conservation

Perspective

Using Botanical Gardens as Butterfly Gardens: Insights from a Pilot Project in the Gran Sasso and Monti Della Laga National Park (Italy)

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Abstract: Butterfly gardens are green spaces designed as places where butterflies can feed, mate, and rest. Here, we present some perspectives on the possible use of botanical gardens in natural areas as butterfly gardens to promote insect conservation through science dissemination and citizen science activities. We explored this possibility with a project developed in the Botanical Garden of the Gran Sasso and Monti della Laga National Park (Italy). We found an extremely high butterfly richness as a result of favorable conditions which can be common in botanical gardens. To promote awareness of insect conservation in the general public and citizen science activities, we have installed within the garden several posters illustrating the butterfly fauna of the park, the species that visitors can easily observe, and the importance of butterfly conservation. Using this case study, we provided reflections and guidelines for the realization and management of butterfly gardens in already existing botanical gardens, especially in natural areas. The realization of butterfly gardens in protected areas to promote awareness of insect conservation, as well as to perform scientific research (namely insect monitoring), may help to ensure that insects will exert a pivotal role in expanding the global network of protected areas under the Post-2020 Global Biodiversity Framework.

Keywords: butterfly monitoring; insect conservation; habitat; insects; Lepidoptera; protected areas; reserves

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1. Introduction

The massive human intervention on the environment is leading to a decrease in biological diversity at taxonomical, functional, and phylogenetical levels [1,2]. Arthropods, which are the largest and most widely distributed terrestrial animal taxon, are experiencing a fast and unprecedented decline worldwide [3–9]. Since insects form the largest arthropod class (with latest estimates counting at least 5.5 million species, of which only one fifth has been discovered and described [10]), it is not surprising that at least half of all the species considered on the verge of extinction in the next decades are insects [11]. However, the conservation status of most insect species is unknown simply because we do not know they exist [5–7], and there is evidence that many insect extinctions may have already occurred even if not documented [12]. This inadequacy of taxonomical knowledge is known as the Linnean shortfall [13–16] and, although observed in many groups, it appears to be a particularly dramatic impediment in insect conservation [17].

The Linnean shortfall arises not only from the obvious difficulties in assessing complete taxonomic inventories for such a large number of species, but also by the complexity of insect species identification, because many species are recognizable only by subtle diagnostic characteristics which need advanced taxonomic skills [18–21]. Difficulties in insect identification inherently result in the lack of basic data necessary for conservation assessments [22]. Out of the 12,161 known species of insects assessed by the IUCN (version 2022), 3121 are classified as data-deficient [23], which means that there is not enough information to determine their risk of extinction. Moreover, there is a bias towards well-resolved groups, whereas other taxa are often ignored, since taxonomic expertise is lacking, a problem that can be only partially circumvented by the use of new technologies [24]. Another important lack of information is the so-called Wallacean shortfall [14,15]: for most species, we do not know adequately their distribution, which is essential to assess their conservation priorities and carry out appropriate conservation actions [22,25]. In addition to the Linnean and Wallacean shortfalls, many other forms of scientific ignorance beset insect research, ranging from the lack of data on population size and dynamics to species ecological preferences [17,26], resulting in a generally small amount of data on insect conservation and scarce funding for research projects. Limited research leads to a further lack of data, thus generating a vicious loop [27].

Arthropod conservation suffers also from social and cultural issues, because most people tend to have low sympathy for most insects and allied taxa. In Western culture, most insects are in fact perceived mainly as pests or nuisances, often associated with unpleasant sensations, such as disgust, fear, and panic [28–31]. As a result, most people are unaware of the crucial role that insects play in maintaining healthy ecosystems, being therefore unable to perceive the importance of funding campaigns to safeguard the "uncharismatic" invertebrates. This can explain why, compared to mammal species, each species of arthropod receives a thousand times smaller amount of funding for conservation [17]. Although flagship species often used to promote conservation continue to be typically large terrestrial mammals (such as large predators, the African elephant *Loxodonta africana* (Blumenbach, 1797), or the giant panda *Ailuropoda melanoleuca* David, 1869 [32,33]), in recent years the paradigm is changing, and there is increasing interest in the possible role of non-mammals, and in particular insects, as flagship species, with a special emphasis on pollinators [34–37]. In this regard, butterflies (Lepidoptera, Papilionoidea) could be ideal candidates for the role of flagship species among invertebrates, and hence can serve as ambassadors of arthropod conservation [38]. Among arthropods, butterflies represent a notable exception to the common negative feelings towards insects, because they are perceived as innocuous, beneficial, and beautiful creatures [31,39–41]. In fact, butterflies are commonly perceived as so different from other insects that most people have difficulties in accepting that they are insects. The positive attitudes of the general public towards butterflies mainly associated with aesthetic perceptions [42] can make these insects a useful lockpick to unhinge negative preconcepts against insects. Thus, thanks to their particularly positive position in the most diverse cultures [43–45], butterflies may be one of the most useful insect groups that can be profitably used to promote sensibility/awareness towards the importance of insects and their conservation.

Despite the general aversion to insects, the so called "insect apocalypse" [46] has attracted media attention, and the general interest towards insect conservation, as well as the importance of insects even for our own well-being, is rapidly rising [5]. Because of their effects on our everyday lives, pollinators are one of the most appealing groups that appeal to the general public. In particular, butterflies, by combining an unparalleled aesthetic appeal with an easily understood ecological function as pollinators, may be particularly useful model organisms to involve people in conservation.

The case of the monarch butterflies (*Danaus plexippus* (Linné, 1758)) in the USA well exemplifies how butterflies can sensitize common opinion towards insects (and successfully rise to the role of flagship species). The monarch is a very easily recognizable species due to its flamboyant coloration and, because of its vast distributional area, it is known in almost all North America. Additionally, the spectacular mass migrations made by this butterfly increase its appeal, also attracting many ecotourists to the wintering and migration areas [38]. Finally, it is an exemplary case of an evolutionary arms race because of its association with the poisonous milkweed (Apocynaceae mainly of the genus *Asclepias*) [47].

All these characteristics contributed to the development of citizen science programs for this butterfly and, although nearly 600 butterfly species show evidence of migratory movements [48], the monarch remains the most known case and the most iconic species in insect conservation [49,50].

The example of the monarch butterfly demonstrates the potential role of butterflies in increasing people's participation and awareness by trying to co-produce, in the most scientifically rigorous way, iconic phenomena [50] that can be used as trojan horses to draw attention to the more general theme of the conservation of all insects. For example, there is a growing interest in understanding the aesthetic characteristics that are positively perceived by people in order to propose as flagship species those that may be more appreciated [4,28,42,51].

People's involvement is essential for effective conservation programs, so the choice of the species to use as conservation ambassadors must be carefully evaluated. To this end, it is important to stress that even in the same context people's attitudes may change notably among different groups (for example, there can be differences between people that are residents in a given area and those that are tourists, and an effective flagship species should be favored by both categories) [28].

The experience of the monarch butterfly also demonstrates that people can be successfully and actively involved in scientific research. The establishment of spaces dedicated to the observation of nature and species, such as butterfly gardens, can be extremely useful for this purpose. Butterfly gardens differ from other artificial green spaces because they are specifically designed to attract butterflies and offer them a space where they can feed, reproduce, or rest. The importance of butterfly gardens in insect conservation has been repeatedly argued, especially in England and North America, as evidenced by the abundance of manuals (e.g., [52–60]) and websites (e.g., [61–69]) for their creation and management.

Despite the great and increasing popularity of butterfly gardening, the scientific literature available on the subject is extremely scarce. However, it is evident that butterfly gardens can be important for butterfly conservation in many ways:

(1) Setting up gardens with suitable host plants can be an effective tool to restore the habitat of some species and thus to mitigate the loss of habitats in agricultural environments [70].
(2) Butterfly gardens can attract not only the most common species, but also rare and endangered species [71], helping their conservation [72].
(3) Butterfly gardens can be an attraction for the public, as they are perceived as an important opportunity for mental refreshment [73]. Butterfly gardens can therefore play an important social role as recreational spaces.
(4) Butterfly gardens can be an important tool in education programs and to raise awareness of environmental problems [74].
(5) Butterfly gardens may allow people to practice nature photography and other outdoor activities in safe and easy-to-reach areas. Moreover, promoting leisure activities in these spaces may contribute to diverting people away from more natural and fragile contexts.

All these characteristics make butterfly gardens extremely useful in promoting biological conservation [75]. Even green spaces not specifically conceived as butterfly gardens (such as parks, schools, allotments, and cemeteries) can practically act as butterfly gardens (e.g., [76]). This may be particularly true for botanical gardens which, for the variety and abundance of the cultivated plants and for the constant availability of water, may represent potentially important refugia for insect pollinators in urban environments [77–79]. For example, a recent study [80] based on community science data showed that botanical gardens in urban areas of the arid southwest US support higher numbers of butterfly species than other areas of similar size, because of reliable water availability for both plants and insects.

Botanical gardens are already available artificial green areas, which may act as perfect butterfly gardens with few improvements. The advantages of using botanical gardens as butterfly gardens are obviously multiple, ranging from economic (the basic structure already exists) to cultural and scientific (with the possibility of integrating botanical and entomological activities, including scientific dissemination).

In this note, we present an ongoing project for the realization of a butterfly garden in a natural context, with the aim of exploring the potential of an already existing botanical garden in assisting butterfly conservation through science dissemination and citizen science activities. Using this case study, we aim at providing reflections and guidelines for the realization and management of butterfly gardens in already existing botanical gardens, especially in natural and protected areas. Improving insect knowledge in protected areas is of paramount importance, since protected areas may represent the last bastions for the conservation of many insect species [81]. However, insects continue to play a secondary role in the designation and management of reserves [82]. For example, there are few cases of reserves specifically designed for butterfly conservation [81,83,84] and current networks of protected areas tend to not match conservation priorities for lepidopterans [85,86]. Thus, the realization of butterfly gardens in protected areas, possibly using pre-existing botanical gardens, to promote awareness of insect conservation, as well as to perform scientific research (namely insect monitoring), may help to ensure that insects will exert a pivotal role in expanding the global network of protected areas under the Post-2020 Global Biodiversity Framework.

2. Characteristics of the Selected Site

We used as a case study the Botanical Garden (coordinates of entrance: 42.3357 °N, 13.5899 °E) of the Gran Sasso and Monti della Laga National Park (Italy: Marche, Abruzzo, and Lazio Regions) (Figures 1 and 2). This national park includes the highest mountain area of the Apennines (Gran Sasso, 2912 m) and hosts the richest butterfly fauna of the entire Apennine chain [87], with several species characterized by very restricted distribution [88,89]. The botanical garden (known as San Colombo Botanical Garden) is located immediately out of the borders of the protected area to which it belongs (precisely at a distance of 130 m from the border), has an area of about 1.2 hectares, and is situated at an elevation of about 1085 m (specifically, between 1074 and 1086 m). The garden has both cultivated and naturally occurring plants. The garden has been created to cultivate native plants representative of the park's flora, thus exotic plants are almost absent. The exotic plants occurring in the garden and/or in its surroundings include a few invasive species, such as the tree of heaven *Ailanthus altissima* (Mill.) Swingle, the black locust *Robinia pseudoacacia* L., the narrow-leaved ragwort *Senecio inaequidens* DC., and some cultivated exotics, such as the false dittany *Pseudodictamnus mediterraneus* Salmaki & Siadati, the rugosa rose *Rosa rugosa* Thunb., and the multiflora rose *Rosa multiflora* Thunb. Cultivated plants, native to Italy, but absent in the park, are the lavender *Lavandula angustifolia* Mill. and the Jerusalem sage *Phlomis fruticosa* L. The garden is subject to minimal management, with even water mostly supplied by rain. The garden is in a place that is easy to reach (which is essential to attract people) and already subject to relatively intense human pressure compared to other areas of the park. Thus, the use of this space as a butterfly garden does not have further impacts on the natural ecosystems.

Figure 1. The Botanical Garden (San Colombo) of the Gran Sasso and Monti della Laga National Park (Italy). The white line indicates the perimeter of the garden, whereas the red line indicates the transect used for butterfly censusing. The inset shows the position of the botanical garden (red point) in Italy (the Abruzzo region is colored in yellow). Map generated in QGIS® with Bing Virtual Earth background [90].

The botanical garden was the garden of a former convent (the Convent of San Colombo), which is now converted into a reception facility for conferences, weddings, and ecotourism; thus, this site is visited by people that come here for the most disparate reasons. This may be particularly important to promote insect conservation to occasional visitors. In this way, the butterfly garden may also help in promoting insect conservation (especially in the form of awareness) to people that are not already interested in nature. Additionally, the area includes a pre-existing path which zigzags along a slightly steep slope, which is easy to walk. Finally, the garden has a small pond that provides butterflies with water in the driest periods.

Figure 2. Landscape view of part of the Botanical Garden (San Colombo) of the Gran Sasso and Monti della Laga National Park (Italy) in autumn. Note the presence of bee nest boxes used for a project of pollinator monitoring involving both butterflies and bees. Bee nest boxes were installed in summer 2021, and immediately colonized; in summer 2021 they were colonized for about 10%, while in 2022 the percentage of colonization was 30–40%. Photo L. Di Biase.

As a part of a project on the conservation of pollinators (mainly butterflies and bees), this site was included among a set of places for butterfly recording selected in different areas of the park. Butterfly censusing was conducted using transect counting [91], in line with the European Butterfly Monitoring Scheme—eBMS [92]. Specifically, we used a 500 m transect crossing all the garden (Figure 1). The transect was walked every month from June to September 2021, counting butterflies seen within an imaginary box 5 m wide, 5 m high, and 5 m ahead of the observer [91]. For species whose identification was particularly complex (e.g., some lycaenids), observed individuals were taken with a net, identified (or photographed for subsequent identification/confirmation), and then released. As we were interested here in obtaining a checklist of the butterflies of the garden that was as complete as possible, we also considered species observed immediately out of the transect which, however, were separately annotated. Butterfly taxonomy follows Balletto et al. [93] updated with the atlas of mitochondrial genetic diversity for Western Palearctic butterflies [94]. Plant nomenclature follows Conti et al. [95], except for *Foeniculum vulgare*, now indicated as *Anethum foeniculum* L. [96]. Acta Plantarum [96] was also used for species not included in Conti et al. [95].

3. The Butterfly Community of the Garden

The Botanical Garden hosts a very rich community of butterflies, including 40 species recorded during our research (Table 1). This community represents about 27% of the 149 butterfly species known from the whole park (S.F. and L.D., unpublished data).

Based on the number of the individuals observed for each species, a rarefaction/extrapolation curve was constructed using the iNEXT [97] package in R [98]. The rarefaction/extrapolation curve reveals that there is still the possibility that other species will be detected in the future (Figure 3) and an asymptotic evaluation of local species richness indicates the potential occurrence of 46.07 species, with a standard error of 10.52 species and an upper 95% confidence limit of 66.67 species. We have already noted the presence of at least two additional species in the garden (*M. phoebe* and *P. machaon*), although out of the transect. Two other species, *Melitaea ornata* Christoph, 1893, previously unknown from the Abruzzo Region and observed at less than 1 km from the botanical garden (L.D., personal data) and *Carcharodus baeticus* (Rambur, 1839), a species classified as Near Threatened [99] and found at Barisciano (L.D., personal data), might be probably found in the garden. Thus, we can expect that the garden probably hosts 50–60 species. This high diversity may be explained by the presence of many attractive plants for both adults and larvae of butterflies. For example, we recorded here *Gonepteryx cleopatra*, a Mediterranean species, typically associated with open areas of low elevation, known from only few localities in the Abruzzo Region (L.D., personal data).

Table 1. List of the butterfly species recorded in the San Colombo Botanical Garden (Gran Sasso and Monti della Laga National Park, Italy) and number of censused individuals during five sampling sections from June to September 2021. An asterisk (*) indicates species observed immediately out of the transect.

Species	Number of Observed Individuals
Argynnis paphia (Linné, 1758)	10
Aricia agestis (Denis & Schiffermüller, 1775)	7
Brintesia circe (Fabricius, 1775)	5
Callophrys rubi (Linné, 1758)	1
Coenonympha pamphilus (Linné, 1758)	2
Colias crocea (Geoffroy, 1785)	3
Cupido minimus (Fuessly, 1775)	2
Cyaniris semiargus (Rottemburg, 1775)	2
Fabriciana niobe (Linné, 1758)	1
Gonepteryx cleopatra (Linné, 1767)	2
Gonepteryx rhamni (Linné, 1758)	3

Table 1. *Cont.*

Species	Number of Observed Individuals
Hipparchia semele (Linné, 1758)	1
Hyponephele lycaon (Küns, 1774)	5
Iphiclides podalirius (Linné, 1758)	9
Issoria lathonia (Linné, 1758)	1
Lampides boeticus (Linné, 1767)	1
Lasiommata maera (Linné, 1758)	3
Lasiommata megera (Linné, 1767)	1
Leptidea sinapis complex	3
Limenitis reducta Staudinger, 1901	8
Maniola jurtina (Linné, 1758)	9
Melanargia galathea (Linné, 1758)	24
Melitaea didyma (Esper, 1778)	6
Melitaea phoebe (Denis & Schiffermüller, 1775) *	1
Ochlodes sylvanus (Esper, 1777)	8
Papilio machaon Linné, 1758 *	1
Pieris brassicae (Linné, 1758)	15
Pieris ergane (Geyer, 1828)	5
Pieris napi (Linné, 1758)	5
Pieris rapae (Linné, 1758)	9
Polygonia c-album (Linné, 1758)	1
Polyommatus dolus virgilius (Oberthür, 1910)	25
Polyommatus eros (Ochsenheimer, 1808)	1
Polyommatus icarus (Rottemburg, 1775)	4
Polyommatus thersites (Cantener, 1835)	5
Pontia edusa (Fabricius, 1777)	1
Satyrium ilicis (Esper, 1779)	12
Satyrus ferula (Fabricius, 1793)	2
Thymelicus sp.	3
Vanessa cardui (Linné, 1758)	7
Total	214

In addition to the plants that grow in the flowerbeds, which already include host plants and plants attractive to adults, the garden has dividing hedges mainly made up of Fabaceae (*Spartium junceum* L., *Colutea arborescens* L., *Cytisus spinescens* C. Presl, *Cytisophyllum sessilifolium* (L.) O. Lang), which might be host plants for the caterpillars of numerous species of butterflies (*Callophrys rubi*, *Colias crocea*, *Cupido minimus*, *Cyaniris semiargus*, *Lampides boeticus*, *Leptidea sinapsis*, *Polyommatus icarus*, *P. thersites*, *P. dolus virgilius* and possibly *Iolana iolas* (Ochsenheimer, 1816), this latter not yet recorded in the garden). In addition, there are bushes of *Lonicera*, which may support the larvae of *Limenitis reducta*, a charismatic butterfly which is abundant in the garden, where it is attracted by the flowers of oregano (*Origanum vulgare* L.) cultivated in the flowerbeds. In addition to other more modest Fabaceae (*Trifolium campestre* Schreber, *Onobrychis viciifolia* Scop., *Medicago lupulina* L., *Lotus corniculatus* L., *Anthyllis vulneraria* L.), the garden hosts various species of Apiaceae (*Anetum foeniculum* L., *Daucus carota* L., *Orlaya daucorlaya* Murb.), which might act as host plants for *Papilio machaon*; *Reseda lutea* L., a host plant of *Pontia edusa*; various species of Brassicaceae (for example *Diplotaxis tenuifolia* (L.) DC.), which are host plants of pierids; and *Plantago lanceolata* L., a host plant of *Fabriciana niobe*. Spontaneous Asteraceae (belonging to the genera *Sonchus*, *Lactuca*, *Centaurea*, *Taraxacum*, *Crepis*, *Cyrsium*, and *Onopordum*), as well as *Knautia calycina* (C. Presl) Guss., *Eryngium amethystinum* L. and *E. campestre* L., were observed to be very attractive for adult butterflies frequenting the garden. Finally, many species of butterflies (*Hipparchia semele*, *Hyponephele lycaon*, *Brintesia circe*, *Coenonympha pamphilus*, *Lasiommata maera*, *L. megera*, *Maniola jurtina*, *Melanargia galathea*, *Ochlodes sylvanus*) have larvae that feed on a wide range of Poaceae, and their abundance in the open spaces of the garden may make these habitats very attractive for them.

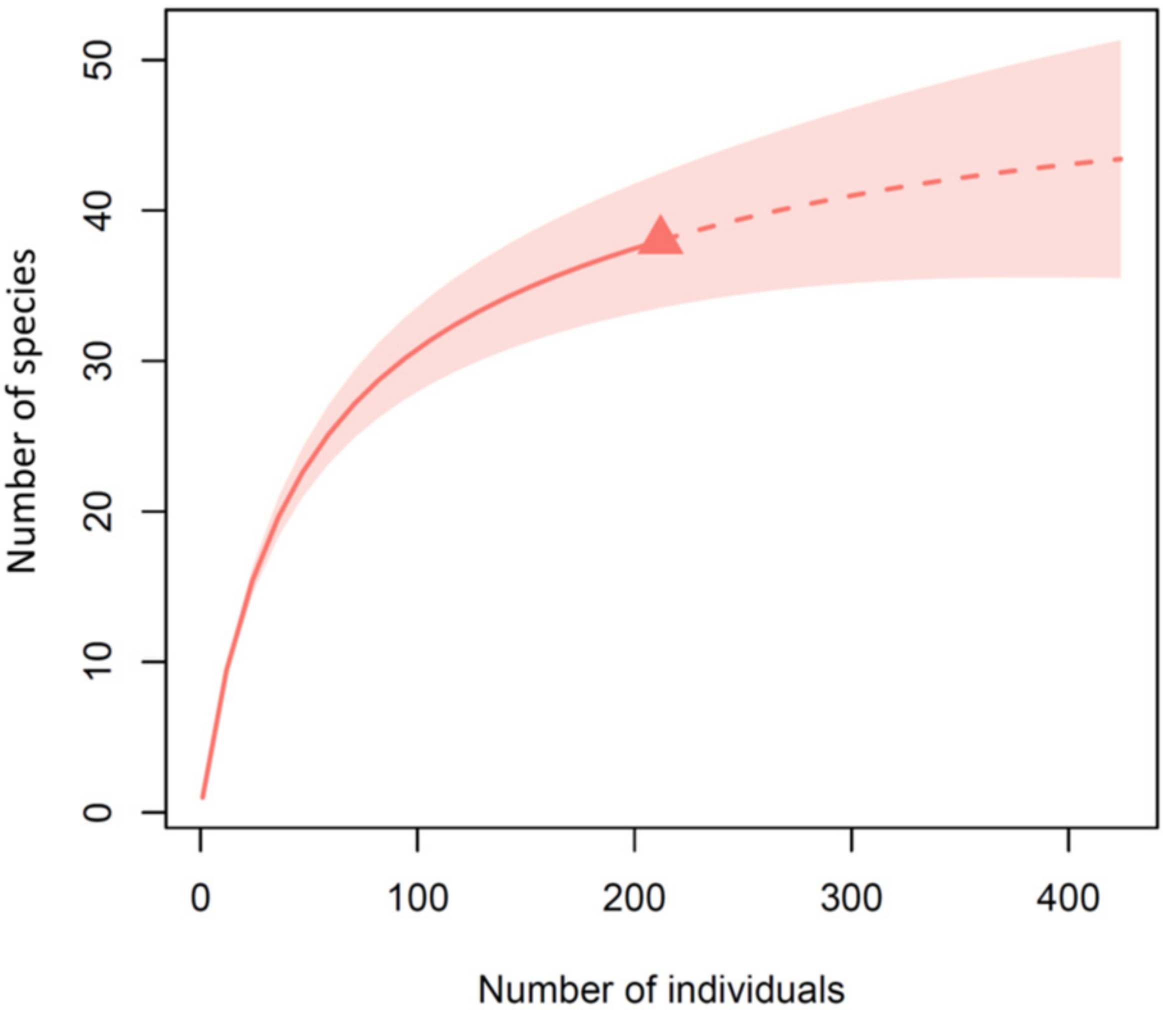

Figure 3. Rarefaction (continuous line)/extrapolation (broken line) curve for the number of recorded butterfly species as a function of the number of observed individuals in the San Colombo Botanical Garden (Gran Sasso and Monti della Laga National Park, Italy). The shaded area indicates 95% confidence limits. The triangle indicates the observed number of species. Only species recorded in the transect were used for calculation.

The high richness of butterflies recorded in the garden may be also connected to its particular location in a relatively natural context. It is well known that matrix quality is very important in determining species richness in green spaces [100–102], a reason why urban green spaces, or other types of fragments in profoundly altered matrixes, may have low diversity values [102]. In our case, the site is in a practically reversed situation, being an artificial space in a mid-elevation natural context. In particular, the presence of wooded areas close to the garden allows the occurrence of species associated with more shady environments, whose larvae develop on undergrowth grasses that would be difficult to maintain in the open context of the garden. This allows the co-existence of both species associated with open environments and species associated with closed environments. More in general, woodlands may be important for butterflies because dense trees reduce wind disturbance. Moreover, some species are known to aestivate in wooded shady areas (e.g., *Maniola jurtina* [103], a strategy that could become fundamental under current and future climatic changes). All species recorded in the garden are classified as Least Concern in the IUCN red list of the Italian butterflies [99]. None of the recorded species are included in the "Habitats Directive" [104]. Some species (*Pieris brassicae*, *P. napi*, *P. rapae*, *Colias* *crocea*, *Lampides boethicus*, *Issoria lathonia*, and *Vanessa cardui*) show more or less marked migratory behaviors.

4. Actions Performed and Planned

Our project started in spring 2022, with the aim of proposing the whole botanical garden as a butterfly garden (thus, the butterfly garden coincides with the botanical garden). As a first and most important action, in summer 2022 we installed within the garden a series of posters illustrating the importance of butterfly conservation, the butterfly fauna of the park, and the species that visitors can easily observe in the garden. This material included five large (150 cm × 120 cm) posters illustrating general issues and four smaller (29.7 cm × 42 cm) posters describing some of the most characteristic and easy to observe/identify species. The larger posters addressed the following themes: one poster was dedicated to introducing the importance of insect conservation and the butterfly garden; one poster presented the variety and peculiarities of the butterflies of the park; three posters illustrated the butterflies present in the garden (Figure 4a–d). The four small posters each illustrated a different species among the easiest to observe and identify by general people (Figure 4e–g).

To improve accessibility, large shrubs of broom (*Spartium junceum* L.) were pruned, but no other intervention was performed for the moment. The presence of an unmanaged portion of land within the garden has allowed the undisturbed development of a multitude of plant species useful for pollinators. This suggests that most of the garden might be maintained as it is, with possible interventions limited to the plantation of a few essences particularly attractive for butterflies. In particular, we recommended preservation of the presence of nettle (*Urtica dioica* L.), as it is used by the larvae of various species of nymphalids, such as *Vanessa atalanta* (Linné, 1758), *Aglais urticae* (Linné, 1758), *Aglais io* (Linné, 1758) (not yet recorded in the garden, but that might be present), and *Polygonia c-album* [105]. It would also be useful to place bushes of nettle along the borders of the garden in sheltered and humid places away from the most frequented parts to avoid problems to the visitors, but it would be important to keep these under control, as the species tends to expand easily. Other recommended species to keep are honesty (*Lunaria annua* L., to be placed in shady areas), stock (*Matthiola* spp.), wild rocket (*Diplotaxis tenuifolia* (L.) DC.), alyssum (*Alyssum* spp.), clover (*Trifolium* spp.), daisy (*Bellis perennis* L.), and star-thistle (*Centaurea triumfettii* All., and others), since all of them attract a large number of butterfly species.

Other attractive plants already present and/or which can be planted in the garden are vervain (*Verbena officinalis* L.), rock cress (*Arabis hirsuta* (L.) Scop. and *A. collina* Ten.), sage (*Salvia verbenaca* L., *S. argentea* L., *S. sclarea* L., and others), pin cushion (*Scabiosa columbaria* L. *portae* (Huter) Hayek), sedum (*Petrosedum rupestre* (L.) P.V. Heath and *Sedum* spp.), thyme (*Thymus striatus* Vahl and *T. moesiacus* Velen.), mint (*Mentha longifolia* (L.) Huds. and *Mentha spicata* L.), wild primrose (*Primula vulgaris* Huds.), rue (*Ruta graveolens* L. and *R. chalepensis* L.), and fennel (*Anethum foeniculum* L., host plant of the charismatic swallowtail *Papilio machaon*). We also observed that lavender (*Lavandula angustifolia* Mill.), oregano (*Origanum vulgare* L.) and savory (*Satureja montana* L.)—all already present in the garden—were particularly attractive for butterflies. Observations conducted in other areas of the park with high richness of butterflies showed that *Adenostyles australis* (Ten.) Iamonico & Pignatti is a highly attractive plant and, therefore, it is recommended to try its breeding in the garden.

Planned activities also included the realization of identification guides (for the butterflies of the garden as well as of the park in general) and other popular publications, as well as the monitoring of the number of accesses to the garden.

Figure 4. Examples of large (**a**–**d**) and small (**e**–**g**) posters installed in the San Colombo Botanical Garden of Gran Sasso and Monti della Laga National Park (Italy) to illustrate the importance of insect conservation and the butterfly garden (**a**), the variety and peculiarities of the butterflies of the park (**b**), the butterfly community of the garden (**c**,**d**), and a selection of species occurring in the garden among the easiest to observe and identify (**e**–**g**). Photos S. Fattorini.

5. Conclusions and Perspectives

The San Colombo Botanical Garden offers a remarkable number of economic and practical advantages for the creation of a butterfly garden, which might be found (or easily implemented) in other botanical gardens worldwide:

(1) There are already numerous species of plants that attract butterflies and that can provide them with food and refuge throughout the year.
(2) There is a small pond from which the butterflies can take water and mineral salts, especially during the most arid period. This is a common situation in botanical gardens that almost always have fountains, ponds, basins for aquatic plants, etc., and may be especially important in regions with dry climates.
(3) The architectural structure of the garden, with many protected places, allows butterflies to be not disturbed by wind. Trees, shrubs, hedges, buildings, or other windbreak structures are commonly found in botanical gardens. Trees, shrubs, and hedges are also important because they provide larvae and pupae with shelter in winter and shade in summer.
(4) The place is already open to the public.
(5) The already existing paths are perfectly suitable for butterfly watching.
(6) No maintenance operations other than those already in place are required. In general, butterfly gardens require professional construction and maintenance techniques, which makes their installation in school gardens difficult, a reason that leads to the proposal of creating virtual butterfly gardens through augmented reality systems [106].

As urban green spaces tend to behave as "islands of nature" in highly disturbed contexts [107,108], their role in the conservation of butterfly populations might be strongly reduced. Urban butterfly gardens might even act as ecological traps, since they might not support sufficiently large numbers of individuals to contribute to the local abundance and persistence of butterfly populations [109]; also, they may attract large numbers of predators and parasites [100]. This risk is, however, absent for butterfly gardens located in natural or seminatural contexts. On the other hand, the possible role of butterfly gardens in supporting butterfly populations in natural areas is probably minimal, since it is obviously much more important than the role played by the natural areas themselves. For example, in our case, all species recorded in the garden are classified as Least Concern in the IUCN red list of the Italian butterflies, and none are included in the "Habitats Directive". Additionally, some of the recorded species might be transient individuals passing by the garden just because the surroundings are favorable for them. Therefore, a botanical garden in a protected area may offer limited opportunities for active conservation, but may contribute to the conservation of the butterflies in other ways, including the following:

(1) Increase in visibility of the park among the population, given the considerable attraction exerted by butterflies.
(2) Promotion of environmental awareness, scientific dissemination, and citizen science projects, which help to increase positive synergies with local cultural agencies, such as schools and universities.
(3) Promotion of nature observation activities in an accessible and safe context. Natural areas cannot be fully accessible to people with mobility difficulties. A properly equipped butterfly garden can be an important place for social inclusion.
(4) Concentration of tourist activities in an attractive area, but of lesser conservation value within the protected area (this is exactly the case of the San Colombo Botanical Garden, which is immediately out of the protected area). Ecotourism can lead, as a negative consequence, to forms of disturbance. For example, nature photography enthusiasts can be a source of disturbance in the best-preserved sites. A butterfly garden can be useful to "divert" these forms of disturbance from the most valuable contexts to a site specifically designed to encourage nature observation and photography activities, thanks to the considerable variety and abundance of butterflies and the ease with which they can be observed and photographed.

Butterfly gardens are known to attract people [110] and the use of botanical gardens as butterfly gardens, especially if they are associated with tourist facilities, may be useful to intercept people that are not already interested in nature. In general, it has been found that people with more positive attitudes about insect conservation tend to already have a general interest in nature conservation, being for example members of environmental organizations [72]. Botanical gardens that are also frequented by people that are not already interested in environmental conservation may be therefore particularly important to promote awareness (and this is the case of the San Colombo Botanical Garden, also visited by people that come here as guests of the associated hotel and restaurant).

Butterfly gardens in natural areas may be an exceptional occasion to promote citizen science. Citizen science is increasingly used to collect data on insect conservation [27] with targeted activities, such as the European Butterfly Monitoring Scheme—eBMS [92]. However, even untargeted initiatives such as the upload of photographs on iNaturalist [111] may lead to the acquisition of important data [80]. Botanical gardens may serve as good places for both targeted and untargeted activities of citizen science. In the specific case of the San Colombo Garden, butterfly monitoring might be particularly useful to trace the effects of climate change. For example, it would be interesting to monitor the presence/abundance of *Gonepteryx cleopatra*, a thermophilic species associated with Mediterranean open habitats which is present in the garden as one of the few known localities on the Apennine mountains. The presence of thermophilic migratory species (such as *Issoria lathonia* and *Lampides boethicus*) should be also monitored.

To familiarize people with butterflies (and possibly other insects) botanical/butterfly gardens might be also perfectly suitable for activities based on new conservation-orientated augmented reality such as the "Pokémon Go" approach [112]. This may be particularly useful for children, who tend to have innate positive feelings for nature [113] and exhibit good classification abilities [114]. For this reason, in the installed posters, lists of species occurring in the garden and, more generally, in the park were provided. We are also preparing guides for the identification in the field of the butterflies known from, or potentially occurring in, the park (anecdotal observations made by us in the study area during citizen science activities demonstrated that children were extremely interested in recognizing butterflies, and very efficient in correctly identifying them).

Butterfly gardens in natural areas may be extremely useful in improving public awareness of insect conservation by showing butterflies in their "natural" context, which can help in surpassing a merely aesthetic positive attitude, with beneficial consequences for insect conservation in general. Barua et al. [28] clearly showed that people have a general sympathy for the adult butterflies, but not for caterpillars! To surpass this biological "schizophrenia" it is important that people evolve a more comprehensive view of butterflies. For example, in North America there is strong interest in cultivating milkweed to sustain the development of the larvae of monarchs (e.g., [115–117]); in this way, the butterfly enters a broader narrative that embraces the entire life cycle of the species. Of course, this may be more difficult with less known and less iconic species, but exactly for this reason a butterfly garden may be an exceptional opportunity to disseminate knowledge of butterfly biology, and especially of their life cycle. Understanding that butterflies and caterpillars are the two sides of the same coin may be extremely important in promoting sensitivity towards the conservation of unpopular insects, and increasing people's sympathy for insects (and other arthropods) with no aesthetic appeal is obviously of paramount importance. Pollinators such as the butterflies may be especially useful to make people aware of the complexity of ecological webs and hence of the role of neglected invertebrates.

Our proposal fits the increasing interest in botanical gardens and natural areas as tools for promoting awareness of insect conservation, as shown by a few similar initiatives already developed even in Italy, including an educational center in the Monti Sibillini National park, especially devoted to children [118]; trials with educational panels on butterflies in the WWF Oasis "Le Cesine" [119], in the LIPU Oasis of Massaciuccoli [120], and in the National Archeological Park of Vulci [121]; an urban garden in Cremona in which plants have been specifically selected to feed butterflies [122]; and the inclusion of the Botanical Garden of the University of Bologna in a Life project on pollinator conservation [123]. However, to the best of our knowledge, our initiative is the first that integrates various aspects, including butterfly monitoring, citizen science projects, and butterfly conservation, and then proposes a "model" of potentially general validity. Since botanical gardens are distributed worldwide and share similar characteristics that can make them perfect butterfly gardens in a variety of contexts, we hope that our proposal may lead to the development of similar projects in other contexts to test the effectiveness of our model. In particular, a wider application of our experience might include the creation of a network of experts working in protected areas for planning butterfly gardens aimed at different conservation purposes, including educational purposes and conservation of rare and threatened species.

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