HOW DO FIRST FLOWERING DATES TODAY COMPARE WITH THOSE RECORDED BY WALTER WATSON IN THE FIRST HALF OF THE 20TH CENTURY?

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Abstract

This paper reports on first flowering dates (FFDs) of 339 vascular plant species in Somerset in 2008, 2009 and 2010, and compares them with those recorded by Walter Watson in the first half of the 20th century (Watson 1949). The results indicate that, in comparison with the dates recorded by Watson, FFDs were on average 12.2 days earlier in 2008, 12.9 days earlier in 2009 and 2.7 days earlier in 2010. Species-level responses varied considerably; an analysis of mean FFDs of the 339 species showed 251 (74.0%) were earlier and 76 (22.4%) later than the average dates given by Watson. Winter- and spring-flowering species were more responsive to between-year temperature differences than summer-flowering species, as indicated by the much larger year-to-year variation in their mean FFDs.

An analysis of 10 years' (2001–2010) FFDs for 14 spring-flowering species in the Taunton area showed a close relationship between FFDs and January–April mean daily temperatures. Mean FFDs advanced, on average, by about 10 days for each 1°C increase in temperature, the warmest spring (2007, 7.9°C) having the earliest average FFD (9 March), and the three coldest springs (2001, 5.5°C; 2006, 5.5°C; 2010, 4.9°C) the latest (7–9 April). For the decade as a whole, the mean FFD for all species combined was 27 March, 13 days earlier than indicated by the dates for these species given by Watson.

Limitations of the recording method are discussed, observer bias, sampling differences and changes in species abundance all potentially having an impact on the validity of the conclusions drawn. Nevertheless, the findings broadly agree with those of other studies, suggesting that in the last decade in Somerset, as in the rest of the UK, FFDs have been significantly earlier than in preceding decades – a change widely considered to be a phenological response to an underlying upward trend in winter and spring temperatures.

WATSON'S 1949 PAPER ON 'AVERAGE FLOWERING TIMES'

Walter Watson was born in 1872, the son of a Yorkshire boot-maker. For much of his working life he lived in Somerset: from 1903 to 1907 he was employed as a botany teacher at Sexey's School in Bruton, then moving to Taunton School where he taught biology until his retirement in 1939. For many years he lived in Cheddon Road, Taunton. Watson was an extraordinarily knowledgeable botanist and a renowned bryologist and lichenologist. He was also a long-standing member of the Somerset Archaeological and Natural History Society, joining the Society in 1912 and acting as its 'botanical recorder' from 1926 to 1947.

For many years Watson kept a 'wild flower diary' in which, amongst other things, he recorded first flowering dates of the plants he saw. The whereabouts of these diaries is a mystery – we cannot be sure they even still exist – but his observations were summarised in a paper entitled 'The Average Times of First Flowering for Somerset Plants',

published in Volume 93 (1947) of the Society's *Proceedings* (Watson 1949).

In this paper Watson was rather vague about when exactly his records were made. We know that his average dates were, for the most part, based on observations 'during ten or more years', and that the results had previously been '…embodied in a paper on the possible evolutionary significance of flowering time… read to the Linnean Society on *4 January 1934*' [my italics]. It therefore seems reasonable to suppose that, despite not being published until 1949, his field observations were mainly made in the 1920s and early 1930s – although it is not inconceivable that earlier (or later) observations could also have contributed to the results presented in his paper.

Watson appreciated that flowering times could be affected by the weather, yet there is nothing in the paper to indicate what the weather was like during the time he was recording. However, the 1920s and 1930s fell within a period of 'early twentieth-century warming' that ran from the start of the century until the end of the 1930s (Kington 2010). So it seems that, with the notable exception of January–March 1929 (which was severely cold), Watson's winters and springs would have been relatively mild and wet. As noted by Sparks and Collinson (2008), in January 1933 a report in the *Cambridge Evening News* stated 'Does the present succession of mild Januaries suggest something in the nature of a change in climate? Today, amateur gardeners have ... a show of flowers usually retarded by frost until spring.'

Annoyingly, Watson gave no information on the *range* of dates from which his averages were derived. Nor do we have any detail about the places he visited, or how often he visited them. In this regard, it is perhaps worth quoting Watson's own assessment of the reliability of his results: 'The [dates] given may be taken as fairly accurate for Somersetshire, though *most of the field work was done in the Taunton area'* [my italics]; furthermore, 'for West Somerset the times are quite reliable, but as those given for plants which only occur in East Somerset were obtained during excursions I cannot vouch for their absolute accuracy…'. It should also be borne in mind that he had consulted 'the Wild Flower Diary of the late W. D. Miller, who was Hon Secretary of our Botanical Society for about twenty years' – but it is unclear to what extent Watson's average dates were influenced by Miller's observations, and we do not know when (or where) these observations would have been made.

Whatever its shortcomings, Watson's paper – in a Table running to 19 pages – gives 'average first flowering times' for no less than 843 vascular plant species, together with an assessment of flowering period and peak flowering months. At the time, Watson would have been oblivious to the potential relevance of his observations, 60 years later, to studies of the relationships between weather and the timing of seasonal biological events and, crucially, the possible ecological consequences of climate change. Yet Watson's account presents a rare opportunity to compare flowering times in Somerset today with those observed in the first half of the 20th century.

Is there any evidence, then, to suggest that plant species in Somerset are coming into flower either later or earlier than they did in Watson's day? This question cannot be answered, of course, without first compiling a modern data-set.

ASSEMBLING A 21ST CENTURY DATA-SET: PRINCIPLES AND METHODS

I discovered Walter Watson's paper in 2007, and it changed my life! Watson's 'big Table' was shown to me by Graham Rix, who was aware of my interest in phenology and involvement in the UK Phenology Network. For more than a decade I had been recording first flowering dates (FFDs) for a small selection of plant species, along with bud-burst and leafing dates for a number of trees, butterfly emergence dates, arrival dates of spring migrants, etc. But Watson's paper added a new dimension, and a new challenge. If he could record flowering dates for 843 plant species, then why couldn't I? That was the task I set myself in the spring of 2008, but first I needed to establish some ground rules, the aim being to devise a general approach to field recording that could be repeated in subsequent years.

First, I decided that, as far as possible, I would restrict my observations to within about 10kms of Taunton – on the assumption that Watson's own recording was mainly done within a similarly restricted compass.

Second, while trying to cover a wide range of habitats, I decided to focus my recording, for the most part, on a relatively small number of sites that could be visited both regularly and frequently. I visited the following sites: Thurlbear Wood and Quarrylands, at least twice a week; Orchard Wood, about once a week; the River Tone and Bridgwater–Taunton Canal between Obridge and Hankridge, at least once a week; Trull and Staplehay, at least once

a week; Vivary Park, Sherford, Mountfields and South Road, at least three times a week; and Taunton itself, including the area around my home (Trinity Street), the town centre and Victoria Park, almost every day of the week. Having an unadventurous dog helped enormously, as slowly walking around these places was an unavoidable part of the daily routine. Occasional trips – once a fortnight or less – were made further afield, to Wellington, Milverton, Otterhead Lakes, Cothelstone Hill and Creech St Michael, and, more rarely – perhaps once a month – there were excursions to other parts of the county.

Third, I counted a species as flowering only when I had seen it myself. This meant that reports of plants in flower from friends and colleagues generally had to be ignored; they were extremely helpful, however, in alerting me to the fact that a plant had come into flower, or in guiding me to places where I could see it for myself. Occasionally I did accept another person's first date, usually for species not found (or only rarely found) within the Taunton area and so highly unlikely to be seen on any of my routine walks.

I now have records for three years, 2008, 2009 and 2010, and my initial findings are presented below. The number of species recorded each year varied somewhat: overall I recorded FFDs in one or more years for 454 (53.9%) of Watson's species, but only 339 of these were reliably recorded in all three years. To aid comparison between years, and between each year's dates and those given by Watson, the following analysis is confined to the 339 species recorded in every year. In addition, I summarise the main features of the weather in the winter (December–February), spring (March–May) and early summer (June) of each year, based on personal observations and regional (South-west England and South Wales) data and analyses available on the Met Office website (http://metoffice.gov.uk/climate/uk/). Records of air frosts and ground frosts were from my back garden.

2008

The weather

Daily mean temperatures were above the long term (1971–2000) regional average in all months from December to June. It was another noticeably mild winter: monthly mean daily temperatures were close to average in December 2007, but January was above average by more than 2°C, and February by more than 1°C. March, April and June recorded close-to-average temperatures, but May was more than 2°C above average. In terms of days with air frost or ground frost, there were a total of 36: 11 in December, 3 in January (a very low figure), 13 in February, 2 in March and 7 in April. In general, sunshine levels were close to or slightly above average – with February, in particular, being noticeably sunny – and rainfall was markedly above average in January, March and May, and below average in February and June. In Taunton there was a complete lack of snowfall. The sunny, relatively dry and warm weather in February marked out 2008 as another in a long line of 'early springs' in many people's minds, a view reinforced in Taunton by frequent sightings of bumble-bees and red admiral butterflies, and the early emergence of several hoverfly species; by the end of February hazel was in leaf and chiffchaffs were singing in Thurlbear Wood.

First flowering dates

The FFDs of 339 species are shown in Fig. 1, which plots these dates against the 'average times of first flowering' given by Watson. It appears that the majority of species came into flower earlier in 2008 than they did, on average, in Watson's day, but there were considerable differences between species: Sweet Violet (*Viola odorata*), for example, was first recorded flowering 33 days earlier than Watson's average first date, Snowdrop (*Galanthus nivalis*) (Fig. 2) 24 days earlier, Moschatel (*Adoxa moschatellina*) 22 days earlier, and Elder (*Sambucus nigra*) 17 days earlier; whereas Lesser Stitchwort (*Stellaria graminea*) and Germander Speedwell (*Veronica chamaedrys*) were 4 days later, Hoary Ragwort (*Senecio erucifolius*) 8 days later, and Wild Parsnip (*Pastinaca sativa*), remarkably, 36 days later. As can be seen from Fig. 1, winter- and spring-flowering species appeared to be flowering relatively earlier, in comparison with Watson's average dates, than summer-flowering species. Taking all species combined, 2008 FFDs were an average of 12.2 days earlier than those recorded by Watson.

2009

The weather

In contrast to 2008, the winter period was quite cold, with daily mean temperatures below the regional

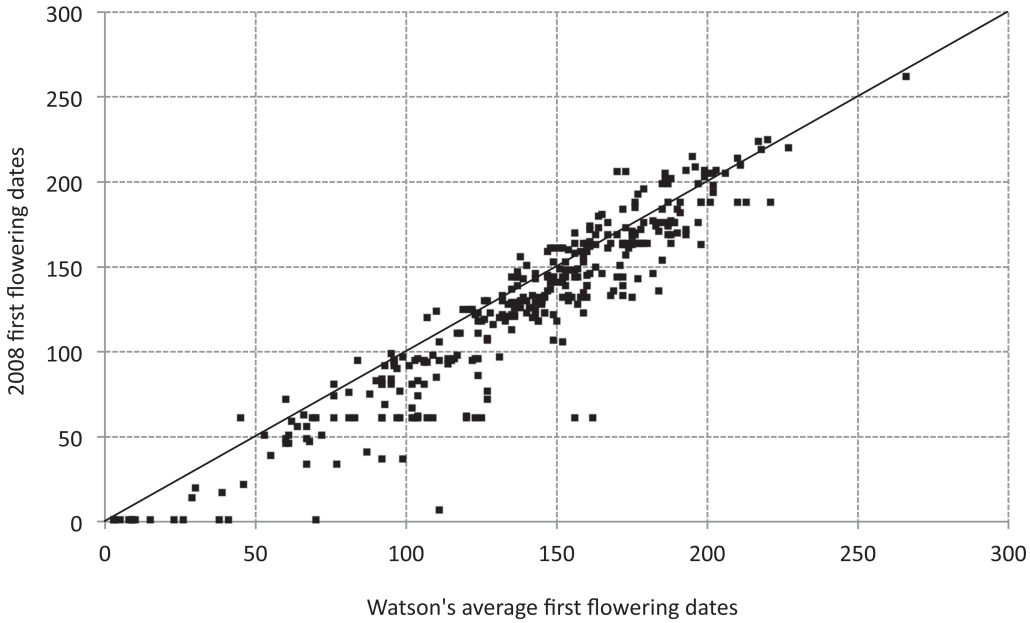

Fig. 1 First flowering dates for 339 species in 2008, plotted against 'average first flowering times' given by Watson. Dates are shown as day no. (1 January = day 1). The diagonal line marks the line along which the data-points would lie if 2008 FFDs were identical to those given by Watson; above the line the 2008 date is later than Watson's date, below the line earlier

1971–2000 average in all three months. December and January were particularly cold, being more than 1°C below the long term average. There were 62 frost-days, 26 more than in 2008: 21 in December, 17 in January, 12 in February, 9 in March and 3 in April. February's weather was unusual (for Taunton) in the amount of snowfall recorded; snow was recorded falling on six days and 'lying' on seven mornings. This snowfall, coupled with lower winter temperatures generally, meant that spring 2009 seemed to get off to a faltering start in comparison with 2008. There was further snow in early March, but temperatures soon picked up after that, with those for March and May being 0.6°C above average and April and June more than 1°C above average. This was clearly a 'spring of two halves', with below-average temperatures between December and the beginning of March and above-average temperatures from early March onwards. Sunshine totals were above average in all months except February, while rainfall totals were close to average in January, April, May and June, and much lower than normal in February and March.

*Fig. 2 Snowdrop (*Galanthus nivalis*), Quaking House Lane, Milverton*

First flowering dates

The FFDs for 2009 are shown in Fig. 3. Unsurprisingly, given the weather, species first

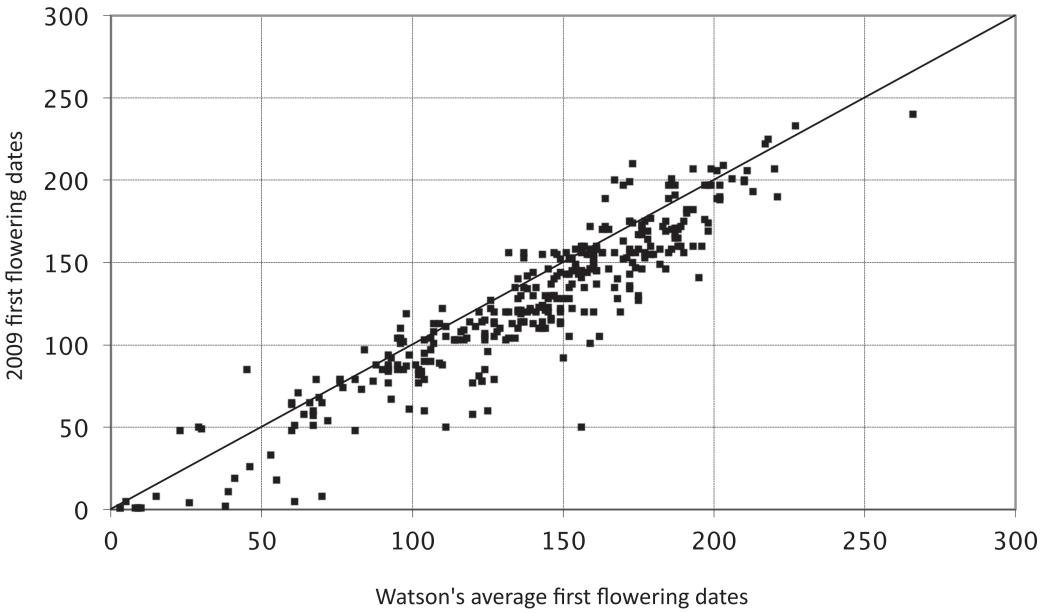

Fig. 3. First flowering dates for 339 species in 2009, plotted against 'average first flowering times' given by Watson. Dates are shown as day no. (1 January = day 1). The diagonal line marks the line along which the data-points would lie if 2009 FFDs were identical to those given by Watson; above the line the 2009 date is later than Watson's date, below the line earlier

flowering in January–April were discernibly later in 2009 than in 2008 (many of the dots are much closer to the diagonal line), but those coming into flower from May onwards were, on average, slightly *earlier* than in 2008. For example, of the early-flowering species, Dog's Mercury (*Mercurialis perennis*) was first seen flowering 29 days later, Lesser Celandine (*Ficaria verna*) (Fig. 4) 19 days later, and Ground-ivy (*Glechoma hederacea*) 18 days later than in 2008; whereas, amongst later-flowering species, Elder and Purple Loosestrife (*Lythrum salicaria*) were both 10 days earlier in 2009 than in 2008. Taking all species combined, FFDs in 2009 were an average of 12.9 days earlier than those recorded by Watson.

2010

The weather

This was without doubt the coldest of the three winters. Daily mean temperatures were nearly 2°C below the regional 1971–2000 average in December, almost 3°C below average in January, and 1°C below average in February. In the garden, between the end of December and the first week of March a day-time maximum temperature of >10°C was recorded on only two days. Even March (in contrast to the previous two years) had below-average daily mean temperatures (–0.5°C), and May was also very

*Fig. 4 Lesser Celandine (*Ficaria verna*), Staple Fitzpaine*

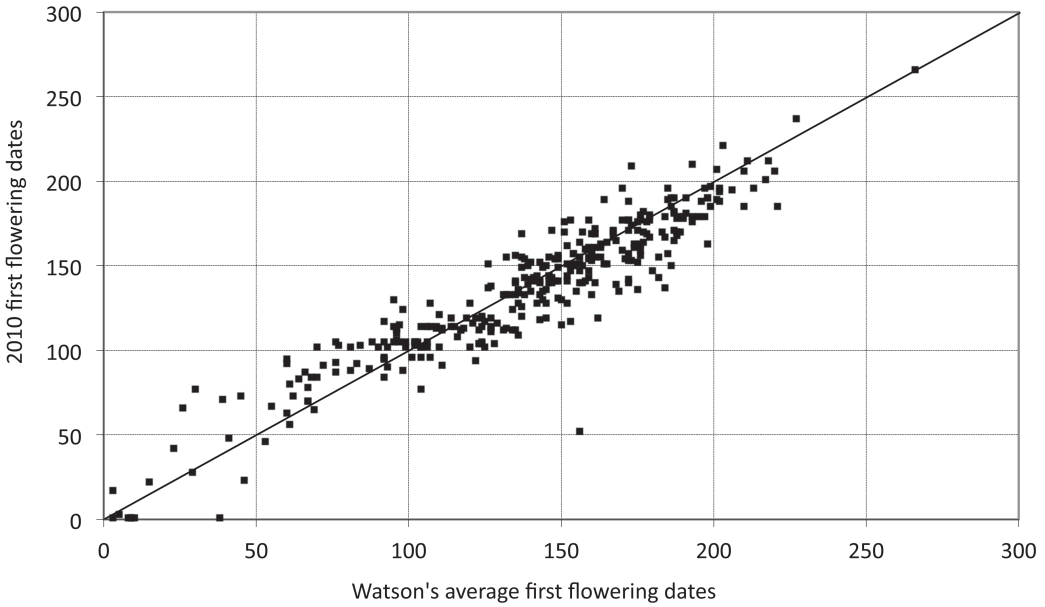

Fig. 5 First flowering dates for 339 species in 2010, plotted against 'average first flowering times' given by Watson. Dates are shown as day no. (1 January = day 1). The diagonal line marks the line along which the data-points would lie if 2010 FFDs were identical to those given by Watson; above the line the 2010 date is later than Watson's date, below the line earlier

slightly below average. Only two months, April and June, had above-average temperatures (0.9°C and 1.4°C respectively). There were 67 frost-days, 5 more than in 2009 and 31 more than in 2008: 15 in December, 21 in January, 9 in February, 14 in March, 6 in April and 2 in May. In January snow was recorded falling in Taunton on 8 days and 'lying' on 9 mornings. Sleet or wet snow was also recorded falling (but not settling) in Taunton on 7 days in February.

Unsurprisingly, the cold winter was followed by a delayed start to spring: the first back-garden hoverflies did not appear until early March, while bumble-bees emerged significantly later than in 2008, the first queens of *Bombus terrestris* in the garden being recorded on 14 March – more than a month later than in 2008. The cold weather was not without its compensations, however: 2010 sunshine totals were much higher than normal – every month was above average, with January, April and June particularly so. Rainfall, on the other hand, was generally well below average, with especially low totals in January, April, May and June; overall, the first half of 2010 was one of the driest on record.

First flowering dates

The FFDs for 2010 are shown in Figure 5. As might be expected, given the generally low temperatures, FFDs of species coming into flower between January and May were considerably later in 2010 than in 2008 and 2009, and for many species the dates were 'above the line', meaning that they were later even than the average FFDs given by Watson. Moschatel, for example, was first recorded in flower 31 days later than in 2008 and 9 days later than Watson's average, while Spurge-laurel (*Daphne laureola*) (Fig. 6) was 32 days later, and Dog's Mercury 47 days later, than the dates given by Watson. From June onwards, however, the FFDs resumed a broadly similar pattern to 2008 and 2009, with many summer-flowering species once again tending to come into flower earlier than the dates indicated by Watson, eg Woolly Thistle (*Cirsium eriophorum*) 4 days earlier, and Western Gorse (*Ulex gallii*) 14 days earlier. Taking all species combined, the FFDs in 2010 were an average of 2.7 days earlier than the dates given by Watson, but about 10 days later than those recorded in 2008 and 2009.

*Fig. 6 Spurge-laurel (*Daphne laureola*), Poundisford*

BETWEEN-YEAR VARIATION

The differences between Watson's average dates and the recorded FFDs in 2008, 2009 and 2010 are summarised in Table 1. There appears to be a fairly close relationship between FFDs and the weather, in particular temperature. Overall, the coldest of the three years, 2010, was also the year with, on average, the latest FFDs, as well as the greatest contrast between the FFDs of winter- and spring-flowering species (which were, on average, *later* than Watson's dates) and those of summer-flowering species (generally *earlier* than Watson's dates).

As already noted, 2009 and 2008 recorded very similar average FFDs, but there was a clear difference between the two years: species flowering in January, March and April (but not February, strangely) tended to be later in 2009 than in 2008, while those flowering from May onwards tended to be earlier. This difference, too, was probably related to temperature, although other factors – such as rainfall or sunshine – could also have had an influence.

The FFDs of winter- and spring-flowering species were much more variable than were summer-flowering species (see the 'range' column in Table 1), presumably reflecting a greater sensitivity to temperature differences between years.

COMPARISON OF 2008–10 AVERAGE FIRST FLOWERING DATES WITH THOSE RECORDED BY WATSON

For all species and years combined FFDs were an average of 9.3 days earlier than the dates given by Watson, but there was considerable variation between species (Fig. 7). There is a marked bias towards negative values in the graph: of the 339 species recorded, 251 species (74.0%) had earlier mean FFDs, and 76 (22.4%) later mean FFDs, than the average FFDs given by Watson.

A 10-YEAR COMPARISON WITH WATSON'S DATES FOR 14 SPECIES

A major drawback of the above analysis is that the modern data-set was gathered over just three years, whereas Watson's average dates were based on observations over ten or more years. However, through my recording for the UK Phenology Network I do have a decade's observations (2001–10) for 14 species, the results of which are

TABLE 1: DEVIATION (IN DAYS) BETWEEN MONTHLY AVERAGE FFDS IN 2008–10 AND THOSE CALCULATED FROM THE AVERAGE DATES GIVEN BY WATSON. THE 339 SPECIES ARE DIVIDED INTO MONTHLY GROUPS USING WATSON'S AVERAGE FFDS. NEGATIVE VALUES INDICATE EARLIER FLOWERING THAN WATSON'S DATES, POSITIVE VALUES LATER FLOWERING. THE RANGE (IN DAYS) BETWEEN EARLIEST AND LATEST AVERAGE FFDS FOR EACH MONTH IS GIVEN, AS IS THE NUMBER OF SPECIES (N) COMPRISING EACH MONTHLY GROUP

Month	**2008**	**2009**	**2010**	**Range**	**n**
Jan	-10.5	+0.1	+7.5	18.0	12
Feb	-17.9	-17.6	+1.7	19.6	7
Mar	-14.8	-8	+14.8	29.6	27
Apr	-21.4	-10.8	+3.3	24.7	55
May	-11.4	-16.5	-3.7	12.8	89
Jun	-9.6	-13.5	-7	6.5	93
Jul	-6.9	-13.7	-11.2	6.8	49
Aug	-8	-10.3	-11.3	3.3	7

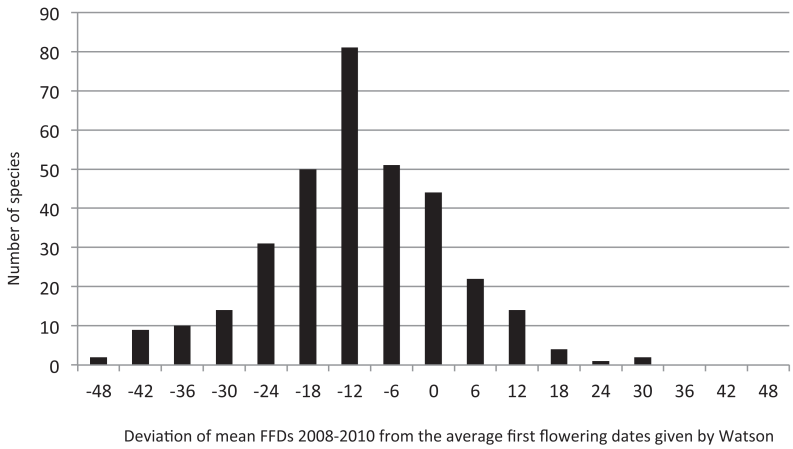

*Fig. 7 Frequency distribution of deviations in mean FFDs in 2008–2010 of 339 species from the average FFDs given by Watson. Categories are 6-day periods, the numbers shown representing the lower limit of each category. Negative values indicate earlier flowering than suggested by Watson's dates, positive values later flowering. Three species with extreme negative deviations are omitted (*Senecio squalidus *(-62 days),* Matricaria discoidea *(-67 days) and* Mercurialis annua *(-102 days))*

summarised in Fig. 8. The average FFD for these species varied by 31 days, between 9 March (2007) and 9 April (2001), with a mean of 27 March. As with the larger 2008–2010 data-set, there seemed to be a close relationship between FFDs and temperature: the three coldest years (2001, 2006 and 2010) were the years with the latest average FFDs – 9 April, 7 April and 8 April respectively – while the mildest year (2007) recorded the earliest average FFD (9 March). Interestingly, the average FFD for these 14 species calculated from Watson's dates is 9 April, remarkably close to the average FFDs for the

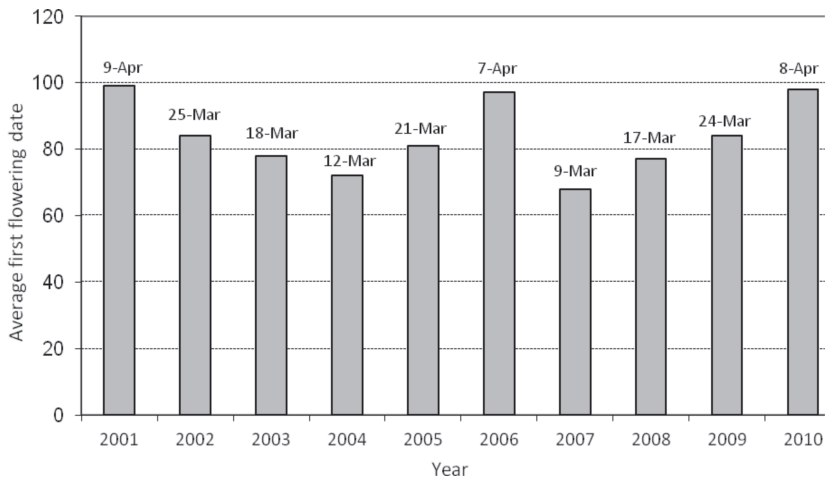

Fig. 8 Average FFDs for 14 species, 2001–2010 (1 January = day 1). Species included: Alliaria petiolata *(Garlic Mustard),* Alopecurus pratensis *(Meadow Foxtail),* Anemone nemorosa *(Wood Anemone),* Cardamine pratensis *(Cuckooflower),* Corylus avellana *(Hazel),* Crataegus monogyna *(Hawthorn),* Dactylis glomerata *(Cock's-foot),* Ficaria verna *(Lesser Celandine),* Galanthus nivalis *(Snowdrop),* Hyacinthoides non-scripta *(Bluebell),* Leucanthemum vulgare *(Oxeye Daisy),* Prunus spinosa *(Blackthorn),* Rosa canina *(Dog-rose),* Sambucus nigra *(Elder)*

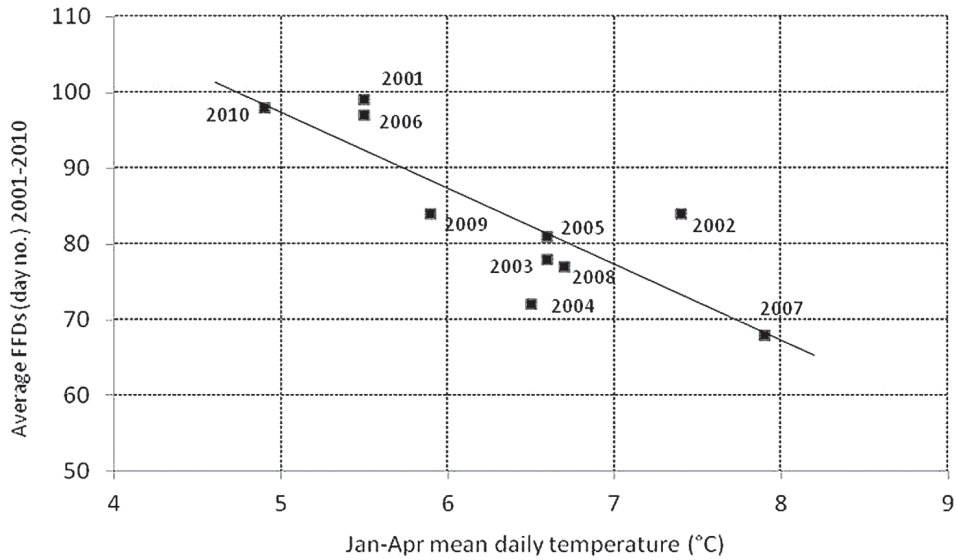

Fig. 9 Relationship between regional January–April mean daily temperature (°C) and average FFDs. Each year's average FFD is calculated from the individual FFDs of the 14 species listed in Fig. 8. Temperature values are derived from monthly averages for SW England and S Wales region, published at http://metoffice.gov.uk/climate/uk/ (© Crown copyright 2011, Met Office)

three coldest years of the period 2001–2010 and suggesting that, in terms of flowering dates, these years bear the closest resemblance to what Watson would have regarded as an 'average' year.

A plot of 2001–2010 average FFDs against regional January–April mean daily temperatures shows a clear relationship between FFDs and temperature (Fig. 9), with a 1°C increase in temperature advancing the average FFD by 10 days.[1] However, once again, the averages mask a considerable variation in responsiveness both within and between species: Ox-eye Daisy (*Leucanthemum vulgare*), for example, had FFDs between 20 March and 23 May (range: 64 days), while Cuckooflower (*Cardamine pratensis*) had FFDs between 30 March and 29 April (range: 30 days).

The difference between mean 2001–2010 FFDs and Watson's dates for the 14 species is shown in Figure 10. All but one species (Cuckooflower) had earlier mean FFDs than indicated by Watson's average first flowering dates. But is Cuckooflower really coming into flower later now than it did in Watson's time? My FFDs suggest this to be the case, but FFDs can be affected not only by the timing of first-flowering, but also by both *sampling frequency* (how often species are searched for) and *population size* or 'commonness' (which determines how easy it is to find them within a given area) (Miller-Rushing *et al.* 2008). The *recorded* FFD for a common species is likely to be closer to the *true* FFD than one for a rare species; essentially, one is unlikely to come across a rare species frequently enough to stand any chance of seeing it on the day it first comes into flower. Cuckooflower is not rare, but it is decidedly 'thin on the ground' in the Taunton area and occurs only sparsely (or not at all) on my regularly visited sites; thus, the 'late' FFDs for this species could have been partly or wholly due to a lack of visits to sites where Cuckooflower was common.

Taking this argument one step further, if Cuckooflower had been common in Watson's day but had since declined, the 'late' FFDs could, in part, simply be a reflection of its increased scarcity. With other species, of course, the converse may be true: a species scarce in Watson's time (or at least rarely found on the sites he visited), but which has since become more abundant, might be expected to have an earlier average FFD than the one recorded by Watson even supposing its *true* FFD was unchanged. However, it is likely that all of the 14 species analysed here would have been at least as common in Watson's time as they are today.

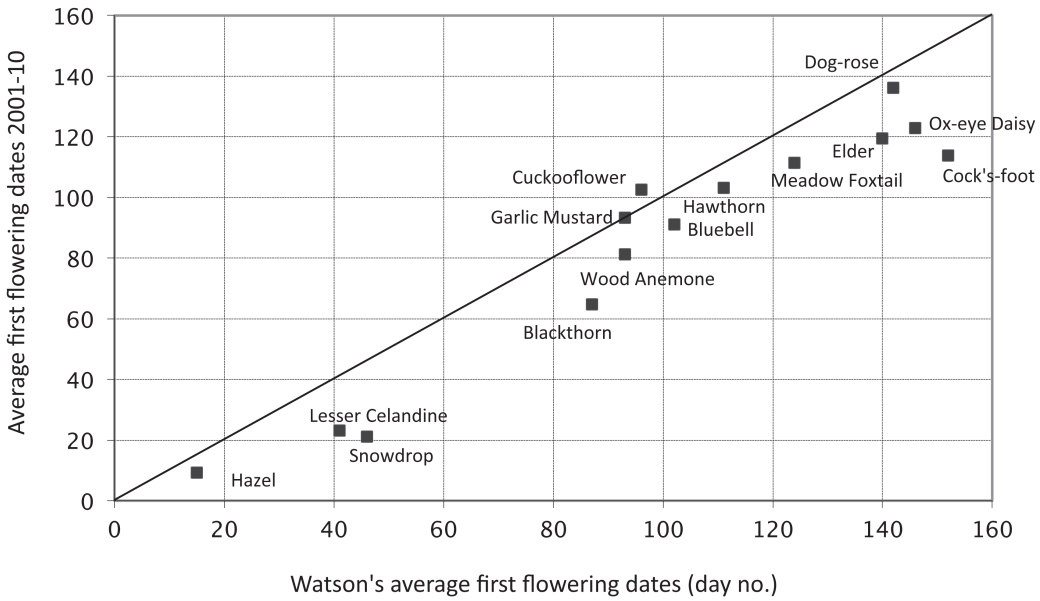

Fig. 10. Average FFDs 2001–2010 for 14 species, in comparison with the dates given by Watson. The 14 species are those listed in Fig. 8. Dates are shown as day no. (1 January = day 1). The diagonal line marks the line along which the data-points would lie if the 2001–2010 average FFDs were identical to those given by Watson; above the line the FFD is later than Watson's date, below the line earlier

DISCUSSION

The 'cuckooflower conundrum' highlights an important issue needing to be borne in mind when comparing FFDs today with those recorded in the past. Certainly, several species showing especially big advances in their mean FFDs are non-native species that are almost certainly more abundant now than in Watson's day, eg Annual Mercury (*Mercurialis annua*),[2] 102 days earlier than Watson's average date, Pineapple-weed (*Matricaria discoidea*),[3] 67 days earlier, Oxford Ragwort (*Senecio squalidus*),[4] 62 days earlier, and Keeled-fruited Cornsalad (*Valerianella carinata*),[5] 51 days earlier. On the other hand, the relatively late mean FFDs of a few native species could be partly a reflection of their increasing scarcity within the Taunton area, eg Hoary Ragwort (*Senecio erucifolius*),[6] 35 days later than Watson's average date, Wild Parsnip (*Pastinaca sativa*),[7] 30 days later, and Early-purple Orchid (*Orchis mascula*),[8] 13 days later.

There are other issues, too, not least the fact that the historic records were made by a different observer, probably visiting different sites and spending a different amount of time in the field; indeed, one begins to wonder whether any two such data-sets can ever be truly comparable. In addition, Watson's average first flowering dates are just that – averages – and we have no idea of the range of dates from which they were calculated, nor do we know for sure in which years his observations were made.

Nevertheless, in the present study of 339 species the average FFD (for all species combined) during the period 2008–2010 was 9.3 days earlier than indicated by Watson's average dates, with between-year variation in FFDs closely related to winter/spring temperatures and milder springs leading to markedly earlier onset of flowering. An analysis of 14 species for the period 2001–2010 suggested that a 1°C increase in spring mean daily temperatures caused average FFDs to advance by ten days. This is a bigger change than the 4.5–7 days indicated by a number of other local and national studies (Fitter and Fitter 2002;Sparks and Collinson 2006; Amano *et al.* 2010).

On the whole, these results tend to support the prevailing view that a warming climate – or, at any rate, the recent run of mild winters and springs – may be having a significant impact on the FFDs of

many species, particularly those flowering in winter or early spring. The findings are also in broad agreement with the results of the UK Phenology Network (eg Collinson and Sparks, 2003; 2004; 2005), which show for 23 species that mean FFDs across the UK in the last decade have been significantly earlier than in preceding decades. It is widely accepted that earlier onset of flowering in the spring is a phenological signal of rising temperatures, and FFDs therefore have considerable value as biological indicators of climate change (Sparks *et al.* 2000, Menzel *et al.* 2006; Hopkins 2007; Amano *et al.* 2010).

My own observations, however, offer little more than a partial 'snapshot' in comparison with Watson's in the first half of the 20th century, not to mention Richard Fitter's extraordinary 47-year record of FFDs in Oxfordshire for the period 1954–2000 (Fitter *et al*. 1995; Fitter and Fitter 2002). My findings should, for now, be treated with the suspicion they deserve – the run of data needs to be much longer before conclusions can be drawn with any degree of certainty. However, it is hard not to conclude that the FFDs of most species within the Taunton area were markedly earlier in the first decade of the 21st century than they were when Watson was keeping his wild flower diary.

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ENDNOTES

1 This should be taken as no more than a provisional estimate, particularly as the temperature figures being used are regional means rather than values calculated from weather-station records made within the study area.

2 A very local species in Watson's day, not known from the Taunton district by Murray (1896), but said to be '...gradually extending its area in the county'; reported by Green *et al.* (1997) to be 'frequent' and 'more widespread than formerly'.

3 Not recorded in Somerset until about 1903; Marshall (1914) reported it to have been '... recently introduced, and as yet very local, but likely to become common ... this American invader is almost sure to spread rapidly'. Green *et al.* (1997) report that it is now 'very common throughout the county'.

4 '...introduced on walls in Taunton by the Rev. W. Tuckwell' (Murray 1896); Marshall (1914) gives no further records, so likely to still have been rare and local in Watson's day; now described by Green *et al.* (1997) as 'frequent' and '...especially plentiful on verges of the M5 motorway'.

5 'Very rare', with no records from the Taunton district (Murray 1896), whereas Green *et al.* (1997) noted it as 'frequent' and '... an increasing species which has extended its range in recent years, especially near habitation.'

6 'Rather common ... in all districts' (Murray 1896), but recorded by Green *et al.* (1997) as being '... only common on clay and calcareous soils'.

7 'Very common throughout the greater part of the county' (Murray 1896), but a century later reported as 'scarce' (Green *et al.* 1997).

8 'Pastures, woods and bushy places ... very common ... noted in all Districts' (Murray 1896), but a century later only 'frequent' (Green *et al.* 1997), and likely to have been declining in pastures as a result of widespread grassland 'improvement'.

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