Giant panda loan exhibitions in China underdeliver on educating visitors: insights and recommendations for improvements

Xuemei Yao, Wei Li, Wenhao Hu, Ling Zhang and Dingzhen Liu

Abstract Giant panda *Ailuropoda melanoleuca* exhibits are popular attractions for zoos and wildlife parks. However, it remains to be investigated whether such exhibits enhance visitor knowledge about pandas and broader conservation issues. We conducted questionnaire surveys at giant panda exhibits at three city zoos and five wildlife parks in China. Although visitors were generally interested in the giant panda, this was not reflected in their post-exhibit knowledge of giant panda biology. Socio-demographically, men were more knowledgeable of giant panda biology than women. Knowledge correlated positively with respondent level of education. Younger respondents (< 45 years) knew most about giant pandas and expressed an interest in learning more about them using social media. The most informed respondents had visited other giant panda exhibits previously. Respondents were generally satisfied with the giant panda exhibits (mean score 4.44/5). Wildlife parks delivered a better educational outcome than city zoos. We recommend approaches to improve the visitor experience further and to leverage public interest in broader conservation engagement and action in China.

Keywords *Ailuropoda melanoleuca*, China, conservation engagement, giant panda, questionnaire survey, visitors, wildlife park, zoo

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Introduction

The giant panda *Ailuropoda melanoleuca* (hereafter 'panda') is an iconic species of conservation concern, an Evolutionarily Distinct and Globally Endangered (EDGE) species categorized as Vulnerable on the IUCN Red List (Jiang, 2021), and emblematic of conservation organization WWF (Nicholls, 2011; Collard, 2013). In an online survey the panda ranked sixth in appeal amongst Western respondents (behind the lion *Panthera leo*, tiger *Panthera tigris*, elephants *Loxodonta* spp. and *Elephas maximus*, giraffe *Giraffa camelopardalis* and leopard *Panthera pardus*; Albert et al., 2018), whereas in China pandas are synonymous with national conservation policy. Because of this charismatic appeal, panda loan exhibits have a particular capacity to increase attendance at zoos and wildlife parks within China and internationally (Wilson et al., 2003; Ren, 2013; Sally et al., 2017). For example, the pair loaned to Edinburgh Zoo in 2012 increased visitor numbers by 200% (Li, 2012). As of 3 February 2021, 633 giant pandas were in captivity, including in panda breeding centres, city zoos and wildlife parks in China and elsewhere, with 1,864 free-living pandas in 67 nature reserves (Yu, 2021).

The flagship status of the panda has been used to leverage conservation benefits for wild populations, leading to regional habitat protection in China (Li et al., 2013), where pandas provide an umbrella under which a diversity of species can prosper (Li & Pimm, 2016). Given the increasingly important role that zoos are playing in global conservation (Patrick et al., 2007; Clayton et al., 2017; Barriault & Rennie, 2019; Consorte-McCrea et al., 2019; Godinez & Fernandez, 2019) and in informal education about wildlife conservation issues (Fernandez et al., 2009; Moss et al., 2015), there could also be substantial scope to utilize the unique appeal of pandas to broaden public engagement in biodiversity conservation issues (Olive & Jansen, 2017; D'Cruze et al., 2019). To achieve this, it is crucial to apply lessons learnt from the ways in which pandas are exhibited and promoted. For instance, educational messaging must be capable of engaging intergenerational family members, from young children and teenagers through to adults and grandparents no longer engaged in classroom education (Seybold et al., 2014; Therkelsen & Lottrup, 2015). Children often have a particular concern about and interest in environmental conservation after visiting zoos and similar facilities (Padua, 1994; Cheng & Monroe, 2012). Subsequently, their enthusiasm can influence the opinions and behaviours of their parents (Therkelsen & Lottrup, 2015; Spooner et al., 2019). Effective engagement is a vital precursor in any learning scenario (Altman, 1998; John, 2005; Roe & McConney, 2015); therefore, providing an enjoyable and entertaining experience

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(Spooner et al., 2019) and enabling visitors to see animals or plants first-hand can be a powerful teaching opportunity (Seybold et al., 2014). Conversely, a poor experience in which visitors feel that animals are exploited or mistreated can be counterproductive (Hancocks, 2001; Rose et al., 2009). Nevertheless, few studies have examined the specific benefits of visiting a single iconic species (but see Moss et al., 2016; Clayton et al., 2017; Skibins et al., 2017; Ojalammi & Nygren, 2018; Consorte-McCrea et al., 2019).

Although we recognize that a zoo visit experience involves a wide range of sensory inputs and that learning and enjoyment outcomes can depend strongly on context, emotional bias (Myers et al., 2004; Tsaur et al., 2007; Barongi et al., 2015), motivation and beliefs (i.e. the theory of planned behaviour; Ajzen, 1991; Ajzen & Driver, 1992), panda exhibits all adopt the pragmatic criteria established by Godinez & Fernandez (2019). Following this approach, panda exhibits have been conceptualized and designed to direct visitors through a series of sequential steps supplemented with booklets and information board messaging: Visit (with conservation messaging) → Knowledge → Concern → Intent → Post-visit action. The outcomes and successes of this approach in relation to visitor education, however, remain to be tested thoroughly.

Informed by previous studies (Waller et al., 2012; Pearson et al., 2013) and based on visitor questionnaires that we administered at eight zoos/wildlife parks across China, we hypothesize that visiting a panda exhibit will enhance visitor knowledge about panda biology, and that outcomes will be affected by (1) visitor age, gender and educational background, and (2) by the type of facility exhibiting the pandas, either a city zoo or wildlife park. These hypotheses lead us to predict that: (a) visitors who had either visited a panda exhibit previously and/or had received a higher level of formal education would attain a higher knowledge score on panda biology, (b) younger visitors would be more interested in learning about panda biology and thus score higher in our surveys, and men would be more interested in reading the educational material and thus score higher in knowledge-based questions, whereas women might be more interested in observing the animals than reading about their biology, and (c) on average, wildlife park visitors would score higher than zoo visitors because a greater interest in and knowledge of pandas are needed to observe pandas in a wildlife park.

Methods

Specifications for panda loan exhibits

All panda exhibit ('Pavilion') proposals must include a detailed description of the captive panda enclosure, viewing arrangements and accompanying educational activities, following the Giant Panda House Design and Standard Specifications for Domestic Exhibition (LY/T2769-2016), for approval by the Association of Zoological Gardens and the Office of Giant Panda Management of State Forestry and Grassland, People's Republic of China. This educational element must include videos or multimedia footage detailing panda conservation initiatives in China both in the wild and in captivity (Zhang et al., 2014). Providing interpreters is not compulsory, although some facilities (e.g. Shanghai Wildlife Park and Guangzhou Changlong Wildlife World) do so. Thereafter, exhibit quality is inspected annually by a team comprising a member of staff from the Office of Giant Panda Management of State Forestry and Grassland, two or more panda experts and one member of staff from the facility loaning out the pandas.

Zoos and wildlife parks investigated

To examine the influence of facility type, we conducted surveys at three zoos and five wildlife parks with a wide regional coverage. The zoos were in urban locations, had limited space, a low entry ticket price (Shanghai Zoo RMB 40 per person; Guangzhou Zoo RMB 20; Chengdu Zoo RMB 20; RMB 6.47 = USD 1) and convenient public transportation, and were state-operated. Zoos tend to exhibit one or two pandas. The wildlife parks were suburban and more spacious, with a higher entry ticket price (Shanghai Wildlife Park RMB 120; Guangzhou Changlong Wildlife World RMB 300; Ordos Wildlife Park RMB 120; Yunnan Wildlife at Kunming RMB 65; Changsha Ecological Zoo RMB 160), good catering and entertainment services but generally poorer transport links, and were privately operated. Wildlife parks often exhibit several pandas and no site charged an extra fee to visit the panda exhibit. Zoos and wildlife parks all offered 50–100% discounts on the ticket price for children, school students and elderly (retired) visitors.

Typical exhibit experience

Panda Pavilions in zoos/wildlife parks all have indoor (>150 m^2) and outdoor (>300 m^2) habitats that pandas are free to move between. Pandas can be observed over a glass/concrete wall in their outdoor enclosures and through a glass wall in their indoor habitats (Supplementary Fig. 1, Supplementary Plate 1). Pavilions exhibiting more than one panda (range = 1–13) often did so across a number of separate enclosures. Visitors enter the exhibit hall along a corridor displaying information boards and posters and/or playing video footage. They then get to observe live pandas playing, eating or resting before exiting the exhibit. Some wildlife parks also have a zookeeper present to answer visitor questions.

Determining the number of questionnaires needed to validate the survey

To calculate the minimum number of questionnaires necessary to draw accurate conclusions, we followed Schaeffer's formula (Ma et al., 2016):

$$n = \frac{N}{(N-1)\delta^2 - 1}$$

where n is the number of questionnaires, N is the number of people from the total population subject to sampling (i.e. 1.4 billion, the total population of China) and δ is an acceptable 5% sampling error rate (i.e. 0.05). This required at least $n = 400$ respondents to be surveyed. Furthermore, according to empirical statistics, sample sizes for national surveys should aim at 1,500–3,000 recipients (Yuan & Li, 2013). We therefore distributed 2,500 questionnaire surveys (i.e. ≥ 300 per exhibiting facility).

Questionnaire design and interview protocol

We asked all visitors to complete a questionnaire, to assess their knowledge of panda biology after viewing the exhibit. We lacked capacity to undertake any corresponding previsit surveys. The questionnaire included questions about visitor socio-demographic background and questions to ascertain their acquired knowledge of panda biology based directly on information provided in the exhibit. We also asked how they had acquired any prior background knowledge of pandas, the educational media used in the panda exhibition that they preferred and their opinion on using panda exhibits (on a Likert scale) to promote broader conservation. The questionnaire was in Chinese (see Supplementary Material 1 for an English version).

We conducted questionnaire surveys during 28 March–21 April 2019 and during 5–10 June 2019. Our survey team intercepted visitors upon their exit from the Pavilion and invited them to read and answer the questions on their own. Amongst children, we only surveyed those ≥ 8 years old, with 6 of 494 under-18s requiring our assistance with completing the questionnaire. We incentivized participation by providing small rewards for completion (e.g. gel pens, keychains, soft toys), and we disclosed that we were an impartial university-based research team not employed by the exhibiting facility and not invested directly in visitors approving of the exhibit.

Data processing and analysis

We first tested and established that not all questionnaire data were normally distributed, and therefore used non-parametric tests for all analyses. For socio-demographic variables we quantified the frequency distribution of gender, age and education level. For the eight specific biology questions we set an adequate knowledge level of 60%, equating to a score of 4.8/8. We used the Mann–Whitney U test to explore whether knowledge scores and preference for educational media differed between genders. We used Kruskal–Wallis tests to evaluate whether age and educational background influenced knowledge scores and preferences for educational media, complemented by post hoc Mann–Whitney U tests.

To determine which factors had the greatest influence on knowledge of panda biology, we then conducted a principal component analysis (PCA), including gender, age, formal education level and the location of the zoo/wildlife park as factor loadings. In brief, we classified factors, performed a dimensionality reduction and then applied a Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett's test of sphericity (Tobias & Carlson, 1969). We determined the number of principal extracted factors from a scree plot of eigenvalues and performed factor rotation to minimize the complexity of the factor loadings and to make the structure simpler to interpret. We then applied the maximum variance method to determine the factor loadings of each principal component. We used one-way ANOVA followed by post hoc Tukey tests for pairwise comparisons to examine the answers to the five questions on visitor attitudes to the quality and educational benefits of the panda exhibits.

We conducted all statistical analyses using *SPSS 22.0* (IBM Corporation, Armonk, USA). We set the alpha value to 0.05 and all tests were two-tailed. We plotted all figures and those data on the attitudes of the respondents to the panda exhibits using *Origin 9.0* (OriginLab Corporation, Northampton, USA).

Results

Who visits panda exhibits? Socio-demographic characteristics of visitors

Of the 2,500 questionnaires we distributed, 2,430 (97%) were returned. Of these, 2,314 (95%) were valid and suitable for subsequent analysis; we excluded the remaining 16 surveys from all analyses because they were not complete.

The overall gender ratio of respondents was female skewed at 1.00 : 1.40 (male : female) but with a stronger skew in the < 18 (1.00 : 1.47, n = 494) and 18–35 age classes (1.00 : 1.45; n = 1,341; Fig. 1). The majority (n = 1,340; 58%) of respondents were aged 18–35 (Fig. 1), probably because children under the age of 18 were often accompanied by parents belonging to this age class. In terms of education level, 40% of respondents aged 18–60 had undergraduate degrees and 24% had post-secondary specialized college degrees (Fig. 1).

Respondents were spread evenly between the eight facilities: Ordos Wildlife Park = 17%; Chengdu Zoo = 13%; Changsha Ecological Zoo = 12%; Guangzhou Changlong Wildlife World = 12%; Yunnan Wildlife at Kunming = 12%, Guangzhou Zoo = 12%; Shanghai Wildlife Park = 12%; Shanghai Zoo = 10%.

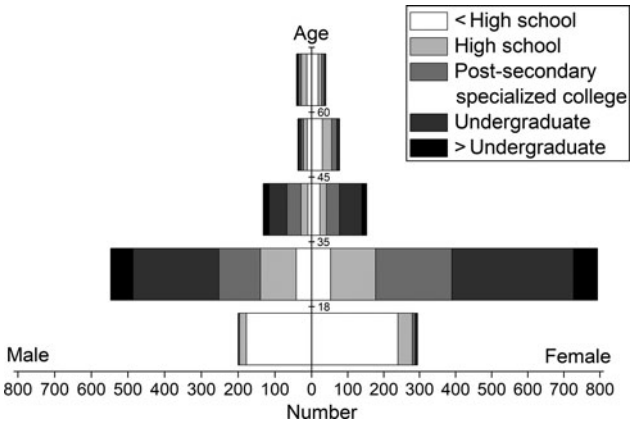

FIG. 1 Demographic and educational profiles of the 2,314 questionnaire respondents visiting giant panda *Ailuropoda melanoleuca* exhibits in zoos and wildlife parks in China.

Visitor knowledge of panda biology

Even after visiting the exhibit, in which media material provided the answers to all of the questions we posed, respondent understanding of panda biology was poor but varied substantially by topic (Fig. 2). For example, 64% answered correctly on panda diet (Certain bamboo); 55% answered correctly on hibernation (No). Only 12% of respondents answered correctly concerning the size of the wild panda population (> 1,500), with many (34%) answering that they did not know, followed by 20% who underestimated panda numbers approximately three-fold.

Of the three Chinese provinces where wild pandas are extant, Sichuan was the most well-known (87%), with Gansu second (15%) and Shaanxi the least known (14%). Only 4% of respondents named all three correctly. In contrast, 7% of respondents incorrectly thought that wild pandas inhabited Ningxia.

Amongst the four listed animal species sympatric with the panda the golden snub-nosed monkey *Rhinopithecus roxellana* was the most well-known (58%), followed by the red panda *Ailurus fulgens* (44%), golden pheasant *Chrysolophus pictus* (19%) and takin *Budorcas taxicolor* (16%). Only 1% of respondents identified all four correctly. In contrast, 17% of respondents thought incorrectly that Asian elephants *Elephas maximus* are co-resident with wild pandas. The maximum possible score for the knowledge questions was 8 for answering all questions correctly, and partial points were scored if in questions 12 or 13, which had multiple correct answers, some but not all of the correct answers were selected. Overall, 5% of respondents scored 0.0–0.9 on the knowledge questions, 15% scored 1.0–1.9, 23% scored 2.0–2.9, 27% scored 3.0–3.9, 17% scored 4.0–4.9, 9% scored 5.0–5.9, 3% scored 6.0–6.9 and 1% scored 7.0–8.0. The median number of correct answers was 3.2 and the modal group who answered 2–4 questions correctly accounted for 51% of respondents.

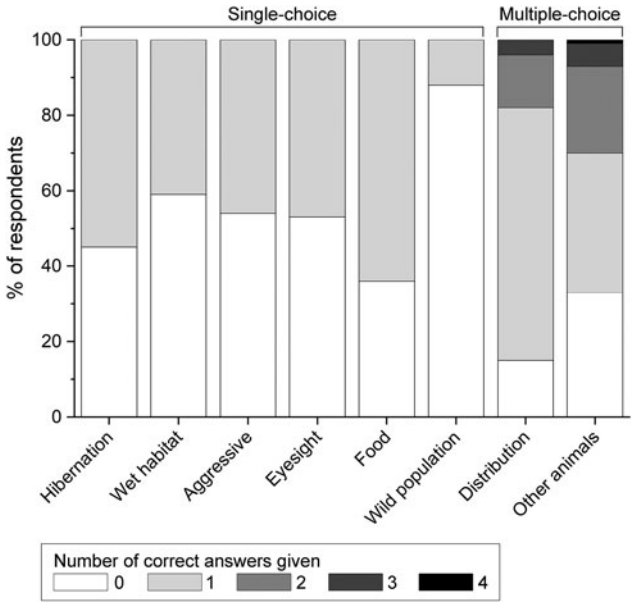

FIG. 2 Scores of 2,314 survey respondents answering six single-choice (true/false) questions and two multiple-choice questions on giant panda biology (Supplementary Material 1). The single-choice questions each had one correct answer, the question on the distribution of pandas had three correct answers, and the question asking which other animals co-occur with pandas had four correct answers.

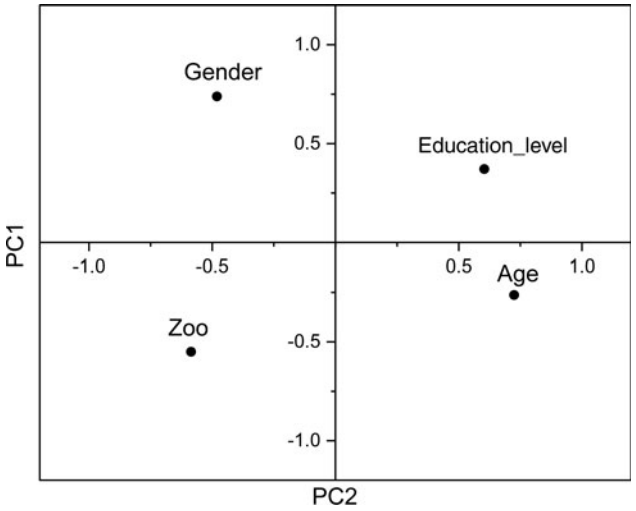

FIG. 3 Principal component analysis of the effects of gender, age, education level (highest level attained) and facility type visited (city zoo or wildlife park) of 2,314 respondents on their scores in questions about giant panda biology. The first two principal components (PC1 and PC2) explained 37 and 26% of the variance, respectively, and 63% in total.

Factors affecting knowledge of panda biology

The proportion of correct answers on panda biology was influenced significantly by respondent gender, age and

education level. Our PCA showed that education level had a positive effect, whereas age had a negative effect (Fig. 3). Principal components 1 and 2 explained 37 and 26% of the variance, respectively, and 63% of the cumulative total variance.

Male respondents scored modestly but significantly higher (3.50) than females (3.25; Fig. 4a). Respondents aged > 46 had lower mean knowledge scores than younger respondent age classes but there were no differences in scores amongst the three younger age classes (Fig. 4b). Respondents with undergraduate or higher degrees achieved significantly higher scores (median = 3.58) than those with only post-secondary specialized college degrees (3.25), high-school qualifications (2.80) or lower levels of education (3.00). There was no statistical difference in scores of adult respondents with high-school qualifications compared to those with lower levels of education (Fig. 4c).

In terms of facility effects, respondents visiting Shanghai Wildlife Park (although they could have travelled from areas other than Shanghai) achieved the lowest panda biology score (median = 2.60), although this was not significantly different from the scores achieved at Shanghai, Guangzhou, Chengdu and Changsha Ecological Zoos. Respondents at Guangzhou Changlong Wildlife World, Yunnan Wildlife at Kunming and Ordos Wildlife Park achieved the highest score (median = 3.55; Fig. 4d). Respondents visiting Chengdu Zoo in Sichuan, which is within the natural geographical range of wild pandas, achieved relatively low scores (median = 2.85). In general, respondents visiting wildlife parks achieved significantly higher scores (median = 3.30) than respondents visiting city zoos (3.00; Fig. 4e).

Preferred prior sources of panda information

Of the 2,296 respondents (99% of the total of 2,314) reporting they had learnt about pandas prior to their visit, the majority (52%) had previously visited other zoo exhibits and panda conservation sites. These respondents scored significantly higher ($r_s = 0.109$, $P < 0.001$) on panda knowledge (median = 3.50) than those without prior visit experience (median = 3.10). Respondents also acquired prior knowledge by watching online videos (45%) and public media news items (45%) or through the messaging app WeChat (36%), books and magazines (34%) and the

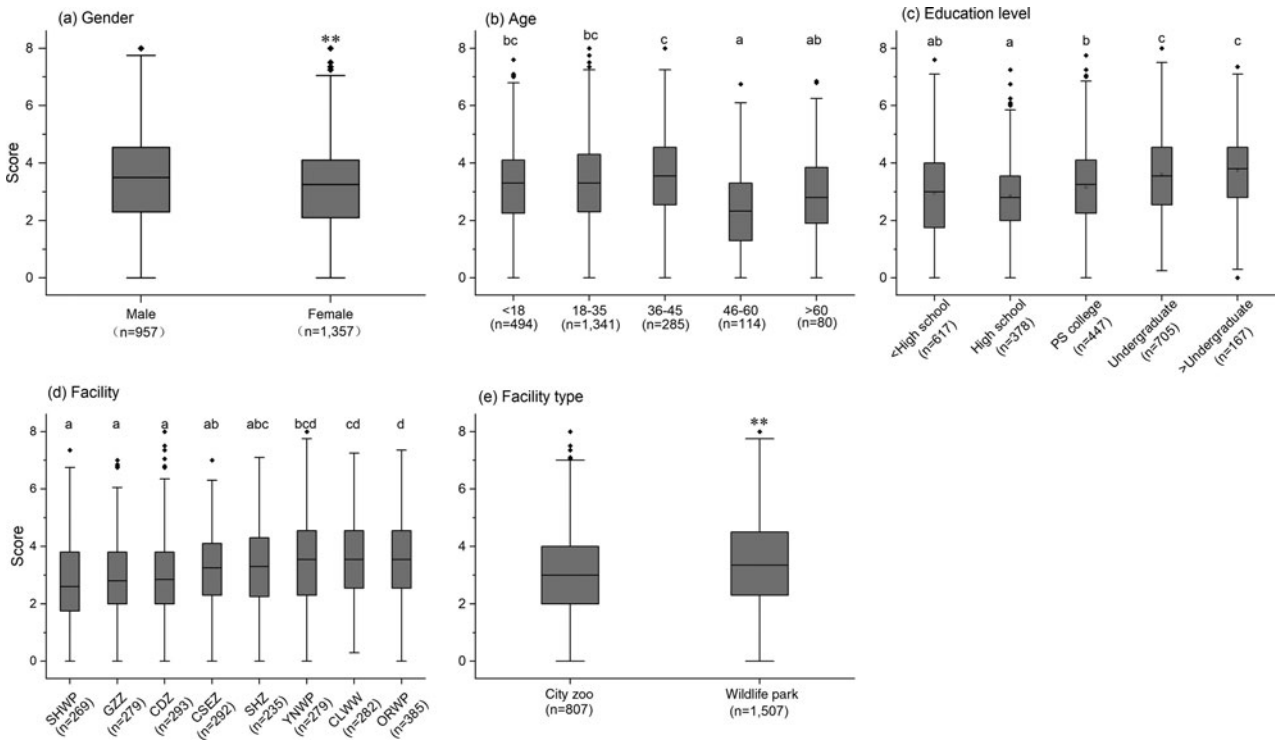

FIG. 4 Effects on respondents' knowledge of giant panda biology of (a) gender, (b) age, (c) education level (PS, post-secondary specialized), (d) facility at which surveys were conducted (SHWP, Shanghai Wildlife Park; GZZ, Guangzhou Zoo; CDZ, Chengdu Zoo; CSEZ, Changsha Ecological Zoo; SHZ, Shanghai Zoo; YNWP, Yunnan Wildlife Park; CLWW, Changlong Wildlife World; ORWP, Ordos Wildlife Park), and (e) facility type (city zoo and wildlife park). The horizontal lines within the Box–whisker plots represent the median scores, the boxes the interquartile ranges (IQR; between the 25th and 75th percentile), whiskers represent the minimum ($Q_1 - 1.5 \times IQR$) and maximum values ($Q_3 + 1.5 \times IQR$); diamonds represent outliers. **$P < 0.01$; Mann–Whitney U test. For multiple tests, boxes headed by the same letters were not significantly different (Kruskal–Wallis tests followed by post hoc Mann–Whitney U tests).

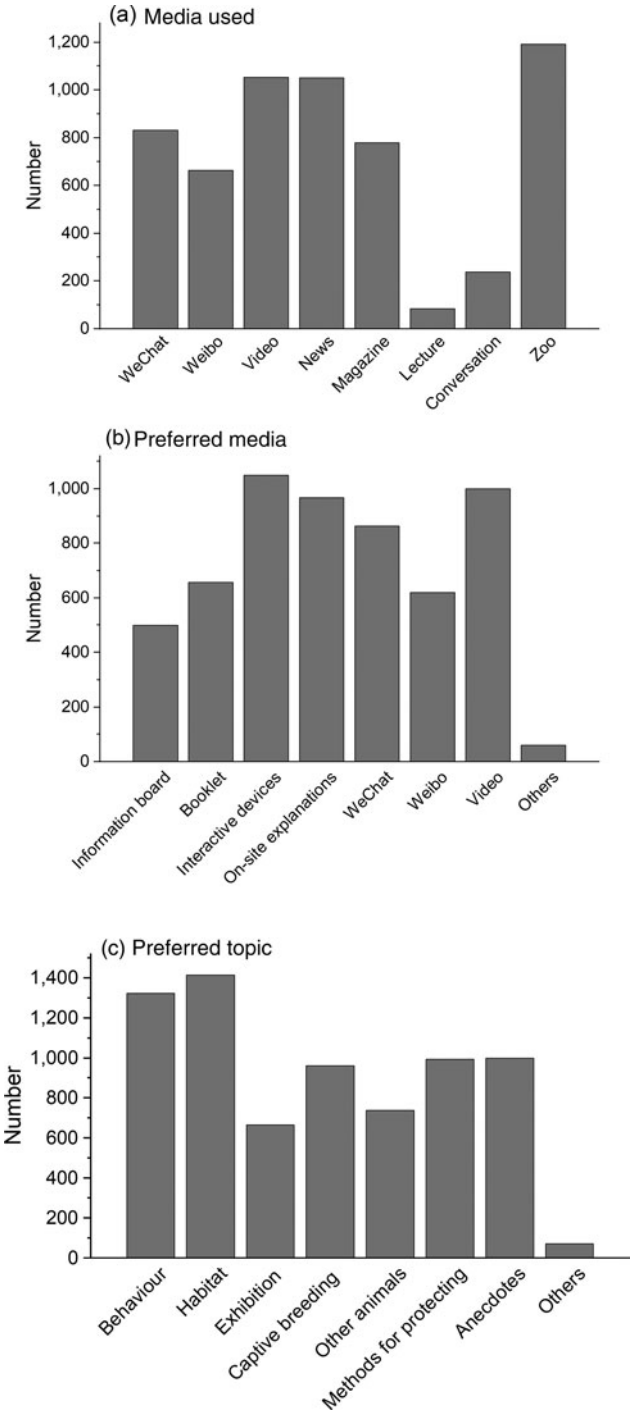

FIG. 5 (a) Media used by 2,296 respondents to acquire information about giant pandas, (b) media preferred by 2,314 respondents for learning about giant pandas, and (c) preferences of 2,314 respondents for topics on which they would like to gain more information.

microblogging site Weibo (29%). These sources of information are not mutually exclusive. Relatively few respondents acquired knowledge about pandas through conversations with friends and relatives (10%) or by attending lectures (4%; Fig. 5a).

Preferred sources of information at the exhibits

Nearly half (45% of the total of 2,314) of respondents expressed a preference for learning more about pandas at the exhibits through interactive devices, followed by online videos (43%), on-site explanations by zoo staff (42%) and WeChat (37%); the least preferred media were booklets (28%), Weibo (27%) and information boards (22%; Fig. 5b).

In terms of exhibit content, the greatest proportion of visitors expressed an interest in learning about panda habitats (61%), whereas 57% expressed an interest in panda biology (behaviour), 43% enjoyed anecdotes about pandas, 43% were interested in panda conservation and protection and 42% were concerned with managing inbreeding; 32% of respondents were also interested in other animals found in panda reserves and 29% were interested in other exhibition information (Fig. 5c).

Visitor attitudes to the panda exhibits and panda conservation

In response to our final five questions on attitudes towards the exhibition of pandas, all respondents agreed with all five statements provided in these questions (Supplementary Material 1), with respondents ranking the statement 'I would recommend this panda exhibition to others' as most applicable to their experience, yielding a mean satisfaction score of 4.44/5 (Fig. 6).

Discussion

Contrary to our principal hypothesis, visiting panda exhibits failed to increase respondent knowledge of giant panda biology above 60%. This is below the level of pedagogic success

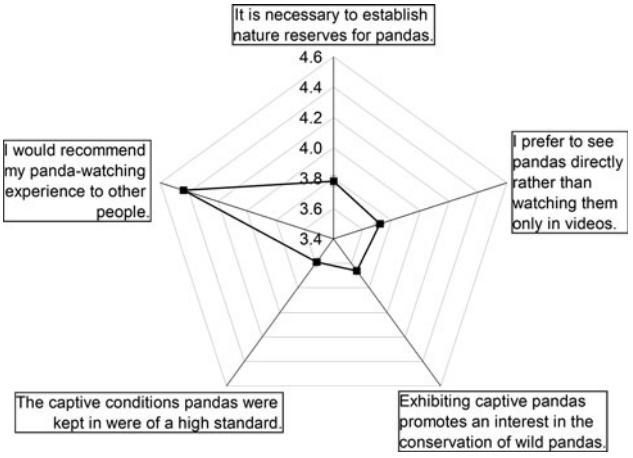

FIG. 6 Opinions (weighted means) of 2,314 respondents regarding five statements on giant pandas scored on a five-point Likert scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree).

of zoo exhibits reported previously (Moss et al., 2015). Moreover, only the question about the main food of pandas was answered correctly by > 60% of respondents (Fig. 2), it being well-known generally that pandas eat bamboo. Nevertheless, all visitors were interested in seeing the pandas. This suggests predominantly a hedonic (enjoyment) or eudemonic (meaningful) motivation for visitation (sensu Buesching et al., 2015), meaning that respondents visited mainly for the pleasure of observing the pandas, which is a more common motivation amongst the general public than a pedagogic motivation to learn about wildlife. Despite the unique flagship status of the panda in China, this outcome is contrary to previous findings showing that zoo visits increased biodiversity knowledge (Clayton et al., 2017; Moss et al., 2017); however, it has also been shown previously that zoo visits do little to promote attitude change amongst visitors (Marino et al., 2010, 2011). It thus should not be assumed that panda exhibits in China promote pro-conservation attitudes or action. More engagement with panda conservation issues beyond supplying information boards appears to be necessary to increase any educational benefits (Clayton et al., 2017).

In accord with our first prediction (a), formal education had a positive effect on visitor knowledge of panda biology and their appreciation of the exhibit. For instance, amongst the 36–45 age class, those with higher levels of education (undergraduate degrees and above) achieved the highest scores on the panda biology questions (Fig. 4b,c). This probably occurred because formal education can increase interest and improve perceptions regarding conservation (Moss et al., 2016; Abdullah et al., 2019) in China (Li, 2018) and elsewhere (Sola, 2014; Morrison & Beer, 2017). Visitors bringing children were more interested in reading educational information boards than visitors without children. Applying the parenting typology of Moore & Moschis (1983; including laissez-faire, protective, pluralistic and consensual parenting), it has been reported previously that Chinese parents most often fit the consensual type, engaging extensively in both social as well as concept-orientated communication (Chan & McNeal, 2013), especially better-educated parents with higher household incomes (Dawson, 2014). Future sociological research into the educational potential of zoos should investigate these links with parenting styles.

Also in accord with prediction (a), we found that previous experience of visiting a panda exhibit substantially and significantly increased correct responses to questions about panda biology. Supporting subsidiary hypothesis (2), however, we found that the type of facility was also influential: visitors to rural wildlife parks achieved higher scores in answering the panda biology questions than did visitors to city zoos. This could have a motivational factor as city residents often visit zoos for fun and to relax whilst simultaneously feeling more removed and isolated from wildlife and environmental issues of concern in their daily lives (Chen et al., 2011; Zhang et al., 2014; Wilkins et al., 2019). City zoos often contain leisure areas, such as playgrounds and restaurants, and have lower entry prices. Alternatively, these differences could arise because of variation in the quality of the panda exhibits. Wildlife parks tend to be more modern (Shanghai Wildlife Park, Guangzhou Changlong Wildlife World, Yunnan Wildlife at Kunming, Changsha Ecological Zoo and Ordos Wildlife Park opened in 1995, 1997, 2004, 2010 and 2012, respectively) and more spacious than city zoos. Therefore, panda exhibits in wildlife parks often include more individuals, are larger in size and more varied in enclosure structure, and offer more educational resources, using a wider variety of information (although we found no effect of type of media on beneficial educational outcomes). The higher cost of entry to wildlife parks could also deter visitors who are less motivated to acquire knowledge on conservation issues.

In accord with prediction (b), visitor characteristics affected their scores significantly. Our socio-demographic analysis revealed that the majority of questionnaires (59%) were completed by women. This compliance bias conforms to general patterns showing women more willing to complete surveys (Rourke & Lakner, 1989). Nevertheless, men on average scored slightly but significantly higher than women in questions about panda biology (Fig. 4a). There was, however, an interactive age effect, in which female respondents were skewed towards the 46–60 age class (Fig. 1) and older visitors scored lower on panda biology questions on average (Fig. 4b) than younger visitors (< 18, 18–35 and 36–45 age classes). This could be because younger people have been brought up in a more environmentally aware age and culture and subjected to more positive and better-targeted messaging on environmental issues (Hubbert, 2015; Ramzan et al., 2019; Song et al., 2019). In comparison, visitors aged 46–60 underwent at least some of their education during the Cultural Revolution in China (1966–1976). Conservation biology was considered unimportant in China at that time (Du, 1982). Instead, the Four Pests Campaign (Zhao & Su, 2011) aimed to reduce or eliminate pestilent diseases by killing rodents, flies, mosquitoes and sparrows that consumed fruits and seeds. This campaign caused significant ecological damage. Furthermore, in 1977 < 5% of people went to university in China (Liu, 2019). The first Chinese panda nature reserve was established in 1963 (Hu et al., 2011) and the first Law of the People's Republic of China on the Protection of Wildlife was issued in 1989 (Cao & Wang, 2004). Since then the culture has shifted towards support for wildlife protection and conservation. For instance, information about wildlife protection was not added to official school and college textbooks until 1999 (Lu, 2000).

In relation to prediction (c), we found that the geographical locations of zoos and wildlife parks had a strong effect

on visitor knowledge about pandas (Fig. 4d). For instance, and counterintuitively, visitors to Chengdu Zoo, which is within the geographical range of pandas, had on average less knowledge of panda biology than visitors elsewhere despite regional promotion of panda conservation. Further evaluation, however, suggested that such was the reputation of Chengdu Zoo that it drew in many visitors from far beyond Sichuan and Chongqing. This tourism represents visits motivated by the pursuit of enjoyment rather than by an interest in understanding panda biology and conservation issues. To investigate this effect more thoroughly, future surveys should ask respondents where they have travelled from.

Regarding satisfaction with exhibits in terms of both panda husbandry and with the educational material detailing efforts to conserve pandas in the wild, we found that only 6% of visitors expressed dissatisfaction and 88% were satisfied. Visitors also expressed a willingness to recommend the zoo or wildlife park to others and to learn more about pandas in the future. In the UK, eco-literacy is often acquired from informal word-of-mouth sources such as parents and friends rather than from television or in school (Pilgrim et al., 2007; Andersson & Öhman, 2017), whereas in the USA social media has become the dominant resource informing the public about environmental or wildlife issues (Barry, 2014). In contrast, we found that in China the majority of visitors with prior knowledge of pandas acquired this knowledge by visiting other zoos and panda conservation sites or by watching online videos and public media news items, supplemented by information available on social media platforms such as WeChat and Weibo. This indicates a preference for more passive media in China (information and education through exposure) rather than active research or participation in social media forums. This has important implications for refining the design of exhibits in zoos and wildlife parks in China, suggesting the focus should be on anecdotal material, videos and education through narratives (Pye, 2022). Despite younger people exhibiting a bias favouring modern social media, Duan & Fortner (2010) found that even college students in China prefer information supplied by traditional mass media (Gil de Zuniga et al., 2017), which is managed by the central government. However, we found that under-18s expressed a much greater preference for display panels and booklets than older people, possibly because these students are still undertaking formal education and are accustomed to learning from written sources such as textbooks. Future studies should test the longitudinal learning experience of people making repeated visits to zoos (following Moss et al., 2016).

In conclusion, our survey identified that visitors to panda exhibits still came away with poor knowledge of panda biology, although, on average, men knew a little more about pandas than women and older visitors knew a little less than younger visitors. Although people visiting wildlife parks were better informed about pandas than those visiting city zoos, all visitors preferred learning about pandas through live on-site explanations by zoo staff, especially regarding panda habitats and behaviour. Importantly, visitors to zoos and wildlife parks were satisfied generally with the panda loan exhibits and felt that zoo exhibits contribute towards ex situ panda conservation.

Based on our survey results we recommend the use of age- and gender-specific media to improve knowledge about giant pandas, especially via interactive devices. People over 45 years old and women would benefit most from more targeted information campaigns, cognizant that childcare and early education remain the traditional responsibilities of mothers and cohabiting grandparents in China. We also advocate for integration of biodiversity and conservation into the formal education curriculum on ecosystems and ecology, with the panda serving as an umbrella species by which other plants and animals can be introduced (Li & Pimm, 2016).

To improve future surveys of this type, we recommend questioning visitors before and after viewing panda exhibits, to ascertain the specific and intrinsic benefits of their experience. This approach, however, presents two practical constraints: it would require twice as many research staff to administer (or half the sample size), and it could increase the risk of respondent fatigue, according to which visitors might be less willing to donate their time to answering two sets of questionnaires, impinging on their enjoyment of a recreational trip to a zoo/wildlife park with their families and thereby altering their satisfaction responses. Preconceptions could also influence visitor experiences, as the theory of planned behaviour (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980) posits that the likelihood of an outcome relates to the strength of the intention of an individual to engage in a behaviour (Ajzen, 1991). This can depend on personal attitudes, subjective norms and perceived behavioural control, all of which are complex sociological variables, the investigation of which would require a more complex questionnaire than the one we used. However, one minimally intrusive additional question we would include in future surveys is to ask where visitors have travelled from. This would enable an improved investigation of regional differences in visitor scores and the interactive effect of tourism on outcomes of visitor experience. It would also be valuable to survey non-zoo-goers from the general population and compare whether their knowledge of panda biology differs from that of people who have visited panda exhibits.

Target 1 of the Aichi Biodiversity Targets in the United Nations Strategic Plan for Biodiversity 2011–2020 called for action to ensure 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' (Moss et al., 2015). Some aspects of zoo exhibits are still underdelivering on

their potential for environmental education. Ultimately, therefore, we hope that our findings will inform the Office of Giant Panda Management regarding ways to modify and improve the design standards of the panda loan programme to better promote biodiversity conservation in China.

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Author contributions Study conception and design: WL, LZ, DL; material preparation, data collection and analysis: XY, WH; writing: XY, DL.

Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards. All questionnaire protocols employed in this study conformed with the Social Research Guidelines of Beijing Normal University (compatible with policies of the Social Research Association) and underwent departmental ethical review. Survey permits were obtained from the administration of each zoo/wildlife park. All questionnaire data were anonymized and all participants were made aware of the purpose of our study and consented to our use of these data (including parental consent for children participating in the survey). The data are all stored securely on a protected server.

Data availability The data that support this study are available from the corresponding author, DL, upon reasonable request.

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