

Dandelion (*Taraxacum officinale*) has successfully adapted to Grow in Suburban Environments

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Research Article

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Abstract

Dandelion (*Taraxacum officinale* (L.) Weber ex F.H. Wigg) is a perennial herbaceous plant that, although not native to its current habitats, has become invasive, posing economic challenges by outcompeting indigenous flora and agricultural crops. The precise factors enabling its dominance remains unclear. We hypothesized that morphological adaptations may play a role in contributing significantly to the dandelion's invasive success. This study focused on two main drivers: 1. Phenotypic changes in the seed head stalk, and 2. Phenotypic plasticity facilitating adaptation to diverse environments. While dandelion seeds are efficiently dispersed by wind, the precise mechanisms are not fully understood. Research reveals that during seed head formation, the seed head stalk elongates and grows vertically, potentially aiding in seed dispersion. Morphological variations across habitats, including natural environments, suburban lawns, and playgrounds, contribute to dandelion's success. In suburban lawns, dandelions exhibit adaptations such as small leaves, short flower stalks angled at 30 degrees or lower, growing parallel to the lawn grass to evade mowing, while in playgrounds, they develop shorter structures to withstand trampling pressure. Dandelions thriving in the undisturbed fringes of lawns and playgrounds have large flower stalk and leaves revealing the true extent of their growth potential when allowed to flourish in their natural state. These findings highlight dandelion's adaptability and resilience, attributed to phenotypic plasticity, which enables them to thrive across diverse ecological landscapes.

Introduction

Dandelion (*Taraxacum officinale* (L.) Weber ex F.H. Wigg) is a perennial herbaceous plant belonging to the Asteraceae family and is distributed in North America, Europe, and Asia (Stewart-Wade et al., 2002; Di Napoli and Zucchetti, 2021). The genus *Taraxacum* was initially described by Wiggers (1746–1811), and the current classification was established by Georg Heinrich Weber in 1780 (Britton and Brown, 1970). In North America, dandelions are non-native and invasive species.

Typically flowering in early spring, dandelions are commonly regarded as weeds in various settings, including gardens, lawns, agricultural lands, and wastelands. Despite their weed status, dandelions offer value beyond mere nuisance. The edible leaves find use in diverse culinary preparations, and the plant is recognized for its medicinal properties, attributed to phytochemicals present in leaves, flowers, and roots (Di Napoli and Zucchetti, 2021).

As non-native and invasive plants, dandelions can exert a considerable impact on food and forage crop production. They compete with desirable plants for essential resources such as nutrients, water, and sunlight, resulting in reduced yields in agricultural fields (McPeck and Wang, 2007). Additionally, their presence can diminish the visual appeal of lawns and gardens. Being ruderal species, dandelions are quick to colonize disturbed lands (Pisman et al., 2020), although the precise mechanisms enabling their success as non-native invasive weeds remain unclear.

Dandelions employ a mixed reproductive strategy, combining sexual and apomictic reproduction. Apomixis, a form of asexual reproduction, enables the production of clonal seeds without fertilization, resulting in genetically identical offspring. Triploid apomictic dandelions, particularly efficient in rapidly establishing new individuals, do so without the need for pollination. This adaptability aids them in coping with changing environmental conditions and successfully colonizing new areas (Mazumder and Kesseli, 2021). Dandelion seeds are dispersed by the wind, and the mechanisms used by dandelions for widespread seed dissemination are not fully understood.

Urbanization facilitates environmental and evolutionary change (Santangelo et al. 2022). Urban environments subject plants to unique selection pressures due to changes in microclimatic conditions, habitat fragmentation, and altered interactions with different plant species (Pisman et al. 2020). Urbanization is known to reduce plant diversity richness and can also impact plant growth and physiology (Hou et al. 2023; Gregg et al. 2003). To thrive in urban and suburban conditions, plants must adapt to the new environment. The study of plant adaptation to urban settings is a complex field, requiring a comprehensive understanding of interactions between plant species, environmental conditions, and human activities. Phenotypic plasticity, the ability of plants to modify physical characteristics in response to environmental changes, is a key factor contributing to the success of certain plant species in urban settings (Molina-Montenegro et al. 2018b). This adaptability plays a crucial role in shaping species' responses to environmental shifts, influencing their expansion or decline (Manfredini et al. 2019).

Dandelions exhibit success as weeds due to their resilience against mowing, grazing, and competition with grasses, persisting even between lawn grass (Baker, 1974). Their ability to regrow from the roots, even after damage from mowing or grazing, contributes to their survival. Found in various habitats such as nature reserves, urban areas, lawns, playgrounds, pavement cracks, and brownfield plots, how dandelions adapt to diverse environments remains unclear. Leveraging phenotypic plasticity, dandelions have successfully adapted to urban and suburban settings, becoming ubiquitous across the Northern hemisphere. While their widespread presence in urban and suburban areas is well-documented, the specific mechanisms of adaptation remain a scientific puzzle. This paper aims to address this knowledge gap by exploring the morphological adaptations that enable dandelions to thrive in the playgrounds and suburban environments of Philadelphia, exemplifying the challenges posed by urban and suburban landscapes.

Materials And Methods

The dandelion (*Taraxacum officinale* (L.) Weber ex F.H. Wigg) flower length, flower stalk angle, flower diameter, seed head stalk length, seed stalk angle, and leaf length were measured from plants growing in lawns and playground of the suburban area or wild (nature reserves). Suburban area are regions outside the city limits. The regions have few people compared to cities. They have also less habitat fragmentation compared to urban areas. Wild area (nature reserves) are protected areas that does not have any human activities. The length and diameter were measured using a ruler and the angle measured using a protractor. The angles were measured in relation to the ground level. The dandelions were analyzed growing in plot size of 20m X 20m at various sites. The data on 100 plants were taken from each plot. The dandelion plants were analyzed from the following areas of Pennsylvania, (suburb of Philadelphia), USA: Ridley Creek State Park (Media, Delaware County) (wild area), Exterior of Glenwood Memorial Gardens (Broomall, Delaware County) (wild area), Broomall playground (Delaware County), Havertown (Delaware County) (wild area), Wynnewood (Montgomery County) (wild area), Cambridge Road (Broomall) (lawn), Okehocking Preserve (Chester County) (lawn), Haverford Reserve (Delaware County) (lawn and playground), Bryn Mawr (Coopertown playground)

(Delaware County) and Willow Grove (Montgomery County) (lawn). The selected plots are in adjacent counties and within 25-kilometer radius; they have the same weather and temperature patterns. The soil in the area is loamy (websoilsurvey.nrcs.usda.gov). The weather in the counties is the same throughout the year; the summers are warm, the winters are freezing and snowy, and it is partly cloudy year-round. Over the course of the year, the temperature varies from -6°C to 35°C. The data of plants were taken during early spring of 2022, 2023 and 2024. The lawns were mowed twice every month. They were fertilized at least once a year before spring season with turf grass fertilizer (NPK: 10-10-10). Dandelions are seed dispersed and germinate if they have favorable conditions; they are uniformly distributed. Very few people walk on the lawns other than during mowing. Spectators stand around the edge of the playground, while children use the playground.

Statistics. When indicated, one-way ANOVA was used for comparison of multiple groups or unpaired two-tailed t test was used for comparison of two groups. All results are expressed as Mean $\pm$ SD. $P < 0.05$ was considered significant. Statistical analysis was performed using the GraphPad Prism software (GraphPad Software, USA).

Results

The environment influences the length of flower stalk of dandelion

Dandelions bloom in early spring. They are observed in the lawns of residential or commercial property, nature reserves, and wastelands. We observed that in nature reserves or wastelands/"Wild Area", dandelions are taller with longer flower stalks and leaves. However, the dandelion flower stalks in the lawns of the suburbs are shorter in length than found in the nature reserves or wastelands.

We measured the length of the flower stalks of dandelions in the wild (nature reserves) or in the lawn of the suburbs. There was significant variation in the length of flower stalks in the nature reserves ($P < 0.0001$). On an average, the flower stalk in the nature reserves had a length of 15-20 cm.

The lawn grass in the suburbs is generally maintained at a height of around 5 to 6 cm. A typical suburban lawn is mowed twice a month. Dandelions grow in tiny spaces between the lawn grasses. There was also significant difference in the flower stalk in the lawns of different areas ($P < 0.0001$). On an average, the flower stalk of dandelions on the lawns had a length of 5 to 8 cm.

We also measured the flower stalk of dandelions growing on a playground with heavy foot traffic. The length of the flower stalks of dandelions growing in the playground were significantly shorter than those growing in lawns ($P < 0.0001$) (**Fig. 1A, S1A**).

The length of seed head stalk of dandelion is larger than its flower stalk

The flowers of dandelions turn to seeds in 10-12 days. The seeds of dandelions are wind dispersed. The seed head stalks of dandelions are larger than the flower stalks.

We measured the seed head stalks of the dandelions in the wild (nature reserves) as well as the in the suburban lawns. The seed head stalks of dandelions of the wild (nature reserves) were significantly taller compared to the dandelions from the lawns ($P < 0.0001$). The seed head stalks of the dandelions from the playground were significantly shorter than the seed head stalks from the suburban lawns ($P < 0.0001$) (**Fig. 1B, S1B**).

We also compared the length of the flower stalks with the length of the seed head stalks in the wild (nature reserves) as well as in the lawns of the suburbs. The length of the seed head stalks of dandelions were significantly longer than that of the flower stalks ($P < 0.0001$) (**Fig. 2, S2**).

There is variation in the angle of flower stalk growing in the suburban lawns and wild areas (nature reserves)

We measured the angle of flower stalks, and the seed head stalks in the wild (nature reserves) as well as in the suburban lawns. The flower stalks of the dandelions in the wild (nature reserves) had larger angles. On an average they measured around 70° . However, the angles of the dandelion flower stalks in the lawns were lesser, with median angle ranging from 15 to 30° (**Fig. 3A**).

The dandelion seed head stalks of the wild (nature reserves) or in the lawns were always vertical, at 90° . There was a significant difference in the angles of the flower stalks and seed head stalks ($P < 0.0001$) (**Fig. 3B, S3**).

Flower diameter of dandelion is influenced by the location

The dandelion flowers in the nature reserves were significantly larger compared to the flowers in the suburban lawn ($P < 0.0001$). The dandelion flower in the wild (nature reserves) had an average diameter of 4 cm, whereas the flowers in the suburban lawns had a diameter of 3.5 cm. The flower diameter in the playground was significantly smaller than those found in the nature reserves and the suburban lawns ($P < 0.0001$) (**Fig. 4, S4**).

Dandelion in wild areas (nature reserves) have larger leaves

We also measured the leaf length of the dandelion plants in the wild (nature reserves) and in the suburban lawns. The leaves of the dandelions in the nature reserves were significantly longer compared to the leaves of the dandelions in the suburban lawns ($P < 0.0001$). The leaves of the dandelions in the playground were the shortest ($P < 0.0001$) (**Fig. 5**). Overall, the leaves, floral stalks and seed stalks of dandelion in playground were shorter probably in response to trampling.

Dandelions growing in the periphery of lawns and playgrounds have longer flower stalk and leaves

We hypothesized that dandelions growing in the periphery of lawns and playground will closely resemble the plants growing in the nature reserves. To test the hypothesis, we analyzed the dandelion plants growing in the periphery of the lawns and playgrounds. There were only few plants growing in the periphery of lawns and playgrounds. We measured the angle, length of flower stalk and length of leaves in the dandelion plants growing in the periphery. The dandelion plants growing in the periphery exhibited significantly large flower stalk and leaves compared to the plants growing in the lawns and playground ($P < 0.0001$). The angle of the flower stalk growing in the periphery was similar to the dandelions growing in the nature reserves ($P < 0.0001$) (**Fig. 6, S5**). The collected data unequivocally support our initial hypothesis, revealing that dandelions thriving in both lawns and playgrounds demonstrate a remarkable degree of phenotypic plasticity. This flexibility in their physical characteristics underscores their ability to adapt to diverse environmental conditions. Moreover, the observed morphological variations in these plants can be attributed to their evolutionary strategy for successful survival.

The seed head of dandelions emerge after mowing

In the lawns, dandelions exhibit flower stalks with a distinctive low angle, growing almost parallel to the ground. We hypothesized that dandelion plants that resist lawn mowing would induce vertical seed head stalk several days after lawn mowing. Following lawn mowing, we conducted an observation five days later and noted that the seed head stalks had sprouted upwards, exhibiting vertical growth and growing taller than the lawn grass to aid seed dispersal (**Fig. S6**). Our observation confirms our hypothesis that the lower angle of flower stalks in lawns is an adaptation of dandelions, contributing to their successful survival.

By elucidating the intricate relationship between environmental factors and morphological traits in dandelions, our findings shed light on the adaptive strategies employed by these ubiquitous plants. Understanding the mechanisms underlying their phenotypic plasticity not only enhances our appreciation of their ecological resilience but also provides valuable insights into broader concepts of adaptation and survival in the natural world.

Discussion

Declining agricultural jobs in rural areas, alongside better opportunities in cities, have driven urbanization since the mid-twentieth century. Currently, 55% of the population resides in urban areas, a figure projected to rise to approximately 70% by 2050 (source: UN World Urbanization Prospects). Urbanization contributes to the loss of native plant species, reduced species diversity, habitat fragmentation and isolation, altered microclimates, rising temperatures, and increased pollution across various levels. Anthropogenic activities further impact plant growth (de Barros Ruas et al., 2022). While plants have adapted morphologically and physiologically to urban environments, research on their coping mechanisms remains limited. Urbanization's impact on adaptive evolution has been understudied.

Plants, having evolved over millions of years to adapt to their environments, face significant challenges from changing conditions, climate shifts, and anthropogenic activities. Phenotypic plasticity emerges as a crucial mechanism enabling rapid responses to environmental changes. It allows a single genotype to produce different phenotypes based on encountered environmental conditions (Bradshaw, 1965). Phenotypic plasticity influences morphological, physiological, and behavioral aspects of an organism's phenotype (Sommer, 2020). Some plastic responses are heritable, contributing to adaptation over evolutionary timescales. This adaptability through plasticity is a remarkable feature of plants, enabling them to colonize diverse habitats and effectively respond to environmental challenges.

Dandelions, non-native to the Americas, are the earliest spring flowers with uses in food and medicine. Considered invasive weeds, they compete with agriculture crops, reducing food production (McPeck and Wang, 2007). In suburban settings, dandelions impact the aesthetics of lawns and gardens (Molina-Montenegro et al., 2018a). Plants have evolved various adaptations to evade herbivory. Fujita and Koda (2015) examined grazing patterns by livestock on the capitula and rosette leaves of two *Taraxacum* species in Mongolia. They found that in Mongolia, naturally short capitula at the green bud and brown corolla

stages, as well as rosette leaves of *T. collinum*, were left untouched by grazing. However, artificially elevated capitula and rosette leaves of *T. collinum*, as well as the naturally tall capitula and leaves of *T. ceratophorum*, were grazed. The study revealed that shorter capitulum and leaf heights were effective in deterring livestock grazing in Mongolia.

Dandelions exhibit superior physiological performance, growth, and survival under unfavorable abiotic conditions compared to native plant species (Molina-Montenegro et al., 2012). In Japan, the invasive *T. officinale* replaces the native *T. japonicum*, attracting more pollinator visits possibly due to its increased nectar production. This results in reduced seed set for *T. japonicum* (Kandori et al., 2009). Struik (1967) observed dandelion behavior in various grassland conditions in New Zealand, noting that dandelions in uncut grasslands had greater weight in flowers, leaves, and roots compared to those in stressed environments. He also found that dandelion buds were closer to the ground in mowed and grazed grasslands. Our research explores the morphological adaptations of dandelions thriving in suburban environments and playgrounds, particularly under conditions of heightened stress. We posited that as stress levels escalate, these resilient plants would demonstrate corresponding adaptations to better cope with their environment. Through our investigation, we aim to unravel the mechanisms by which dandelions adjust their morphology in response to various stressors encountered in urban settings.

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Dandelions were introduced in the Americas from Europe by the early European settlers (Iaffaldano et al. 2017). They have since spread all over the continent. The plants are highly successful in adapting to different conditions and environments. In this paper we demonstrate that the dandelion uses different strategies to adapt to the suburban conditions.

Our study areas were confined to the counties west of Philadelphia, Pennsylvania. Urbanization has reduced areas for the habitat of dandelions. The taller dandelions (“wild”) are seen in nature reserves, wastelands, or peripheral areas of the suburbs (“wild areas”) with few human activities. The dandelions of the nature reserves are taller with larger flowers, flower stalks, and leaves. The mean angle of the dandelion’s flower stalks of the wild areas was calculated to be around 70°, and the angle of the seed head stalks was calculated to be 90° (**Fig. 7**).

It has been demonstrated that the peculiar structure of the dandelion seed makes them remain airborne for longer periods, increasing the distance it can travel. Studies have shown that under optimal wind conditions, dandelion seeds can travel distances of up to 150 kilometers (Cummins et al. 2018). This efficient wind dispersal mechanism allows dandelions to colonize new areas and spread their seeds over a wide range, contributing to their success as a weed and their ability to populate various environments. This study demonstrates a direct correlation between seed stalk size and flower stalk length. Specifically, a lengthy flower stalk corresponds to an extended seed stalk, while a shorter flower stalk is associated with a shorter seed stalk. The length of the seed stalk does not influence its angle; overall, the seed stalk had an angle of 90°. The 90° angle of the seed stalks facilitates the wide dispersal of dandelion seeds.

In the suburbs, the dandelions occupy lawns and gardens. They grow in spaces between the lawn grasses. The suburban dandelions have smaller leaves, short flower stalks that are at an angle of 30° or lesser, smaller flowers that grows parallel to the lawn grass and early blooming; features that can escape mowing. However, the seed stalks were significantly longer than the flower stalks to aid in wind dispersal (**Fig. 8**).

In the suburbs, the dandelion blooms, set seeds and disperses the seeds usually before the first lawn mowing. The lawns are mowed regularly when the grass grows during mid-spring. The seed head stalks elongate before the mowing, or after the first mowing. The seed head stalks of the dandelions in the wild, or in the lawn is 90°. The seeds of the dandelions are dispersed by wind. Wind can transport the seeds to long distances (Cummins et al. 2018). A taller seed head stalk can influence the transport of the seeds. Rarely have we observed short seed head stalks in dandelions. Seeds from the short seed head stalks fall in the vicinity of the dandelion plants thereby impacting its germination (**Fig. 9**). Hence, we speculate that longer seed head stalks are an adaptation favoring transport of the seeds to long distances and its survival.

Though the dandelions in the lawns and playgrounds of the suburbs are shorter, those plants growing at the periphery of the lawns, with minimum human activities are comparable to the plants as seen in the nature reserves with longer flower stalks and larger leaves. Thus, a favorable environment elicits larger vegetative growth of the plants demonstrating phenotypic plasticity.

Dandelion is a prime example of how certain plant species can thrive in human-altered habitats due to their ability to exhibit phenotypic plasticity. This plasticity allows them to adjust their traits and behaviors to better exploit the opportunities and challenges presented by these environments, ultimately contributing to their success as invasive species. In the study we demonstrated changes in morphology of the dandelions in the suburban lawns in response to mowing. The dandelions with their large size and floral stalk can not withstand mowing conditions. Hence, they have adapted to the surroundings by growing parallel to the lawn; with smaller leaves and floral stalk. To investigate whether heightened stress could further influence their morphology, we examined their adaptation in playgrounds. In these areas, dandelions exhibited the smallest vegetative features compared to other locations, showcasing adaptations that could withstand the trampling by children. Dandelions on the margin of lawns had large leaves and floral stalks with wider angles demonstrating that absence of stress could change their phenotype. Our study showed that as stress factors decrease and favorable conditions prevail, dandelions exhibit a heightened capacity for morphological adaptation, leading to larger and more robust vegetative structures. This study provided evidence of the morphological plasticity of dandelions in response to environmental stressors. The adaptation of the habit of dandelion in response to human (anthropogenic) activities in the suburbs is an example of *anthroprosarmogi* (human induced adaption; *Greek; Anthros*, human; *Prosarmogi*, adaption).

Dandelions exhibit remarkable plasticity in their morphology and behavior, allowing them to thrive in human-altered habitats. Their small leaves, short floral stalks angled at 30 degrees or less, early blooming, and efficient seed dispersal mechanisms are advantageous for survival, particularly in environments managed by humans. The

elongation of their seed head stalks facilitates wind dispersal, enabling seeds to travel long distances. These combined traits make dandelions well-adapted to human-modified landscapes such as lawns and gardens. They can withstand frequent disturbances, competition from other plants, and habitat changes resulting from human activities. Consequently, dandelions persist and reproduce successfully in urban and suburban settings, establishing themselves as invasive species. As a result, dandelions are an ideal subject for researchers and ecologists investigating invasive plant species. Their adaptable traits and behaviors offer valuable insights into the mechanisms driving invasive success in human-altered environments.

Declarations

Author contributions

Thomas A, TA and ST conceived, designed, collected and analyzed data. ST wrote the paper and prepared figures. Thomas A edited the manuscript. All authors reviewed the manuscript.

Preprint

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Conflict of interest

The authors declare no conflict of interest.

Data Accessibility

The metadata of the graphs will be provided upon request.

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Figures

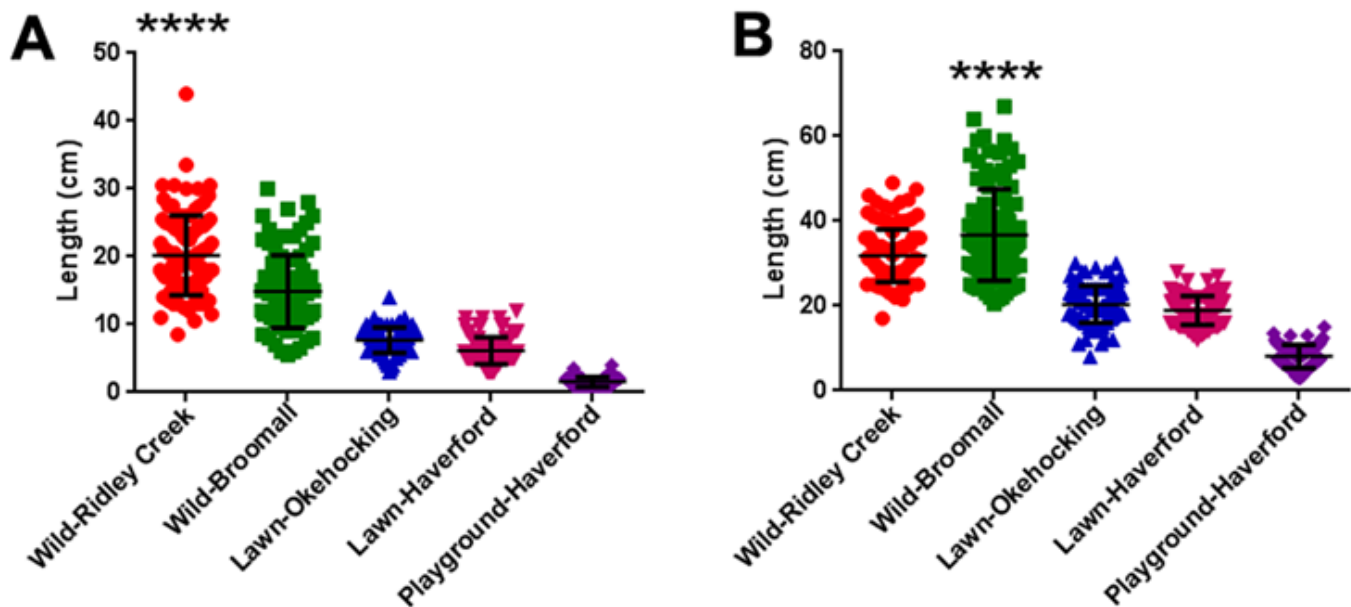


Figure 1

The environment influences the length of flower stalks and seed head stalks. (A) The flower stalks of the dandelions in the pristine nature reserves or wastelands ("wild") are significantly longer than those observed in the lawn of the suburbs. Though Okehocking is also a nature reserve, the grass is cut regularly for the visitors and that impacts the floral stalk length. The flower stalk length of dandelions in the playground was significantly smaller due to heavy foot traffic. (B) The seed head stalks of the dandelions in the wild areas (nature reserves) are significantly longer than those observed in the lawns. The seed head stalks of the dandelions in the playground were significantly smaller compared to the other environments (**** $P < 0.0001$, as determined by one-way ANOVA). Each dot represents the value of a single plant in the individual value plot. Values are compared between plots. All results are expressed as Mean $\pm$ SD; (n = 100 samples per group).

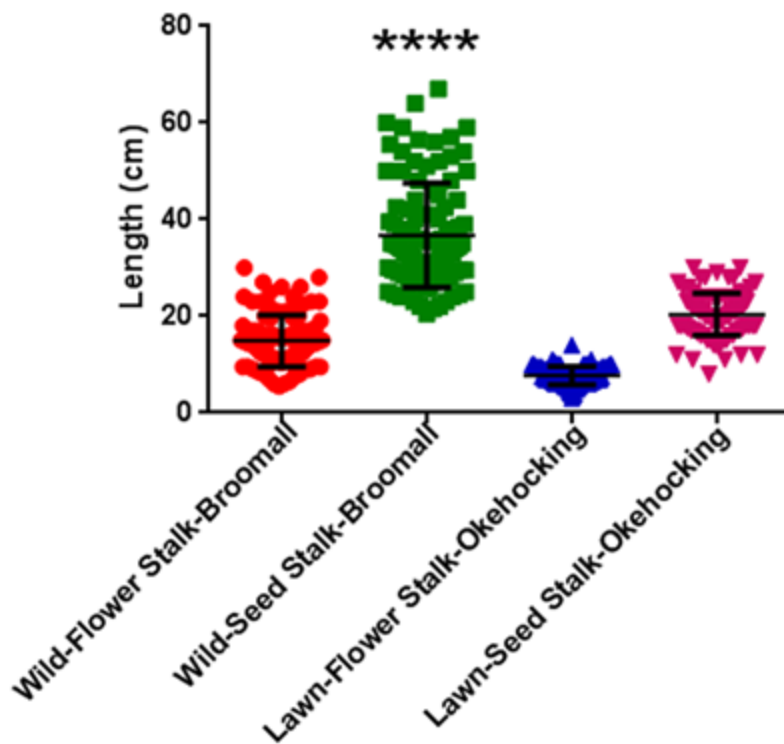


Figure 2

The extended stalks of dandelion seed heads were associated with long flower stalks. The dandelions growing in the wild areas (nature reserves) had longer seed head stalks than those growing in the suburban lawns (**** $P < 0.0001$, as determined by one-way ANOVA). Each dot represents the value of a single plant in the individual value plot. Values are compared between plots. All results are expressed as Mean $\pm$ SD; (n = 100 samples per group).

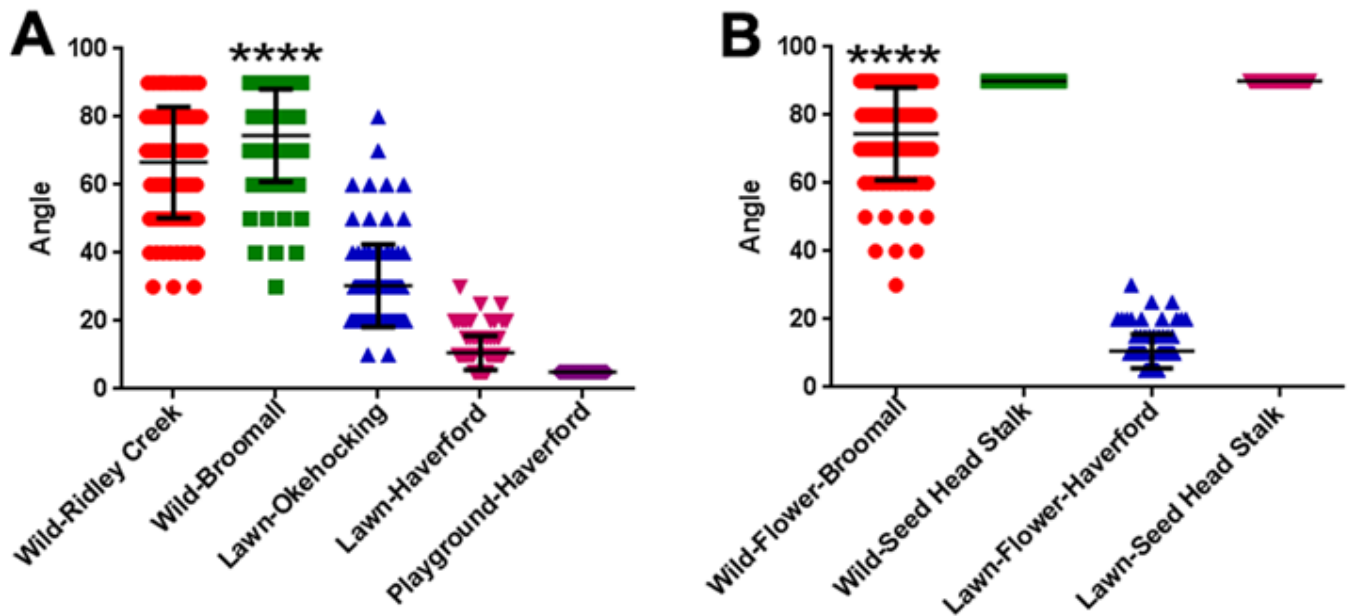


Figure 3

The flower stalks of dandelions in the suburban lawns had smaller angles compared to the dandelions in the wild areas (nature reserves). (A) The flower stalks of the dandelions in the suburban lawns had significantly smaller angles and they grow parallel to the lawn grass compared to the flower stalks of dandelions growing in the wild (nature reserves). (B) The seed head stalks of the dandelions in the wild (nature reserves) and the suburban lawns had an angle of 90° (****P<0.0001, as determined by one-way ANOVA). Each dot represents the value of a single plant in the individual value plot. Values are compared between plots. All results are expressed as Mean ± SD; (n = 100 samples per group).

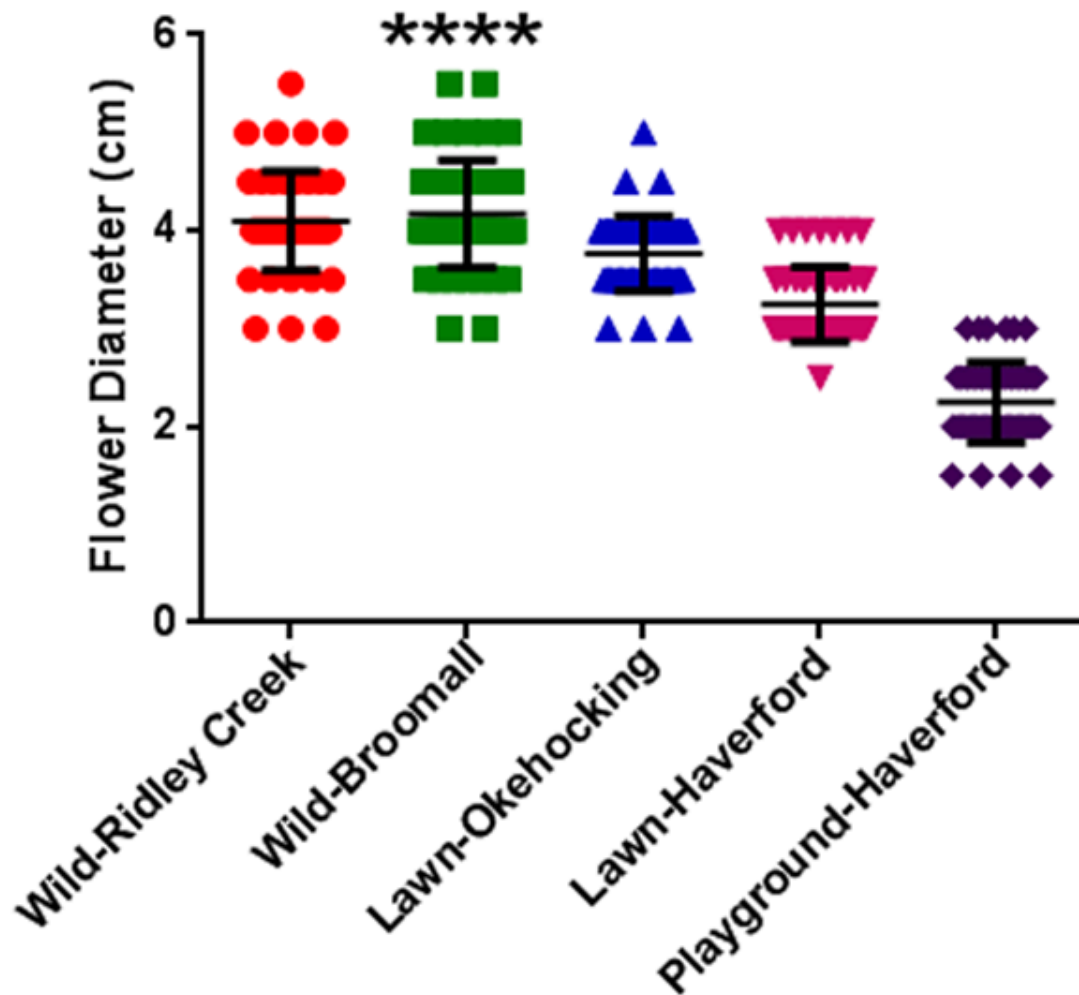


Figure 4

The flower diameters of dandelions in the suburban lawns are significantly smaller compared to the dandelions in the wild areas (nature reserves). The flower diameters of dandelions are significantly smaller in the suburban lawns and playground compared to the diameters of dandelion flowers in the wild (nature reserves) (**** $P < 0.0001$, as determined by one-way ANOVA). Each dot represents the value of a single plant in the individual value plot. Values are compared between plots. All results are expressed as Mean $\pm$ SD; (n = 100 samples per group).

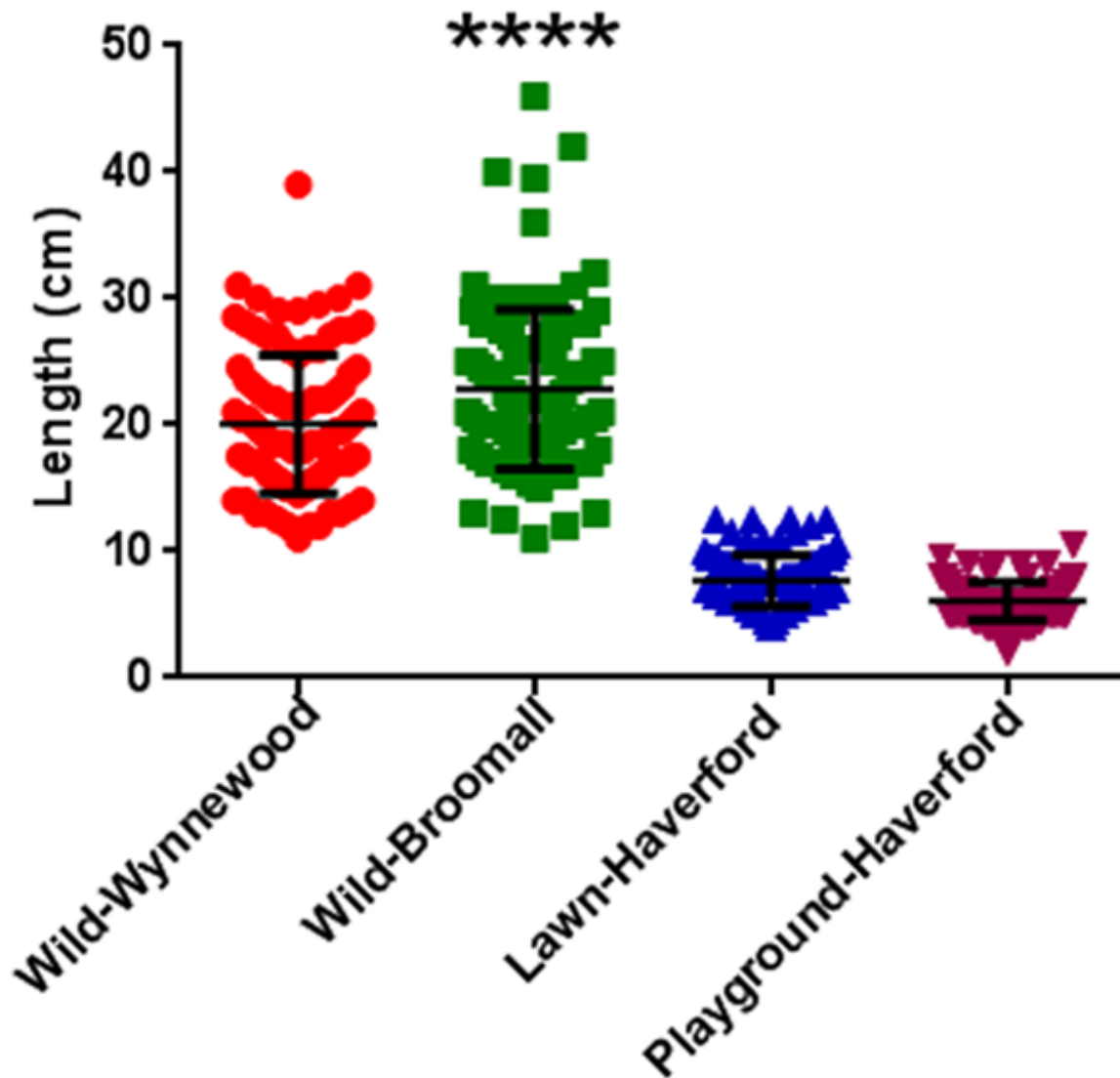


Figure 5

The leaves of the dandelions in the suburban lawns are significantly smaller compared to the dandelions in the wild areas. The leaves of dandelions are significantly smaller in the suburban lawns and in the playground compared to the dandelion leaves in wild areas (nature reserves) (**** $P < 0.0001$, as determined by one-way ANOVA). Each dot represents the value of a single plant in the individual value plot. Values are compared between plots. All results are expressed as Mean $\pm$ SD; ($n = 100$ samples per group).

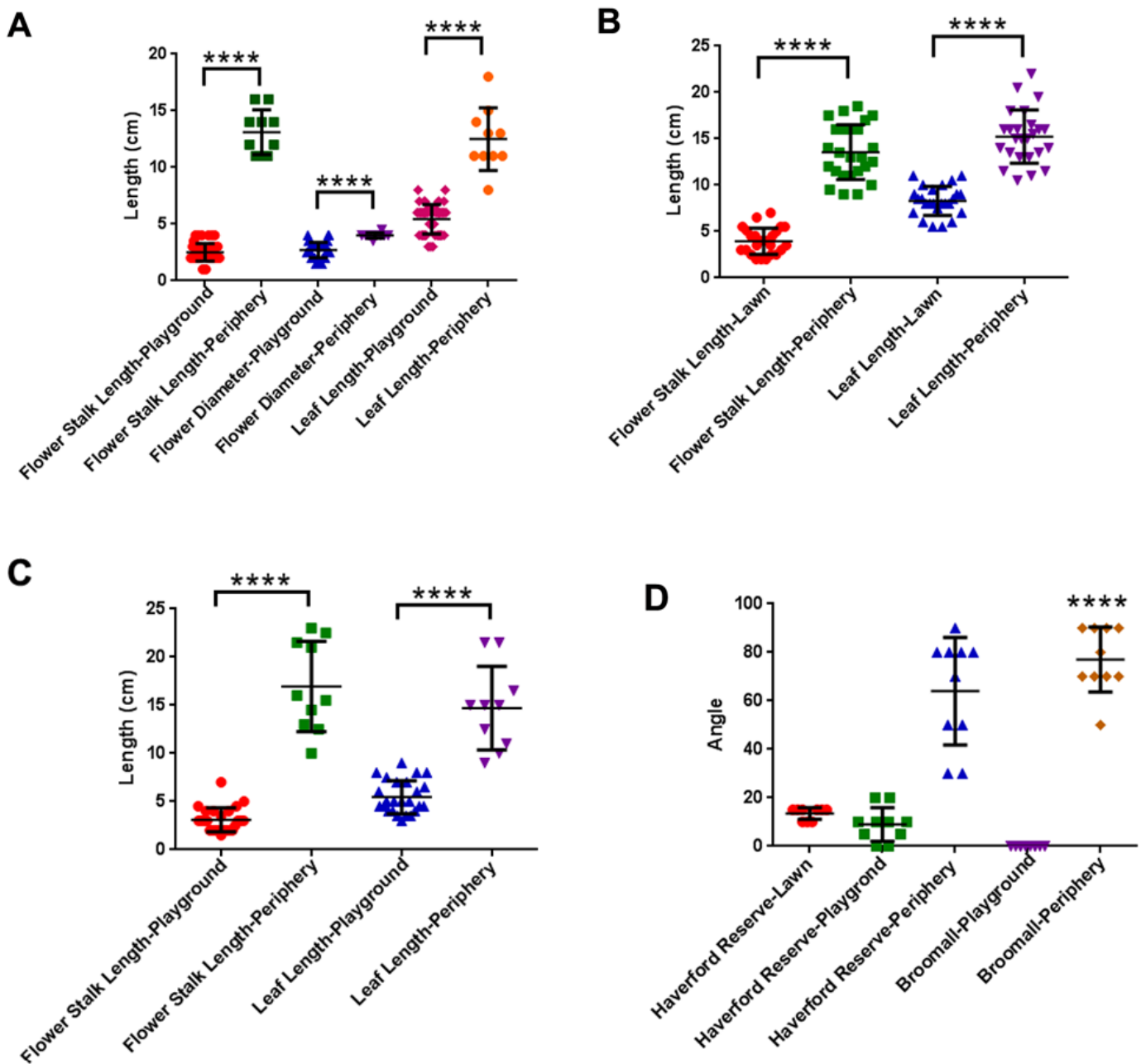


Figure 6

The dandelions bordering lawns and playgrounds stand taller. (A) The flower stalk length, flower diameter and leaf length of dandelions on the periphery of the playground in Broomall, PA is greater than in the playground (**** $P < 0.0001$, as determined by Students t-test). (B). The flower stalk length, and leaf length of dandelions on the periphery of the lawn in Broomall, PA is greater than in the lawn (**** $P < 0.0001$, as determined by Students t-test). (C). The flower stalk length, and leaf length of dandelions on the periphery of the playground in Haverford, PA is greater than in the playground (**** $P < 0.0001$, as determined by Students t-test). (D). The angle of the flower stalk of dandelions on the periphery of the lawn and playground in Haverford and Broomall, PA is greater than in the lawn and

playground. (**** $P < 0.0001$, as determined by one-way ANOVA). Each value represents a single flower stalk. All results are expressed as Mean $\pm$ SD.

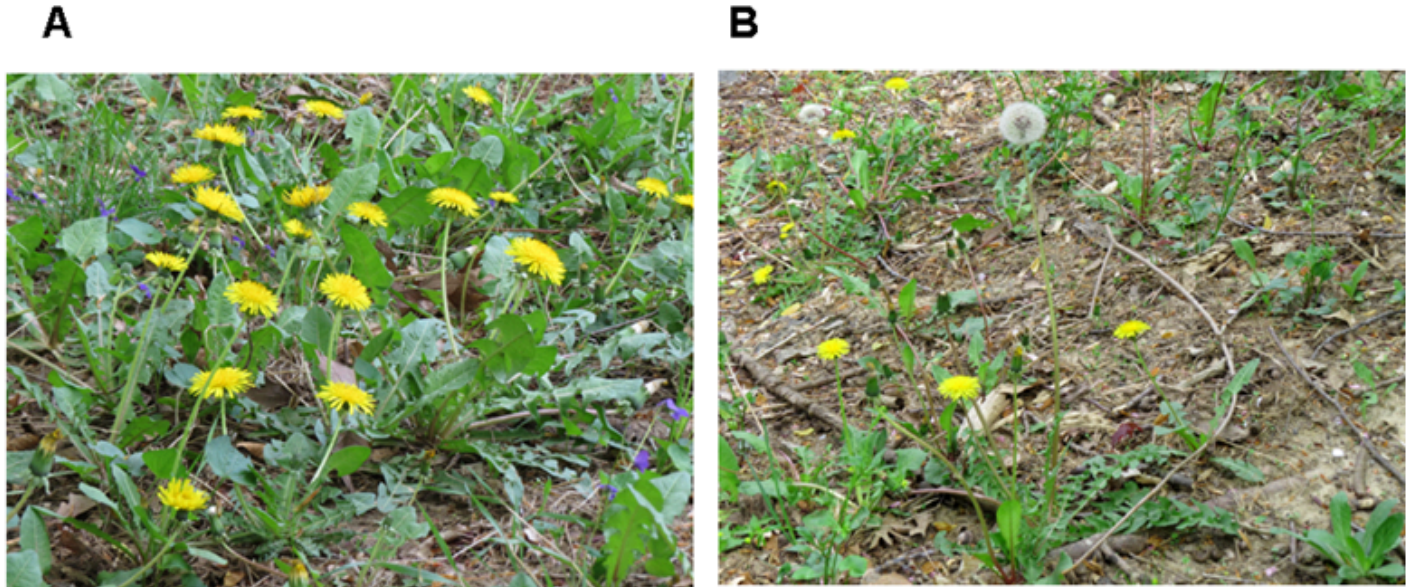


Figure 7

Dandelions in nature reserves and wastelands (wild area) have tall flower stalks and seed head stalks.

(A) The dandelions in the wild areas have tall flower stalks, long floral diameters, and large leaves. (B) The dandelions in the wild areas have tall seed head stalks; they are taller than the flower stalks.



Figure 8

Dandelions in the suburban lawns have short flower stalks and seed head stalks. (A) The dandelion flower stalks in the lawns are shorter with smaller angles almost parallel to the ground. (B) The flowers of dandelions are parallel to the lawn grass. (C) The seed head stalks of the dandelions in the lawns are taller than the flower stalks.



Figure 9

Seeds from a shorter seed head stalk falls in the vicinity of the dandelion plants. Dandelions seeds are wind dispersed; a short seed head stalk is deleterious to germination of seeds.

Supplementary Files

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- [SupplementaryFigures.docx](#)