sincerely thank Elizabeth M. Wolkovich and two anonymous reviewers for their remarks and suggestions.

References

Annales de la Société royale d'Agriculture et de Botanique de Gand. Journal d'horticulture et des Sciences accessoires, rédigé par Charles Morren, l'un des secrétaires honoraires de la Société (1848–1849) Tomes IV and V, Gand, au local de la société (Casino). Bruxelles, Muquardt & Liége

Aono Y, Kazui K (2008) Phenological data series of cherry tree flowering in Kyoto, Japan, and its application to reconstruction of springtime temperatures since the 9th century. Int J Climatol 28:905–914

Arakawa H (1955) Twelve centuries of blooming dates of the cherry blossoms at the city of Kyoto and its own vicinity. Pure Appl Geophys 30(1):147–150

Burri M, Rutishauser T (2009) Johann Jakob Sprünglis Beobachtungen als Quelle der Historischen Klimaforschung Wegbereiter der Historischen Klimaforschung. In: Stuber M, Moser P, Gerber-Visser G, Pfister C (eds) Kartoffeln, Klee und kluge Köpfe. Die Oekonomische und Gemeinnützige Gesellschaft des Kantons Bern OGG, 1759–2009, Paul Haupt Bern, pp. 107–110

Cappel A (1980) Societas meteorologica Palatina (1780–1795). Informationen für den Fachdienst, 11^{e} Jg., Heft 1, Offenbach am Main, 10–27

Chen X (2003) East Asia. In: Schwartz MD (ed) Phenology. An integrative environmental science. Kluwer, Dordrecht, pp 11–26

Chuine I, Yiou P, Viovy N, Seguin B, Daux V, Le Roy Ladurie E (2004) Gripe ripening as a past climate indicator. Summer temperature variations are reconstructed from harvest dates since 1370. Nature 432:289–290

Collard A (1928) La vie et l'œuvre d'Adolphe Quetelet (1796–1874) (Suite). Ciel Terre 44:310–321

Crépin F (1903) Morren, Charles-François-Antoine. Biogr Natl 15:275–280

Demarée GR (1996) Adolphe Quetelet (1796–1874): Précurseur du réseau belge d'observations climatologiques - Initiator van het Belgische klimatologische waarnemingsnet. Bull Astron XI (1):41–52

Demarée GR, Chuine I (2006) A concise history of phenological observations at the Royal Meteorological Institute of Belgium. In: Nicolas R, Dalezios and Stergios Tzortzios (eds) HAICTA2006 Conference, 20–23 September 2006, Volos, Greece, III:815–824

Demarée G (2009) The phenological observations and networking of Adophe Quetelet at the Royal Observatory of Brussels. Riv Ital Agrometeorol 1:22–24

Demarée GR, Rutishauser T (2009) Origins of the word "Phenology". Historical note. Eos, Vol. 90, No. 34, 25 August 2009:291, Supplementary material to "Origins of the Word 'Phenology' "

Grove J (1988) The little Ice Age. Methuen, London

D'Hombres-Firmas L-A (1838) Recueil de mémoires et d'observations de physique, de météorologie, d'agriculture et d'histoire naturelle. Nîmes, Ballivet et Fabre, 2 vol

Ihne E, Hoffmann H (1884) Beiträge zur Phänologie. J. Ricker'sche, Giessen

Keatley MR, Hudson IL (2010) Introduction and overview. In: Phenological research. Methods for environmental and climate change analysis. Springer, Berlin

Kreutzer CJ (1840) Anthochronologion plantarum Europae mediae. Blüthen-Kalender der Pflanzen des mittleren Europa. F. Volke, Wien, p 236

Le Roy A (1869) Morren, Charles-Franç.-Antoine. In: Liber memorialis. L'Université de Liége depuis sa fondation. Liége, Imprimerie de J.-G. Carmanne:446–479

Linné C (1788) Philosophie botanique de Charles Linné, … dans laquelle sont expliqués les fondaments de la botanique, …, enrichie de Figures. Traduite du Latin par Fr.-A. Quesné. Paris & Rouen

Mailly E (1875) Essai sur la vie et les ouvrages de L.-A.-J. Quetelet. Hayez, Bruxelles

Maurer C, Koch E, Hammerl C, Hammerl T, Pokorny E (2009) BACCHUS temperature reconstruction for the period 16th to 18th centuries from Viennese and Klosterneuburg grape harvest dates. J Geophys Res 114:D22106. doi:10.1029/2009/JD011730

Meier N, Rutishauser T, Luterbacher J, Pfister C, Wanner H (2007) Grape harvest dates as a proxy for Swiss April to August temperature reconstructions back to AD 1480. Geophys Res Lett 34:L20705. doi:10.1029/2007GL031381

Morren C (1842) Observations anthochronologiques sur la périodicité des motilités sexuelles pour les plantes & Observations anthochronologiques sur les périodes diurnes. Manuscript letters. Library of the Royal Observatory of Belgium, Brussels

Morren C (1843a) Observations anthochronologiques sur la périodicité des motilités sexuelles pour les plantes, Observations anthochronologiques sur les périodes diurnes, Observations zoologiques. Nouveaux Mémoires de l'Académie royale des Sciences et Belles-Lettres, Tome XVI, Bruxelles, Hayez:104–107

Morren C (1843b) Fleurs éphémères. Librairie encyclopédique de Périchon, Bruxelles, p 448

Morren C (1845) Lettre de M. Morren à M. Quetelet, sur les phénomènes périodiques observés en Chine. Bulletins de l'Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique. XII(2):235–238

Morren C (1849a) Le Globe, le Temps et la Vie. Bulletins de l'Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique, XVI(2):660–684

Morren C (1849b/1850) Lettre de M. Morren à M. Quetelet, sur les phénomènes périodiques observés en Chine. In: Fuchsia ou Recueil d'Observations de Botanique, d'Agriculture, d'Horticulture et de Zoologie. Bruxelles, Decq:9–12

Morren C (1849c/1850) Phénomènes périodiques. Lettre à M. Ad. Quetelet sur les phénomènes périodiques; Liste des phénomènes périodiques du mois de juin, observés dans leur rapport avec l'agriculture, l'économie forestière et l'horticulture de Belgique. In: Fuchsia ou Recueil d'Observations de Botanique, d'Agriculture, d'Horticulture et de Zoologie. Bruxelles, Decq:77–83; 84–86

Morren C (1851) Le globe, le temps et la vie, ou discours sur les phénomènes périodiques auxquels la physiologie de la terre est soumise. In: Lobelia ou recueil d'observations de botanique et spécialement de tératologie végétale, […]. Bruxelles, Hayez:1–25

Morren C (1853) Souvenirs phénologiques de l'hiver 1852–1853. Bulletin de l'Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique. XX(1):160–186

Morren C. (1852–74) Souvenirs phénologiques de l'hiver 1852–1853. In: Clusia. Recueil d'observations de tératologie végétale, suivies de quelques Notices de Physiologie, de Pathologie, d'Économie rurale, d'Anatomie comparée et d'Entomologie par Charles Morren (1852–1853). Publié, avec une préface & une introduction par Éduard Morren, Liége, p. 1–27

Morren E (1860) Notice sur Charles Morren, Membre de l'Académie, Né à Gand, le 3 mars 1807, mort à Liège, le 17 décembre 1858. Annuaire de l'Académie:167–251

Možný M, Brázdil R, Dobrovolný P, Trnka M (2011) Cereal harvest dates in the Czech Republic between 1501 and 2008 as a proxy for March-June temperature reconstruction. Climatic Change. doi:10.1007/s10584-011-0075-z

Pfister C (1975) Agrarkonjunktur und Witterungsverlauf im westlichen Schweizer Mittelland zur Zeit der Ökonomischen Patrioten 1755–1797 Geographica Bernensia, Geographica Bernensia G2, Bern

Puppi G (2007) Origin and development of phenology as a science – Origine e sviluppo della fenologia como scienza. Ital J Agrometeorol (3):24–29

Quetelet A (1841) Phénomènes périodiques. Bulletins de l'Académie royale des Sciences, des Lettres et des Beaux-arts de Belgique, VIII(2):231–232.

Quetelet A (1842a) Instructions pour l'observation des phénomènes périodiques (Bruxelles, le 13 janvier 1842). Bulletins de l'Académie royale des Sciences, des Lettres et des Beaux-arts de Belgique, IX(1):65–92.

Quetelet A (1842b) Calendrier pour la floraison, d'après les observations faites en 1839, dans le jardin de l'Observatoire. Calendrier pour la floraison, d'après les observations faites en 1840, dans le jardin de l'Observatoire. Annales de l'Observatoire Royal de Bruxelles, Tome II, Bruxelles, Hayez:203–204; 292–294

Quetelet A (1843) Instructions pour l'observation des phénomènes périodiques. Académie royale des Sciences et des Belles Lettres de Bruxelles, 1er décembre 1843, 16 pp

Quetelet A (1849) Sur le Climat de la Belgique. Tome Premier, Première Partie Chapitre IV, Des phénomènes périodiques des plantes. Hayez, Bruxelles, pp 1–187

Quetelet A (1853) Instructions pour l'observation des phénomènes périodiques. Académie royale des Sciences et des Lettres de Bruxelles et des Beaux-Arts, 25 avril 1853, 15 pp

Randerson JT, Hoffman FM, Thornton PE, Mahowald NM, Lindsay K, Lee Y-H, Nevison CD, Doney SC, Bonan G, Stöckli R, Covey C, Running SW, Fung IY (2009) Systematic assessment of terrestrial biogeochemistry in coupled climate-carbon models. Glob Change Biol 15(10):2462–2484

Rosenzweig C, Casassa D, Imeson A, Liu C, Menzel A, Rawlins S, Root T, Séguin B, Tryjanowski P (2007) Assessment of observed changes and responses in natural and managed systems. In: Climate Change 2007: impacts, adaptation and vulnerability. contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2007, 79–131

Rosenzweig C, Karoly D, Vicarelli M, Neofotis P, Wu Q, Casassa G, Menzel A, Root TL, Estrella N, Seguin B, Tryjanowski P, Liu C, Rawlins S, Imeson A (2008) Attributing physical and biological impacts to anthropogenic climate change. Nature 453:353–357

Rutishauser T (2009) Historical phenology in Central Europe. Seasonality and climate during the past 500 years. Geographica Bernensia G82

Schnelle F (1955) Pflanzen-Phänologie. Geest & Portig, Leipzig

Schwartz MD (ed) (2003) Phenology: an integrative environmental science. Kluwer, Dordrecht

Sekiguchi T (1969) The historical dates of Japanese cherry festival since the 8th century and her climatic changes. Tokyo Geogr Pap 13:175–190

de Selys-Longchamps (1853) Le calendrier de Faune, en Belgique. La Belgique horticole, Tome III, Liège:344–352

Smithsonian Miscellaneous Collections (1860) Directions for meteorological observations and the registry of periodical phenomena. Smithsonian Institution, Washington, pp 63–67

Sparks TH, Carey PD (1995) The responses of species to climate over two centuries. an analysis of the Marsham Phenological record 1736–1947. J Ecol 83:321–329

Sparks T, Lines J (2008) Chapters in the life of Robert Marsham Esq. F.R. S. of Stratton Strawless, Norfolk. St. Margaret's Church, Norfolk

Tagami Y (2008) Recent warming and viniculture changes in Europe – especially on Germany and its surrounding areas in North Europe. Memoirs of the Faculty of Human Development, University of Toyama 3(1):103–120 (in Japanese, with English abstract)

Tollemer A (1879) Journal manuscrit d'un sire de Gouberville et du Mesnil-au-Val, gentilhomme campagnard, au Cotentin, de 1553 à 1562. Rennes, Oberthur et fils, 2e éd

Wegmann M (2005) Naturwahrnehmung im Mittelalter im Spiegel der lateinischen Historiographie des 12. und 13. Jahrhunderts. Peter Lang, Bern, XII

Wellens-De Donder L (1964) La correspondance d'Adolphe Quetelet. Bruxelles, Centre national d'histoire des sciences. Arch Biblio XXXV(1):49–66

Yoshino M (2004) Development of phenological Recognition and phenology in Ancient China. Jpn J Biom 41(4):141–154