Evaluating the Contribution of Zoos and Aquariums to Aichi Biodiversity Target 1

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Contributed Paper

Evaluating the contribution of zoos and aquariums to Aichi Biodiversity Target 1

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Abstract: *The United Nations Strategic Plan for Biodiversity 2011–2020 is a key initiative within global efforts to halt and eventually reverse the loss of biodiversity. The very first target of this plan states that "by 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably." Zoos and aquariums worldwide, attracting more than 700 million visits every year, could potentially make a positive contribution to this target. However, a global evaluation of the educational impacts of visits to zoos and aquariums is entirely lacking in the existing literature. To address this gap, we conducted a large-scale impact evaluation study. We used a pre- and postvisit repeated-measures survey design to evaluate biodiversity literacy—understanding of biodiversity and knowledge of actions to help protect it—of zoo and aquarium visitors worldwide. Ours was the largest and most international study of zoo and aquarium visitors ever conducted. In total, 5661 visitors to 26 zoos and aquariums from 19 countries around the globe participated in the study. Aggregate biodiversity understanding and knowledge of actions to help protect biodiversity both significantly increased over the course of zoo and aquarium visits. There was an increase from previsit (69.8%) to postvisit (75.1%) in respondents demonstrating at least some positive evidence of biodiversity understanding. Similarly, there was an increase from previsit (50.5%) to postvisit (58.8%) in respondents who could identify actions to help protect biodiversity that could be achieved at an individual level. Our results are the most compelling evidence to date that zoo and aquarium visits contribute to increasing the number of people who understand biodiversity and know actions they can take to help protect biodiversity.*

Keywords: aquarium, education, impact, visit, zoo

Evaluación de la Contribución de los Acuarios y Zoológicos al Objetivo 1 de Biodiversidad de Aichi

Resumen: *El Plan Estratégico de las Naciones Unidad para la Biodiversidad 2011-2020 es una iniciativa clave dentro de los esfuerzos globales para detener y eventualmente revertir la pérdida de la biodiversidad. El primer objetivo de este plan manifiesta que "para 2020, a más tardar, la gente estará consciente de los valores de la biodiversidad y los pasos que pueden dar para conservarla y usarla de manera sustentable". Los zoológicos y acuarios a nivel mundial, que atraen a más de 700 millones de visitantes cada año, pueden brindar potencialmente una contribución positiva a este objetivo. Sin embargo, no existe una evaluación global del impacto educativo de los zoológicos y acuarios en la literatura contemporánea. Para enfrentar este vacío informativo llevamos a cabo un estudio de evaluación de impacto a gran escala. Usamos un diseño de encuesta de medidas repetidas previa y posterior a la visita para evaluar los conocimientos sobre la biodiversidad – entendimiento de la biodiversidad y conocimiento de acciones para ayudar a protegerla – de los visitantes de zoológicos y acuarios a nivel mundial. Nuestro estudio fue el estudio más grande e internacional de visitantes de zoológicos y acuarios que se ha llevado a cabo. En total, 5661 visitantes a 26 zoológicos y acuarios de 19 países de todo el mundo participaron en el estudio. Tanto el agregado del entendimiento de la biodiversidad y el del conocimiento de acciones para ayudar a protegerla incrementaron significativamente durante las visitas a los zoológicos y acuarios. Hubo un incremento entre la encuesta*

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previa a la visita (69.8%) y la posterior a la visita (75.1%) con respecto a los encuestados demostrando por lo menos un poco de evidencia positiva en cuanto al entendimiento de la biodiversidad. También hubo un incremento similar entre la encuesta previa (50.5%) y la posterior (58.8%) con respecto a los encuestados que podían identificar acciones alcanzables a nivel individual para ayudar a proteger la biodiversidad. Nuestros resultados son la evidencia más convincente a la fecha de que las visitas a los zoológicos y acuarios contribuyen al incremento del número de personas que entienden la biodiversidad y conocen acciones que pueden realizar para ayudar a protegerla.

Palabras Clave: acuario, educación, impacto, visita, zoológico

Introduction

In 2010, governments agreed to the Strategic Plan for Biodiversity 2011–2020, which is aimed at halting and eventually reversing the loss of biodiversity on the planet (http://www.cbd.int/sp/default.shtml). To build support and momentum for this urgent task, the United Nations General Assembly declared 2011–2020 the United Nations Decade on Biodiversity. There are 5 strategic goals and 20 ambitious targets, collectively known as the Aichi Biodiversity Targets (http://www.cbd.int/sp/targets/default.shtml). Their purpose is to inspire broad-based action in support of biodiversity over this decade. Target 1 of strategic goal A states that "by 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably." To achieve such a goal will require a major global effort from governments and civil society organizations, such as zoos, aquariums, science museums, and many others. The World Association of Zoos and Aquariums (WAZA)—the global industry association for zoos and aquariums—has officially committed to contributing to this biodiversity awareness target.

With more than 700 million visits worldwide every year (Gusset & Dick 2011), zoos and aquariums are uniquely placed to contribute to the goal of raising understanding of biodiversity and actions to help protect biodiversity. In addition to the quantity of annual visits, the majority of zoos and aquariums already have in place an institutional and in some cases legal commitment to public education on biodiversity conservation and wider environmental themes. Zoos and aquariums often highlight their role as education providers as one of their key contributions to biodiversity conservation. For example, Patrick et al. (2007) found that 131 out of 136 studied zoo mission statements contain specific reference to the theme of education and 118 mention the theme of conservation itself. However, zoo and aquarium marketing practices may not always align with these mission statements. In a comprehensive study of zoo Web sites, Carr and Cohen (2011) report that zoos are primarily portraying themselves as providers of entertainment and that conservation and education messages are diluted by this portrayal.

Zoos and aquariums are undoubtedly providers of environmental education (e.g., Packer & Ballantyne 2010; Esson & Moss 2013; Dove & Byrne 2014). However, they have been guilty of making strong causal claims regarding the educational impacts of visiting zoos and aquariums on the basis of insufficient empirical evidence (RSPCA 2007; Dawson & Jensen 2011; Jensen et al. 2011; Moss & Esson 2013). Of equal concern, Luebke and Grajal (2011) found that although many zoos and aquariums undertake visitor research, it is largely based on operational needs, rather than attempts to measure impact in relation to mission statements (also see Jensen 2011). The largest ($N = 3018$) single-zoo visitor study to date is a repeated-measures impact evaluation conducted with schoolchildren 7- to 15-years old visiting London Zoo. Results of this study showed significant aggregate increases in biodiversity-related learning after a visit to the zoo (Wagoner & Jensen 2010, 2014; Jensen 2014). A multi-institutional research program in the United States (Falk et al. 2007) is probably the largest study of adult visitors to date. The main study gathered data from "a random sample of 1862 adults" from 2 zoos and 2 aquariums with a postvisit survey (which also included a "retrospective pretest"). Falk et al. (2007) reported broadly positive visitor impacts relating to the conservation mission of zoos and aquariums based on their survey data. For example, 57% of respondents self-reported that their zoo or aquarium visits strengthened their connection to nature. However, the study's research design, survey instrument, and theoretical assumptions have been criticized (Marino et al. 2010; Dawson & Jensen 2011).

Balmford et al. (2007) surveyed 1340 visitors to 7 U.K. wildlife attractions and found "very little evidence ... of any measurable effect of a single informal visit on adults' conservation knowledge, concern, or ability to do something useful" to help biodiversity. In an Australian study, Smith et al. (2008) investigated whether a zoo-based educational presentation promoting specific conservation actions had its desired impact. The researchers assessed visitors' recall of the presentation, the recommended conservation actions, and their intentions to follow through on those actions. Respondents were asked to self-report whether they "recalled hearing" the recommended conservation actions from the presentation (81% said yes); 59% of these individuals said they already knew of all the actions mentioned in the presentation (14% acknowledged not knowing the actions beforehand). Although this research seems to indicate that zoo-based educational presentations are well remembered by audiences and that zoo audiences are already well versed in conservation actions, the results must be interpreted with caution. Because the researchers did not collect data before the presentation, their data may be biased because respondents may have given answers they believed were socially desirable. If respondents had been asked to list conservation actions before and after the presentation, it would have been possible to establish that the zoo-based educational presentation was the determining factor in any new knowledge. Clearly, there is a need for an international study with scientifically rigorous methods to directly measure outcomes relevant to Aichi Biodiversity Target 1.

We assessed biodiversity literacy—biodiversity understanding and knowledge of actions to help protect biodiversity—in a large sample (5661 visitors to 26 zoos and aquariums) from across the globe. This helps us evaluate Aichi Biodiversity Target 1 by addressing the research question: To what extent are people aware of the values of biodiversity and the steps they can take to conserve and use it sustainably? We also measured the educational impacts of visits to zoos and aquariums on such biodiversity literacy.

Methods

Survey Instrument

Pre- and postvisit surveys were designed to measure our 2 dependent variables (biodiversity understanding and knowledge of actions to help protect biodiversity); to provide an indication of change (positive or negative) in individual participants over the course of their zoo or aquarium visit; and to assess the potential impact of several independent variables on the 2 dependent variables. The survey was designed as a repeated-measures instrument (i.e., the same participants were measured twice). Repeated-measures designs have long been the standard social scientific approach to evaluating educational impacts (Crowder & Hand 1990). We used only open-ended impact measures to reduce the risk of introducing information to the respondents that would confound our impact measurement. There is still a small probability that asking any question (even open-ended ones) about biodiversity before a visit made respondents more attuned to information relating to this topic. However, a repeated-measures design is the only option for directly measuring impacts, other than an experimental design. Because an experimental design requires random allocation to treatment and control groups, it was not an option for a naturalistic field study conducted with regular zoo and aquarium visitors. Previsit respondents were not informed that they would be asked the same open-ended questions after their visit.

Because few previous studies used direct impact measures with zoo and aquarium visitors, particularly with international institutions, there was no robust basis for creating closed-ended survey response options. Therefore, the 2 dependent variables were operationalized with matching open-ended questions in both the pre- and postvisit surveys. To measure biodiversity understanding, we asked respondents to list anything that came to mind when they thought of biodiversity (space for up to 5 responses provided). To measure knowledge of actions to help protect biodiversity, we asked respondents to think of an action they could take to help save animal species (space for up to 2 responses provided).

Limiting responses to a series of closed-response options would not have allowed us to validly assess the variability in zoo and aquarium visitor understanding of biodiversity and the actions to protect it. That is, it would have required us to close off possible responses that visitors would want to give because we did not already have a good account of the range of thoughts and actions visitors may have wished to communicate. This decision increased resources required to input data and affected the way data were analyzed and quantified. In addition to the 2 dependent variables, data relating to a number of independent variables (both categorical and continuous) were collected (Tables 1 & 2).

Survey Procedure

Procedural and sampling guidance documents were produced for all participating institutions to promote consistency in data collection and organization at each site. However, given the diverse nature of participating institutions, some uncontrolled procedural differences likely occurred across sites.

The survey was designed to be printed by participating institutions, distributed on paper by staff members, and self-administered by respondents. It included a previsit component (administered at the zoo or aquarium entrance) and a postvisit component (administered at the zoo or aquarium exit) for the same participants (repeated measures). Potential survey respondents—zoo or aquarium visitors ≥10-year-old—were selected using systematic sampling (every *n*th visitor) or on a continual-ask basis (once 1 survey response was completed, the next visitor to cross an imaginary line was selected as the potential next respondent). Consent from responsible adults was sought before potential respondents of minor age were approached. Staff members administering the surveys were instructed not to wear any overt conservation or biodiversity-related messaging on their clothing and not to offer guidance to respondents completing the survey. Survey questions could be read out and answers

Table 1. Tests of fixed effect factors from linear mixed model output on change in biodiversity understanding before and after a visit to a zoo or aquarium.

	df	*F*	*P*
Intercept	1718.992	411.098	<0.001
World region*	1737.922	11.361	<0.001
First visit to this zoo	1728.870	2.329	0.127
First visit to any zoo	1736.110	2.779	0.096
Zoo member or season ticket holder	1721.429	2.389	0.122
Gender	1726.566	0.316	0.574
Local to area or visitor	1732.582	1.241	0.265
Saw or heard biodiversity information during visit*	1732.956	29.673	<0.001
Attended animal talk or show during visit	1730.843	0.201	0.654
Talked to zoo staff or volunteers during visit	1726.598	2.267	0.132
Watched video or film during visit	1751.305	1.914	0.167
Used smartphone application during visit	1717.782	2.180	0.140
Watched TV nature shows in last 12 months	1724.234	1.312	0.252
Member of environmental group*	1702.775	10.407	0.001
Number of zoo visits in last 12 months	1892.705	0.910	0.340
Age*	1746.361	24.737	<0.001
Years of formal education*	1730.773	23.792	<0.001
Number in visiting group	1729.531	0.254	0.615

**Significant effect.*

Table 2. Tests of fixed effect factors from linear mixed model output on change in knowledge of actions to help protect biodiversity before and after a visit to a zoo or aquarium.

	df	*F*	*P*
Intercept	1551.017	497.394	<0.001
World region*	1549.771	14.948	<0.001
First visit to this zoo	1558.249	0.285	0.594
First visit to any zoo	1560.985	0.399	0.528
Zoo member or season ticket holder	1557.090	1.769	0.184
Gender*	1536.968	10.204	<0.001
Local to area or visitor	1572.226	1.345	0.246
Saw or heard biodiversity information during visit*	1542.459	15.629	<0.001
Attended animal talk or show during visit	1553.962	0.254	0.614
Talked to zoo staff or volunteers during visit	1543.823	1.380	0.240
Watched video or film during visit*	1555.524	7.799	0.005
Used smartphone application during visit	1537.701	0.751	0.386
Watched TV nature shows in last 12 months	1620.923	0.820	0.365
Member of environmental group*	1531.913	5.335	0.021
Number of zoo visits in last 12 months	1734.101	0.404	0.525
Age*	1557.312	16.357	<0.001
Years of formal education*	1544.331	0.714	0.398
Number in visiting group	1609.594	1.518	0.218

**Significant effect.*

completed (verbatim) by staff if the potential respondent requested this. Respondents were informed that the survey was for them to record their thoughts on an individual basis and was not for recording of group responses.

Any refusals to participate in the research were recorded on a refusals log that contained easily observable visual information about the person (gender, apparent age, and apparent ethnicity) plus the stated reason for refusal. From this we calculated a mean refusal rate across participating institutions. Surveys were conducted from 1 November 2012 to 31 July 2013. Twenty-six WAZA member organizations participated, 2 of which sampled visitors at more than 1 institution. Institutions from the following 19 countries participated: Argentina, Australia, Brazil, Canada, Chile, Colombia, Germany, Hong Kong, India, Japan, Mexico, Russia, Singapore, South Africa, Sweden, Switzerland, Uganda, United Kingdom, and United States.

As part of the procedural guidelines, participating institutions were advised to provide those respondents completing the previsit survey with a unique visitor number in the form of, for example, a sticker or wrist band. This was to facilitate recognition of respondents who had completed the previsit survey so they could be approached and asked to complete the postvisit survey before exiting the zoo or aquarium. Small incentives (up to the value of around 5 Euros) were also used by some participating institutions, but only after the postvisit survey had been completed. Incentives included, for example, zoo calendars, guides, and postcards.

Data Processing

Some participating institutions provided English translations of the open-ended survey responses to the 2 dependent variables (biodiversity understanding and knowledge of actions to help protect biodiversity), whereas other non-English responses were translated by multilingual researchers or, in the case of Portuguese language data from 1 zoo, with the assistance of the translation tool Google Translate (http://translate.google.com). Independent variables did not require translation because these consisted of predefined closed-response options.

The qualitative data from the 2 dependent variables (biodiversity understanding and knowledge of actions to help protect biodiversity) were subjected to content analyses to provide quantitative data suitable for statistical analyses. Initial qualitative analyses to explore the range, type, and content of responses directly informed the scoring and coding schemes developed for each of the 2 dependent variables.

Biodiversity Understanding

The preliminary qualitative analysis of data for the variable biodiversity understanding strongly suggested that there were continuous degrees of biodiversity understanding or accuracy. From this, a 5-point unidirectional scale was developed. Each pre- and postvisit response was scored according to the following scale: 1, inaccurate (descriptions contained no accurate elements [e.g., "open air," "everything in general"] or were too vague to indicate accurate knowledge [e.g., "many things"]); 2, ambivalent (some accurate descriptions and some of inaccurate descriptions); 3, some positive evidence (mention of something biological [e.g., "species"], but no other accurate elements or detail); 4, positive evidence (some evidence of accurate descriptions, but only mention of animals or plants, not both [minimal inaccurate elements], or vague but accurate description [e.g., "lots of life," "many species," "variety of species"]); 5, strong positive evidence (no inaccurate elements, specific mention of both animals and plants [e.g., "diversity of flora and fauna of the region," "wide variety of plants and animals in a given environment or ecosystem," "all the animals and plants on our planet," "wildlife and plant life in balance"]).

In addition, we developed a series of binary coding variables (yes or no), all of which were based on the Convention on Biological Diversity (CBD)'s "Value of Biodiversity and Ecosystem Services" (https://www.cbd.int/2011–2020/learn). Individual survey responses were again scored for each of the following queries on a yes or no basis: Interconnections between species and the environment mentioned? Genetic value of biodiversity mentioned? Expressed importance of biodiversity for humans? Expressed need for biodiversity conservation? Mention of environmentally responsible behaviors relating to biodiversity?

A master combined score was calculated as the sum of the biodiversity accuracy scale (1–5 points) and all the 5 binary variables (yes = 1 point and no = 0 points). The maximum combined score per survey response was therefore 10. All data were coded by the same researcher.

Knowledge of Actions to Help Protect Biodiversity

Initial qualitative analysis of data for this variable suggested that the actions reported fell along a continuum ranging from very general to very specific personal actions. Responses were coded under an initial binary variable (yes or no) to determine whether an action or behavior was mentioned (yes = 1 point and no = 0 points). If an action or behavior was mentioned (1 point), then further points were added along a continuous scale as follows (up to a maximum of 5 points per action): 0, action or behavior identified not relevant to conservation; +1, no specific action or behavior mentioned (vague platitudes about need for change [e.g., "save ecosystems"]); +2, specific identification of probiodiversity action or behavior at a general level (not feasible to address as an individual [e.g., "stop hunting," "stop Chinese medicine," "scientific research in environmental studies and conservation," "don't cut our forests," "give animals space and protect their environment"]); +3, very specific identification of probiodiversity action or behavior that can be done at an individual level (e.g., "hanging bird houses, feeding birds in winter time," "drive less to reduce effects of climate change"); +4, very specific identification of probiodiversity action or behavior that the respondent clearly states is a personal action or behavior (e.g., "I recycle my mobile phone for gorillas").

We left spaces for respondents to identify up to 2 different actions. Where 2 actions were reported, each action was coded separately using the scale defined above. The 2 separate scores were then summed to yield a combined score (maximum total of 10). All data were coded by the same researcher.

Content Analysis Reliability

A second trained coder performed intercoder reliability analyses for both dependent variables. A small, randomly selected sample of data ($N = 294$) was coded separately (and blind to the previous coding) by the second coder. A Cohen's kappa statistic was calculated for these matching data (kappa = 0.82, $P < 0.001$, for biodiversity understanding and kappa = 0.84, $P < 0.001$, for knowledge of actions to help protect biodiversity). This indicated nearly perfect agreement between the 2 researchers (Landis & Koch 1977) for both variables.

Data Analyses

Once quantified, we conducted statistical analyses on these data. We used Z tests for normality testing with skewness and kurtosis. We used repeated-measures linear mixed models with independent variables as fixed effect factors and participating institutions as a (categorical) random effect factor. The restricted maximum likelihood method was used to estimate variance components. A global rather than minimal model was sought to identify a suite of independent variables that predicted change in biodiversity literacy between pre- and postvisit. All statistical tests were 2-tailed, had a significance level of $P \leq 0.05$, and were conducted with IBM SPSS Statistics 21.

Results

Participants

The mean refusal rate across participating institutions was 46.2%, but this value differed widely among institutions (minimum 20.3%, maximum 76.5%). The basic demographics of those visitors who chose not to participate in the survey were not different from the study sample.

The mean number of valid surveys received from each participating institution was 184 (SD 80). The largest contribution from any one participating institution was 299, and 6 out of the 26 institutions contributed <100 (minimum of 45). The total number of matched repeated-measures surveys received across the 26 participating institutions was 5661. Four other institutions participated in the overall study and contributed 696 additional survey responses. However, these institutions did not follow a repeated-measures sampling approach and were thus excluded from the impact evaluation aspect of the study.

Overall Pre- and Postvisit Comparison

There was a significant difference between pre- and postvisit data for both dependent variables (Fig. 1): biodiversity understanding ($F = 124.718$, $P < 0.001$) and knowledge of actions to help protect biodiversity ($F = 76.895$, $P < 0.001$). There was an increase from previsit (69.8%) to postvisit (75.1%) in respondents demonstrating at least some positive evidence of biodiversity understanding (scores of 3–7). Similarly, there was an increase from previsit (50.5%) to postvisit (58.8%) in respondents who could identify a probiodiversity action that could be achieved at an individual level (scores of 3–4 for each of the 2 responses to this question).

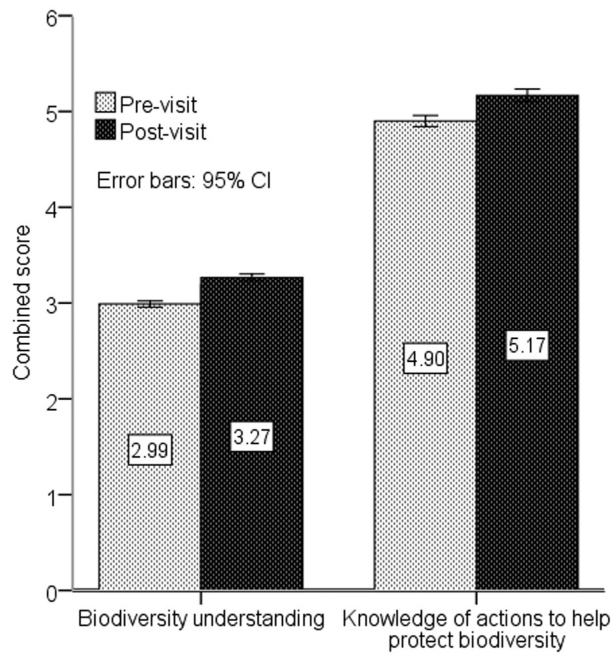

Figure 1. Overall comparison before and after a visit to a zoo or aquarium of the 2 dependent variables of biodiversity literacy—biodiversity understanding and knowledge of actions to help protect biodiversity (combined scores on 10-point scales).

Change in Biodiversity Understanding

Five of the independent variables significantly predicted change in biodiversity understanding between pre- and postvisit (Table 1). On the 10-point scale, respondents from Africa (−0.378) and Asia (−0.314) scored lower and respondents from Europe and the Middle East (0.198) scored higher than respondents from other regions. Respondents who saw or heard biodiversity information during their visit scored 0.287 higher than those who had not. Respondents who were members of a nature, conservation, or environmental group scored 0.235 lower than those who were not. Change in biodiversity understanding was 0.010 higher with each additional year of age and 0.037 higher with each additional year of formal education.

Change in Knowledge of Actions to Help Protect Biodiversity

Six of the independent variables significantly predicted change in knowledge of actions to help protect biodiversity between pre- and postvisit (Table 2). On the 10-point scale, respondents from Africa (−0.659), Asia (−0.755), and Central and South America (−0.974) scored lower than respondents from other regions. Female respondents scored 0.285 lower than male respondents. Respondents who saw or heard biodiversity information during their visit scored 0.365 higher than those who had not.

Respondents who watched a video or film during their visit scored 0.284 higher than those who had not. Respondents who were members of a nature, conservation, or environmental group scored 0.289 lower than those who were not. Change in knowledge of actions to help protect biodiversity was 0.014 higher with each additional year of age.

Discussion

There are 2 distinct components to Aichi Biodiversity Target 1: biodiversity awareness and knowledge of how to conserve biodiversity and use it sustainably. We measured biodiversity understanding because we believe understanding is a more robust and meaningful outcome than *awareness* (the term used in the target statement). For example, someone could have awareness of the term *biodiversity* but could conceivably have an incorrect understanding of it, whereas it is unlikely that someone could understand the concept of biodiversity without being aware of it.

Respondents' biodiversity understanding and knowledge of actions to help protect biodiversity both significantly increased between pre- and postvisit (also see Moss et al. 2014). This suggests that zoos and aquariums can make a positive contribution to Aichi Biodiversity Target 1 because zoos and aquariums are increasing the number of people who understand biodiversity. They are also bolstering the ranks of those who are aware of the steps they can take to conserve and use biodiversity sustainably by improving knowledge of actions to help protect biodiversity. Zoos and aquariums are attended by a considerable proportion of the global human population (Gusset & Dick 2011) and visitors represent a socioeconomic cross-section of this population (Davey 2007). Thus, our findings may have wide-ranging ramifications. Our findings also provide a much-needed baseline for CBD to measure progress toward achieving Aichi Biodiversity Target 1.

The challenge for zoos and aquariums is how to use these findings to directly improve the conservation of biodiversity. An increase in knowledge (or even proconservation attitudes) is not necessarily a reliable predictor of a related change in behavior (Schultz 2011; Heberlein 2012). Understanding more about biodiversity and increasing knowledge of actions to protect it are nevertheless valuable outcomes of a zoo or aquarium visit. Building upon this knowledge and driving proconservation behavioral and social change should be seen as an equally important task for the zoo and aquarium community. Zoos and aquariums can contribute, for example, by campaigning for policy changes and wildlife protection zones, modeling positive conservation behavior, rallying support for proconservation initiatives, working with other conservation groups and governments to make structural improvements that make proconservation behavior the easy choice, and targeting problematic social norms (e.g., Jensen & Wagoner 2009; Gusset & Lowry 2014).

Respondents exposed to biodiversity information during their visit showed a significantly larger change in both biodiversity understanding and knowledge of actions to help protect biodiversity. In particular, respondents who had watched a video or film during their visit showed a significantly larger change in knowledge of actions to help protect biodiversity. However, just over half of the respondents (56.5%) reportedly saw or heard biodiversity information during their visit. Thus, zoos and aquariums would be well advised to increase visitors' exposure to biodiversity information at their institutions to reap the benefit of improved learning outcomes we identified. For example, screening videos and films, which only about a quarter of respondents (27.3%) reported watching during their visit, could promote knowledge of probiodiversity actions in conjunction with physically visiting a zoo or aquarium.

Respondents self-identifying as a member of a nature, conservation, or environmental group showed a significantly smaller change in both biodiversity understanding and knowledge of actions to help protect biodiversity. This finding of less educational impact is likely due to the significantly higher baseline of previsit biodiversity literacy among members of such groups (A.M., E.J., & M.G., unpublished data). It is also noteworthy that demographic factors, such as region of origin, age, gender, and formal education levels, were predictive of visitors' propensity to develop greater biodiversity literacy; these factors also influenced previsit biodiversity literacy (A.M., E.J., & M.G., unpublished data). This finding contrasts with Falk et al.'s (2007) claim that such factors are not important predictors of educational impacts. We found that, in fact, a combination of demographic and within-visit variables predicted the likelihood of improvements in visitors' biodiversity literacy (also see Jensen 2014). Future research should further inform our understanding of "complexity, change over time, and the interwoven and developmental nature of sociocultural variables influencing visitors' appropriation of new ideas" relating to biodiversity and conservation (Dawson & Jensen 2011:137).

By using a repeated-measures survey design, we were able to detect differences in the direction and magnitude of zoo and aquarium visitor outcomes from pre- to postvisit. Our overarching finding was that a significant number of visitors to zoos and aquariums from across the globe increased their understanding of biodiversity and their knowledge of actions to help protect biodiversity. Although it is always difficult to confidently assign causes to an aggregate statistical relationship such as this, it is reasonable to infer that the zoo and aquarium visits that took place between survey administrations have at least some bearing on these positive changes. Our results therefore highlight the important potential of zoos and aquariums as public engagement institutions dedicated to halting and eventually reversing the loss of biodiversity on the planet, as called for in the United Nations Strategic Plan for Biodiversity 2011–2020.

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