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German pollen calendar 4.0 – update based on 2011–2016 pollen data

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To the editors

Background

The evidence for links between the pollen count/exposure and the onset of allergy symptoms is manifold [1, 2]. It is important for allergy sufferers to know the pollination period. Most plant species dynamically react to changes in their environment. The rise in mean global temperatures associated with climate change has a major effect on the phases of plant development. Therefore, pollination times may change over the years and necessitate an update of previous pollen calendars (PC). The most important requirements for creating current interregional PC are continuous, coordinated, and standardized monitoring of airborne pollen in a pollen monitoring network and archiving the data thus obtained.

Methods

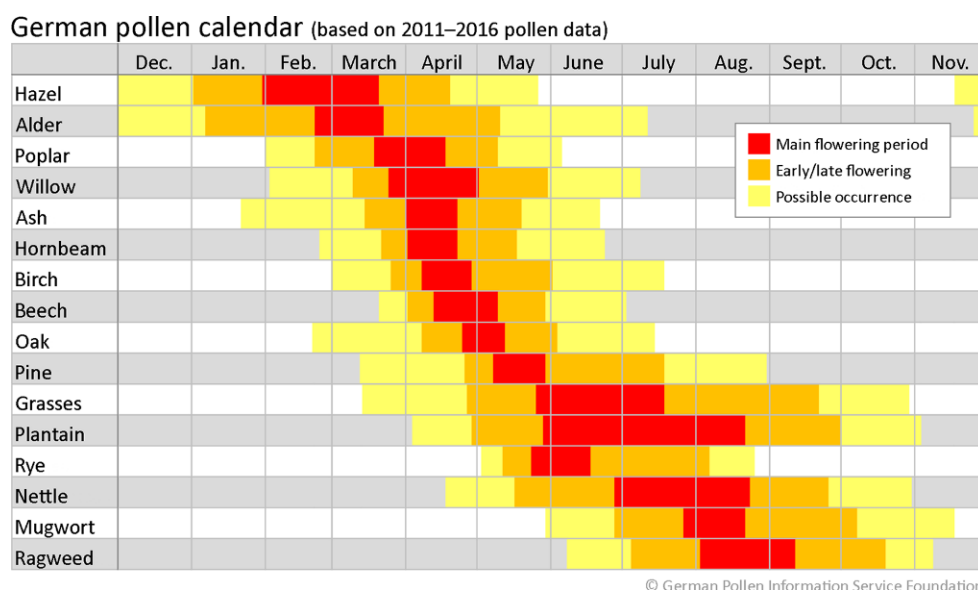
The German Pollen Information Service Foundation (Stiftung Deutscher Polleninformationsdienst, PID) has been operating a monitoring network in Germany comprising volumetric pollen traps since 1983 [3]. To date, three PC have been published on the basis of measurement data from previous years. In order to create the current calendar (Fig. 1), daily pollen measurement data from at least 33 and up to 41 PID measuring stations was used, depending on the respective pollen type and year. The measured pollen levels represent daily averages expressed in pollen per cubic meter (m³). The archived pollination data underwent a plausibility check before being used. For example, a high birch pollen count in February was deemed incorrect, and this data was removed from the calculations.

The new PC 4.0 presented here was created on the basis of results from a 6-year monitoring period (2011–2016). Based on daily levels measured at the individual monitoring stations, it was possible to produce daily average levels for 16 types of pollen for the whole of Germany all year round. The main flowering period of a year was calculated based on the percentage total of the daily averages. If the first 10% of the annual value were reached, the day before the 10% threshold was exceeded was deemed the beginning of the high season, and the day before the 90% threshold was reached was deemed the end of the high season. This means that approximately 80% of the annual pollen exposure occur during the main flowering period. The period preceding this is the early flowering period, starting at the latest on the day when a count of 0.49% of the annual total is reached. The second bloom refers to the period from the end of the main flowering period to the day when at least 99.5% of the annual total have been reached. Since, theo-

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Fig. 1 German pollen calendar 4.0 according to pollen count data compiled between 2011 and 2016. (By the pollen monitoring stations belonging to the German Pollen Information Service Foundation [Stiftung Deutscher Polleninformationsdienst], as well as up to three other cooperating stations)



retically, individual pollens can occur all year round as a result of resuspension, the period of the earliest possible occurrence of a pollen type was limited to no more than 30 days before the earliest possible start of early flowering, and the latest possible occurrence to no more than 30 days after the latest end of the second bloom. The six values that resulted for the main, early, and second flowering periods as well as possible occurrences for the years 2011–2016 were averaged, and the resulting days of the year were put into the PC.

Results

A short and often intensive pollen season is seen in the case of wind-pollinated tree species comprising only one species (e.g., hornbeam and beech) or a limited range of species (e.g., birch and oak). For example, 80% of annual birch pollen (main flowering period) circulate within a period of only 15–24 days. The main flowering period of grasses or perennial meadow herbs that develop early in the year, such as dock and plantain, on the other hand, lasted 43–62 days for grasses and 93 days for plantain. At up to 74 days, hazel's main flowering period can also be long.

Large seasonal differences at the beginning of the early flowering and main flowering periods were seen from year to year in hazel and alder. The start of the main flowering period can vary by up to 27 days (hazel) or 28 days (alder) during the period under consideration. The range was significantly smaller year-on-year for grasses and herbs at a maximum of 20 and 13 days, respectively. The appearance of the first fresh pollen at the start of a pollen season is signaled when hazel and alder start to flower. The first pollen from these species was detected at individual stations as early as November during the period in question. Their pollen then regularly appears at the time around the turn of the year. The pollen

season usually ends with the fading of nettle, mugwort, and the last late-flowering grass species during the transition from summer to autumn. As ragweed (*Ambrosia* spp.) becomes more widespread, the importance of its role in prolonging the pollen season continues to increase since the main flowering period of the two naturalized species *Ambrosia artemisiifolia* and *A. psilostachya* can last well into September. The period of the most intensive pollination and the highest number of simultaneously flowering plant species lasts from the end of March to mid-June, peaking in April.

Discussion

Plant species that flower early in the year, especially hazel and alder, respond in a particularly sensitive manner to changes in temperature patterns during winter and early spring in our climate. Furthermore, both species are able to rapidly respond to temperature fluctuations with the development and release of pollen (mild spells during winter) [4]. Longer interruptions in the pollen release due to the onset of winter are not uncommon, meaning that the pollen season can span a comparatively long period of time with varying intensity and corresponding fluctuations from year to year. For plant species that flower later in the year, the sunshine duration, vernalization, accumulation of precipitation and humidity as well as fixed variables such as day length have an effect on flower development and the period of pollen release [5].

The duration of the occurrence of certain pollen types (season length) in the air is explained by the number of species involved in pollen release belonging to a particular pollen type, among other things. For example, since the pollen from the various grass species cannot be differentiated, or can only be mi-

croscopically differentiated from one another with great difficulty, they are—with the exception of cereal/maize pollen—classified as a single pollen type. Therefore, differences in the flowering phenology of the individual species result in a longer season, whereby numerous grass species release their pollen at the same time during the main flowering period [6]. The pollen season also has region- and altitude-specific components. For example, the favorable climatic conditions of the Lower Rhine and the southwest of Germany cause numerous species to release pollen early. Lower average temperatures at higher altitudes delay both the start of pollination and the period of maximum pollen levels [7]. A German PC can only cover these regional or local features to a limited extent. The main flowering periods described in PC 4.0 do not follow the new definitions of a pollen season or peak pollen periods that are relevant to the assessment of immunotherapy studies [8] and which also correlate with documented symptom data [9]. The pollen calendar 4.0 can be found on the website of the PID (www.pollenstiftung.de); its use by third parties is subject to licensing.

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Conflict of interest M. Werchan, B. Werchan and K.-C. Bergmann declare that they have no competing interests.

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