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ORIGINAL PAPER

Botanic gardens can positively influence visitors' environmental attitudes

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Abstract Botanic gardens often highlight public education as a priority. Increasing knowledge about biodiversity conservation is a frequently stated aim of environmental education. This is often based on the assumption that increasing knowledge may generate positive environmental attitudes. We investigate the relationship between knowledge and environmental attitudes and whether visits to botanic gardens alter visitors' ecological knowledge and environmental attitudes. We surveyed 1054 visitors at five UK botanic gardens, half of whom were interviewed on entry and half leaving. Our results suggest a strong positive relationship between knowledge and attitudes, although we are unable to disentangle cause and effect. We show botanic gardens have little influence on knowledge, however environmental attitudes are more positive amongst those leaving a botanic garden. This study presents the first quantitative evidence showing botanic gardens can positively influence visitors' environmental attitudes. With over 300 million visitors a year globally, botanic gardens have the potential to greatly improve knowledge about, and attitudes towards plant conservation. Evaluating the influence botanic gardens may have on visitors can be useful both in demonstrating to funders the contribution they make, and to allow

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learning and development of approaches to maximise the benefits of environmental education schemes in botanic gardens.

Keywords Environmental education · New ecological paradigm · Ecological knowledge · GSPC · Conservation

Introduction

Botanic gardens are frequently cited as a global network at the forefront of plant conservation (Donaldson 2009; Pennisi 2010; Blackmore et al. 2011), yet there are few studies critically examining the contribution of botanic gardens to conservation. There are over 2500 botanic gardens around the world and together they receive over 300 million visitors a year (Botanic Gardens Conservation International 2012). Botanic gardens are diverse, and their activities vary depending on funding sources, capacity, location, governance and size (Pennisi 2010; Rae 2011). Traditionally botanic gardens have focused on developing the fields of taxonomy and horticulture but have more recently begun to address wider conservation issues, with particular strengths in ex situ conservation and education (Donaldson 2009). The Global Strategy for plant conservation, the dominant framework guiding global plant conservation activities, highlights education and public awareness as a priority activity to increase capacity for plant conservation practice and public support for plant conservation (Secretariat of the Convention on Biological Diversity 2015). Although education is within the mission statements of 80 % of botanic gardens (Kneebone 2006), the effectiveness of botanic garden education and the influence on casual visitors has not been quantitatively assessed.

Environmental education is often promoted as a way of increasing ecological knowledge ('a general knowledge of facts, figures, concepts and relationships concerning the natural environment and major ecosystems' (Kotchen and Reiling 2000; Fryxell and Lo 2003; Mostafa 2007)) and thus improving environmental attitudes (defined here as 'the degree to which people are aware of problems regarding the environment and support efforts to solve them and/or indicate a willingness to contribute personally to their solution' (Dunlap et al. 2000)). Assuming a link between a person's knowledge and their attitudes is often the implicit assumption of many environmental education programmes (Durant et al. 1989; Arcury 1990; Kaiser et al. 1999; Heberlein 2012). Education activities in collections-based institutions, such as botanic gardens and zoos, can take many different forms, with many gardens coordinating workshops, guided tours and activities for the public to learn about the natural world (Kneebone 2006; Jensen 2014). Visitors that do not participate in these education activities are still likely to be exposed to information about the environment and conservation through informal exposure to signs and exhibits (Stokes 2006; Weiler and Smith 2009).

Zoos and aquaria are more frequently the focus of studies investigating the influence of environmental education (Ballantyne et al. 2007; Askue et al. 2008; Ogden and Heimlich 2009; Jensen 2014). As shown by He and Chen (2012), botanic garden visitor centers can positively influence visitor enjoyment, but conclude that the influence of botanic gardens on ecological knowledge requires further investigation. Indeed, little is known about how much knowledge botanic garden visitors acquire from their visits and how this affects their environmental attitudes. Specifically, if education activities in botanic gardens aim to generate more positive environmental attitudes as suggested by Havens et al. (2006). Furthermore, a greater understanding of how information can influence knowledge and the relationship between knowledge and attitudes is needed (Hart and Nolan 1999; Penn 2008; Potter 2009). Here we assess how ecological knowledge relates to environmental attitudes and examine whether informal education in botanic gardens increases visitors' ecological knowledge and influences their environmental attitudes.

Methods

Sampling strategy

Seventeen UK botanic gardens responded to a survey about their involvement in the Global Strategy for Plant Conservation (Williams et al. 2012). From this survey, gardens that had budgets of more than £500,000 and had listed education as a primary aim were selected for the current research. Five (out of nine) of these botanic gardens were willing to be involved in a further study (Birmingham Botanical Gardens and Glasshouses, The Eden Project, Royal Botanic Gardens, Kew, Cambridge University Botanic Garden and Royal Botanic Garden, Edinburgh). A pilot study (50 individuals) was carried out at Ness Botanic Garden. This garden was chosen for the pilot study as it provides a similar setting to the main study gardens (high visitor numbers, provision of education and interpretation boards, education outlined as one of the main aims of the garden). Using pilot study data collected from Ness Botanic Garden ($n = 50$) to specify the variance in the data, we carried out a power analysis to determine the sample size needed where beta is set at 0.8, the effect size (Cohen's d) is 0.3 and alpha is 0.05. This indicated 200 responses (100 arriving and 100 leaving) per garden were needed to have adequate statistical power to detect a change in knowledge and attitudes.

Interviewers stood next to the main entrance of each botanic garden from 10:00 to 13:00 to collect responses from adults arriving and from 14:00 to 17:00 to collect responses from adults leaving. Three of the botanic gardens (Cambridge, Birmingham and Edinburgh) open at 10 am and two (Kew and Eden) open at 9:30 am. We did not survey visitors who had been in the botanic garden less than 1 hour but included these people in our estimate of non-responses, along with individuals declining to participate. Respondents that completed the survey on arrival were not questioned again when leaving. All questionnaires were verbally administered by the lead author and three trained, research assistants between June and July 2011 (see supplementary material for the full questionnaire). An ethics checklist, as required by Bangor University, was completed prior to data collection and indicated that the research did not require further review. Oral consent was obtained from all study informants and all data were stored anonymously.

Questionnaire design

The questionnaire assessed visitor ecological knowledge, environmental attitudes and socio-demographic data (age, gender, level of education, frequency of visits to the garden) for all respondents. Eight items were used to measure ecological knowledge and were based on the information available in all five botanic gardens. These questions were chosen to reflect different measures of ecological knowledge as suggested by previous studies (Kotchen and Reiling 2000; Fryxell and Lo 2003; Mostafa 2007) including general ecological knowledge, current events in conservation and specific examples of threats and threatened plants. The BGCI Botanic Garden database, the IUCN Red List and the list of Biodiversity Hotspots were used to provide objective measures as a basis for assessing answers. For example, only species listed on the IUCN Red List as threatened or endangered were accepted as correct answer to the question 'Can you name a threatened plant species?. Common names up to family level were accepted e.g. Orchid. Where an unclear response was given respondents were asked 'can you be more specific?' with no further prompting.

The New ecological paradigm (NEP) is the most widely used approach for measuring general environmental attitude (Dunlap and Van Liere 2008). The respondent expresses how strongly they agree or disagree with 15 statements about the environment, with higher scores indicating a more positive environmental attitude (Dunlap and Van Liere 2008). We used the fifteen NEP items with a five point Likert scale to measure environmental attitude. Respondents were given as much time as required to consider the statements and were assured there were no right or wrong answers.

Analysis

Statistical analysis was carried out in R (R Development Core Team, 2009). Differences in age and gender across the five botanic gardens were tested using an ANOVA. Differences between participant's age and gender for those arriving and leaving were also compared using an ANOVA. Ecological knowledge was calculated by summing correct responses the knowledge questions. Each question answered correctly receives one point with a maximum score of eight. We used unidirectional coding, from 1 to 5, for each of the NEP items with positive environmental attitude having higher scores. We then summed across the 15 NEP items to provide a measure of environmental attitude for each individual, with a maximum score of 75. Internal consistency of the new environmental paradigm items was estimated using Cronbach's Alpha. To allow direct comparisons we rescaled explanatory variables to a common range. We used a series of linear models to examine variation in respondent demographics between different botanic gardens and variation in demographics of visitors arriving and leaving.

To assess the relationship between ecological knowledge and environmental attitude (NEP score as a continuous variable), we developed a candidate set of 19 generalised linear models. The global model included ecological knowledge, age, education level, gender and frequency of visits to the botanic garden as explanatory variables. To assess whether a botanic garden visit influences environmental attitudes we include a dummy variable indicating arriving or leaving. Candidate models were ranked and weighted by AICc. There was no single model with clear support so we used model averaging to estimate the parameter coefficients. Uncertainty in parameter estimates was calculated as suggested by Burnham and Anderson (2002).

To examine the impact of a botanic garden visit on ecological knowledge (as a continuous variable) we developed a candidate set of 18 generalised linear models. The global model had the following explanatory variables: a dummy variable indicating arriving or leaving, age, education level, gender, frequency of visits to the botanic garden. We used corrected AIC (AICc) to rank the candidate models and calculate the relative weight of each model. Following Burnham and Anderson (2002) we chose the best supported model as the one with ΔAICc > 2.

Results

We had a mean response rate of 77 % ($\pm$10 %) providing a sample of 1054 completed questionnaires: 523 people arriving and 531 leaving (Table 1). We sampled 616 females

Table 1 Summary of respondents in the five study botanic gardens

Botanic garden	Number of responses	Response rate (%)	Mean knowledge score (max = 8)	Mean NEP score (max = 75)
Birmingham	204	0.72	3.54 (±0.25)	58.10 (±0.97)
Cambridge	207	0.87	3.94 (±0.24)	57.59 (±0.96)
Eden	215	0.86	3.53 (±0.20)	57.08 (±0.90)
Edinburgh	204	0.66	3.71 (±0.21)	57.26 (±0.91)
Kew	224	0.72	3.99 (±0.23)	58.07 (±0.99)
Total	1054	0.77	3.74 (±0.10)	57.62 (±0.42)

Mean ecological knowledge scores and mean environmental attitudes scores are shown with 95 % confidence intervals in brackets

There are no significant differences between gardens in respondent age, ecological knowledge and environmental attitude ($p \geq 0.05$, $F = 0.92$, $df = 4$)

and 438 males, and over 60 % of respondents were aged 46 or above. Forty-five percent of respondents had a university education, 22 % left school at 18 years of age (with A levels or college equivalent), 6.2 % left school at 16 (with GCSE's or equivalent) and 25 % had other training qualifications. There was no significant difference between gardens in the number of respondents interviewed arriving or leaving, and no difference across participants' age and gender ($p > 0.05$, $F_{4,\ 1049} = 0.92$, $df = 4$). The Cronbach's Alpha test indicates a high internal consistency (0.87) for the measure of environmental attitude.

Does ecological knowledge predict environmental attitude?

Table 2 summarises the ten models with the most support, ranked by ΔAICc. As no single model had clear support when assessing the predictors of environmental attitude, Fig. 1 presents parameter averages over 19 candidate models. There is a strong positive relationship between ecological knowledge and environmental attitude. Coefficients for age, gender, education and frequency of garden visits suggest older women that are leaving the botanic garden, with higher levels of formal education and visit the garden frequently, have a more positive environmental attitude.

Does a botanic garden visit impact ecological knowledge and environmental attitude?

Table 3 shows a summary of the ten most supported models developed to assess predictors of ecological knowledge. We present the most supported model in Fig. 2. There is no impact of a single visit to a botanic garden on ecological knowledge. The effect of a single visit was retained in the second most supported model, but the coefficient estimate was small (-0.007 ± 0.1) and the ΔAIC is more than 2 suggesting weak support for the model. Our results suggest more frequent visits to the botanic garden are positively related to ecological knowledge, but the parameter estimate suggests a weak relationship. The level of formal education also indicates people with higher levels of education are likely to have higher ecological knowledge. Figure 1 shows environmental attitudes are higher when leaving the botanic garden and that this is a strong positive relationship.

Table 2 Summary of ten candidate models ranked by AICc developed to assess the effect of ecological knowledge and a botanic garden visit upon environmental attitude, controlling for demographic variables

Leaving	Know	age	Gender	Edu	Garden visits	Know: edu	Age: edu	Know: age	AICc	ΔAICc	Weight
X	X	X	X						6939.13	0.00	0.32
X	X	X	X	X					6940.63	1.50	0.15
X	X		X						6940.96	1.83	0.13
X	X	X	X	X		X			6941.00	1.87	0.13
X	X	X	X	X	X				6941.16	2.03	0.12
X	X		X	X	X				6942.44	3.31	0.06
X	X		X	X					6942.94	3.81	0.05
X	X	X	X	X	X	X	X	X	6943.37	4.24	0.04
X			X	X	X				6985.28	46.16	0.00
X			X	X					6987.72	48.59	0.00

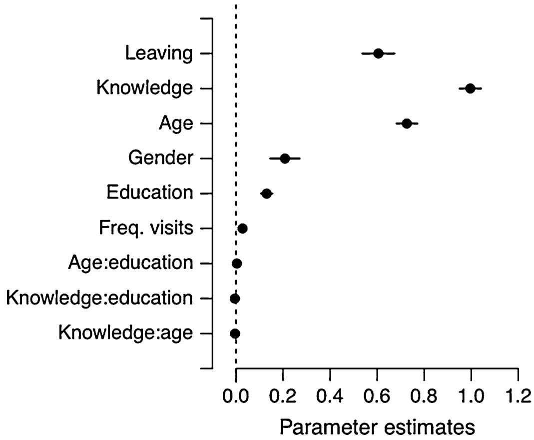


Fig. 1 Average parameter estimates predicting environmental attitude. Intercept = 52.02 (±0.06). *Central circles* are average coefficient estimates for each parameter and *lines* indicate 95 % confidence intervals. Ecological knowledge is the strongest predictor of environmental attitude. Environmental attitude is likely to be higher on the way out of the garden and there is positive effect of age, gender and education level. This suggests that those leaving the botanic garden, particularly women that are older, with higher levels of formal education, have a more positive environmental attitude

Table 3 Summary of ten candidate models ranked by AICc developed to assess the impact of botanic garden visits on ecological knowledge

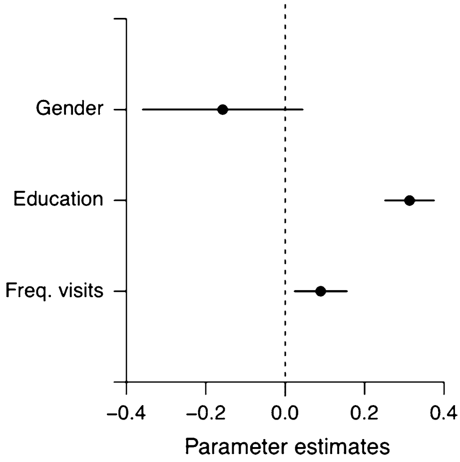
Leaving	Gender	Edu	Age	Garden visits	Age: edu	Leave: edu	Leave: age	AICc	ΔAICc	Weight
	X	X		X				3948.52	0	0.59
X	X	X		X				3950.54	2.02	0.22
X	X	X	X	X				3952.08	3.59	0.09
	X	X						3953.68	5.14	0.04
X	X	X	X	X	X	X	X	3955.39	7.00	0.01
X		X	X					3955.63	7.11	0.01
X	X	X	X					3956.38	7.88	0.01
X	X	X	X			X		3958.38	9.90	0.00
		X		X				4003.96	55.41	0.00
X		X	X	X	X			4007.317	58.83	0.00

Botanic garden visit was retained in the second most supported model with a coefficient of −0.007 (±0.1)

Discussion

It is often assumed, with little empirical evidence, that botanic gardens can change peoples' knowledge and attitudes towards nature (Stokes 2006; Donaldson 2009). This is the first large-scale study to assess how botanic gardens can influence ecological knowledge and environmental attitudes. We discuss how this global network could increase their influence on their visitors, and contribute more successfully towards plant conservation.

Fig. 2 Coefficient estimates for the most supported model predicting ecological knowledge. Intercept = 2.28 (±0.02). *Central circles* are average coefficient estimates for each parameter and *lines* indicate 95 % confidence intervals. People with higher levels of formal education and visit the garden frequently are likely to have higher ecological knowledge. A single visit to a botanic garden is not likely to influence ecological knowledge of visitors



The relationship between ecological knowledge and environmental attitudes

In environmental education there is often the assumption that higher levels of ecological knowledge will lead to more positive environmental attitudes (Arcury 1990). Our results show a strong positive relationship between ecological knowledge and environmental attitude. However we are unable to disentangle cause and effect as it may be that those with a positive environmental attitude preferentially seek out knowledge. Previous research has suggested increasing scientific knowledge results in more favourable attitudes towards science (Sturgis and Allum 2004; Allum et al. 2008). However, these studies are also limited in identifying a causal direction.

Without conducting intervention experiments it is impossible to reach a firm conclusion about the direction of the relationship between knowledge and attitudes. We suggest the direction of this relationship should be the focus of future research investigating ecological knowledge and environmental attitudes.

Influence of botanic gardens on ecological knowledge

Environmental education, technical training and generating public awareness about biodiversity conservation tend to be prominent activities for botanic gardens and these institutions have the potential to communicate plant conservation to a wide audience (Kneebone 2006; Crane et al. 2009; Donaldson 2009). However our results suggest a single visit to a botanic garden is unlikely to substantially affect visitors' ecological knowledge. This is similar to the findings of Balmford et al. (2007) who found no effect of informal education by zoos on visitors' knowledge but in contrast with Penn (2008) and Jensen (2014) who show that even a single visit to a zoo can promote knowledge gain about wildlife conservation. It is unclear whether this disagreement arises from chance, methodological differences or confounding effects. We do find that regular visitors have higher ecological knowledge. However, we cannot determine the direction of the relationship, which could arise from botanic gardens increasing knowledge or the preference of the knowledgeable for botanic gardens. We believe the latter is likely, as the visitor profile of UK botanic gardens is often quite limited and not representative of the general public. Indeed the results show the majority of respondents (45 %) have university level education whereas less than 30 % of people in the UK have qualifications from University or equivalent (Office of National Statistics 2011). A challenge faced by botanic gardens is the public perception that they are for an elite group of older, middle class people (Havens et al. 2006; Dodd and Jones 2010). Many botanic gardens have recently begun coordinating community outreach projects, specifically targeted to encourage new audiences and to attract a broader spectrum of visitors. For example, the Winterbourne House and Garden, part of the University of Birmingham, set up community based urban vegetable growing project, aiming to encourage cultural exchange and learning experience for the Islamic communities of Birmingham (Botanic Gardens Conservation International 2012). To evaluate the impact of these community projects it would be useful to incorporate measures of participants' ecological knowledge and ecological environmental attitudes, ideally before and after the education project. This would provide much needed data on changes in individuals over time and help to identify how botanic gardens are influencing different audiences.

Influence of botanic gardens on environmental attitudes

Our results do indicate botanic gardens can have a positive effect on environmental attitudes. We are unable to directly attribute this positive change in attitudes to the informal education efforts of the botanic garden; the change we observed may be due to the pleasure of visiting the garden itself, as the majority of people visit gardens for enjoyment and relaxation (Ballantyne et al. 2008). There is some evidence to suggest urban green spaces can promote positive environmental attitudes (Budruk et al. 2009).

Botanic gardens are important sites for recreation (Maunder 2008) and it is possible a single visit can encourage people to feel more positive towards the environment, without any changes in their knowledge.

As the measure of environmental attitude was taken directly after a visit to the botanic garden, we are unable to suggest whether there is a longer-term impact. Although environmental attitudes may be positive after a botanic garden visit, attitudes are dynamic constructs and may need reinforcement to be maintained (Stern et al. 2006). In this study we have examined only a single form of education (the use of interpretation boards) within botanic gardens. As botanic gardens usually use a variety of education activities, it would be valuable to compare the relative merit of different approaches on visitors' ecological knowledge and environmental attitudes.

Increasing the influence of botanic gardens on visitors

The Global Strategy for Plant Conservation (a Convention on Biological Diversity framework for plant conservation activities) highlights the importance of communicating plant diversity and conservation through education programmes (Secretariat of the Convention on Biological Diversity 2015). This is based on the assumption that greater knowledge about biodiversity and positive attitudes can lead to behaviour change. Indeed, Havens et al. (2006) suggest an understanding of conservation is necessary to engage public support for conservation and that botanic gardens are well placed to generate this support. It was beyond the scope of this study to assess visitors' behaviour in relation to their knowledge and attitudes and we suggest this should be the focus of future research. Whether increasing knowledge and positive environmental attitudes result in behaviour change is very challenging to study; environmental behaviours are often difficult to record independently of social acceptability (e.g. if an intervention changes a person's attitude towards a behaviour it will also change their willingness to admit to it, (St John et al. 2010). Future research would benefit from in-depth qualitative interviews to explore the nuances of how botanic gardens can influence environmental attitudes. We suggest botanic gardens should regularly evaluate the influence of their education programmes on visitors and share this information with other botanic gardens, perhaps through a network such as Botanic Gardens Conservation International (the umbrella organisation for botanic gardens worldwide). This would allow documentation of progress made towards meeting the Global Strategy for Plant Conservation education target (Target 14). Furthermore, identifying which approaches may have the greatest impact on ecological knowledge and environmental attitudes will ensure the most effective approaches are implemented in botanic gardens around the world and could lead to greater success in influencing visitors. The development on the online GSPC Toolkit to share experience and expertise is one positive step to encouraging the discussion forum needed to investigate these aspects of botanic garden education.

However, this relies on botanic gardens having the capacity to assess and communicate the effect of their education programmes. Echoing Turkowski (1972), botanic gardens and zoos have a considerable role in increasing the general public's knowledge about biological conservation, if given the right support. With the decline of many plant science degrees, many university botanic gardens have been reported as threatened with closure (e.g. Treborth Botanic Garden in 2006 and St Andrews University Botanic Garden in 2013). The Royal Botanic Gardens, Kew, one of the world's leading communicators of plant conservation, has experienced reduced UK Government funding over several years and is facing a £5 million deficit in funding for the 2014–15 financial year (BBC News 2014; Guardian 2014). These are worrying events. Declining funding and support for botanic gardens is likely to limit the ability of botanic gardens to influence the public's environmental attitudes.

Conclusion

Botanic gardens apply a wide range of activities to educate and inspire the public, often aiming to generate support for conservation in its broadest sense. Here, we have focused on the impact of passive informal education in botanic gardens. We investigated the underlying assumption in many environmental education programmes that increasing people's ecological knowledge will affect their environmental attitudes. We show there is a strong positive relationship between ecological knowledge and environmental attitudes (but we are unable to disentangle cause and effect). Although we did not find evidence that a botanic garden visit influences knowledge, we showed that even a single visit can have a positive influence on environmental attitudes. With over 300 million visitors a year globally, botanic gardens have the potential to greatly improve knowledge about, and attitudes towards, plant conservation. We suggest evaluation of this impact can be useful both in demonstrating to funders the contribution they make, and to allow learning and development of approaches to maximise the benefits of environmental education schemes in botanic gardens.

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