Support for wildlife consumption bans and policies in China post-Covid-19

Jessica Bell Rizzolo, Annah Lake Zhu and Ruishan Chen

Abstract The Covid-19 pandemic, which probably arose from zoonotic sources, has provoked wide-ranging discussion on which wildlife policies can best prevent future pandemics. More work needs to be done to investigate support for regulatory frameworks in China post-Covid-19 and specifically to model how perceptions of the relationship between wildlife consumption and risk of zoonotic diseases combine with other variables to influence support for wildlife policies. We report on a 2021 quantitative survey conducted in China. The objectives were to measure attitudes towards the current wildlife consumption ban and wildlife regulations in China and to model which variables correlate with support for bans on wild-caught and farmed wildlife. The sample was almost evenly split between considering the ban on wild animal consumption in China to be adequate (45%) or not strict enough (42%). Protection against future pandemics and protection of the environment were motivators for supporting the ban for c. 80% of respondents. The results also indicated strong support for wildlife bans. A majority of respondents supported bans of both wild-caught and farmed wildlife, although support for bans of wild-caught animals was greater for most taxa. Furthermore, the perceived zoonotic risk of a taxon was a more prevalent correlate of support for a ban for wild-caught wildlife than for farmed wildlife. Our results indicate substantial support for the current wildlife consumption ban in China, and opportunities to further mitigate the environmental and zoonotic risks of wildlife consumption.

Keywords China, Covid-19, pandemic, wet market, wildlife, wildlife consumption, wildlife farm, zoonotic disease

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Introduction

The Covid-19 pandemic, which probably arose from zoonotic sources, has provoked wide-ranging discussion on how best to prevent future pandemics (Chen et al., 2020; Van Kerkhove et al., 2021). It is widely acknowledged that efforts to combat zoonotic disease should include both biosecurity measures (e.g. disease surveillance) as well as policies that target wildlife consumption (Yuan et al., 2020). Proposed interventions include reduced frequency of direct human–wildlife contact (Karesh et al., 2005), increased surveillance of wildlife and traders to monitor potential pathogens (Daszak et al., 2020), risk management tools tailored towards wildlife markets (Wikramanayake et al., 2021), full or partial bans on wildlife consumption (ideally in conjunction with alternative sustenance options), enhanced legal protection for more wildlife species, increased prosecution of wildlife trade violations, and regulations for captive-bred wildlife (Borzée et al., 2020; Chang & Chang, 2020). A common rationale for enhanced regulations is that current wildlife consumption patterns pose a high level of risk, particularly in wet markets (Aguirre et al., 2020).

In China, the government responded to the outbreak of Covid-19 with a ban issued in February 2020 (Koh et al., 2021; Sardana & Fischer, 2021). This prohibits the farming, hunting, selling and purchasing of species defined by law as terrestrial wild animals for food consumption (Huang et al., 2021). However, this ban does not apply to aquatic species and explicitly allows the use of wildlife for medicinal, ornamental or scientific purposes (Rizzolo, 2021; White, 2021). Furthermore, for species that are used for multiple purposes (e.g. small carnivores such as the civet *Paradoxurus hermaphroditus* and racoon dog *Nyctereutes procyonoides*, which are utilized both for food and fur), only their production and consumption for food are banned (Whitfort, 2021).

The February 2020 ban was not without precedent, as the 2003 severe acute respiratory syndrome (SARS) epidemic also led to changes in wildlife regulations in China. However, as the post-SARS ban on wildlife consumption was lifted a few months after its implementation (Li et al., 2020), it remains to be seen whether the severity of Covid-19 could lead to more permanent wildlife regulations (Huang et al., 2021). Although the February 2020 ban can be viewed as an improvement on an outdated and ineffective legal wildlife trade management system (Yang et al., 2020; Koh et al., 2021; Xiao et al., 2021a,b), it is unclear

whether the Chinese public will view the ban as legitimate (Cawthorn et al., 2021).

Furthermore, China has promoted the legal and intensive farming of numerous wildlife taxa, including badgers, bears, bamboo rats, civets, crocodiles, deer, ferrets, foxes, frogs, macaques, mink, muskrats, pheasants, pangolins, raccoon dogs, snakes, the tiger *Panthera tigris* and turtles (Whitfort, 2021). By the end of 2006, there were 19,018 wildlife breeding and farming ventures in China; Wang et al. (2019) estimated the number of farmed wildlife to range from the thousands (c. 5,000 tigers and 10,000 bears) to the millions (70 million mink). China also imports a large number of farmed wildlife. During 1997–2016 on average over half (56%) of wildlife imported into China was captive-bred, and this per cent was higher for birds and fish (Jiao & Lee, 2022). However, farmed wildlife has yet to saturate the demand of Chinese customers, as consumers are often willing to pay more for wild-sourced products (Dutton et al., 2011; Coals et al., 2020), have complex motivations for switching between wild and farmed products (Hinsley et al., 2022) and are influenced by the social acceptability of various forms of wildlife products (Rizzolo, 2021).

The proliferation of wildlife farms can have severe and unintended consequences for the spread of zoonotic diseases (Jiao & Lee, 2021), as wildlife farms are both suppliers to wet markets and also potential sources of disease in their own right (Petrovan et al., 2021). Although the February 2020 ban applies to farmed terrestrial wildlife (You, 2020), addressing the wildlife farming industry in China and its potential links to zoonotic diseases remains a significant logistical challenge (Wang et al., 2020).

Research in China post-Covid-19 has found evidence for decreased wildlife consumption (Liu et al., 2020a,b; Lin, 2021), although this could be motivated by legal enforcement or social stigmatization (Lin, 2021) as well as awareness of food safety (Li & Wang, 2021) and proximity to Covid-19 outbreaks (Zhang et al., 2022). Attitudes towards wildlife consumption in China post-Covid-19 are often complex; in another China-based study, although almost 80% of respondents believed that the wildlife trade facilitated disease transmission, 31% continued to consume wild animals (Li et al., 2021). Furthermore, perceptions of zoonotic risk and the impacts of these attitudes on wildlife consumption behaviours vary across taxa, with the impacts of zoonotic pandemics yielding more significant reductions in the consumption of some taxa than of others (Duonamou et al., 2020). The ongoing debate over the origins of Covid-19 has complicated policy responses further despite documentation of a zoonotic link (Worobey, 2021; Zhu et al., 2023).

Since the emergence of Covid-19 the feasibility of wildlife consumption bans (either broad or targeted) continues to be debated. Although some argue that broad bans are not realistic given cultural and livelihood attachments to wildlife products (Zhu & Zhu, 2020; Biggs et al., 2021), others have noted that wildlife consumption bans are an essential first step towards effective protection of wildlife and human health (Xiao et al., 2021a). Multiple factors such as cultural beliefs, economic conditions, demographic variables and the supposed medicinal properties of wildlife products affect whether and what type of bans will be accepted by the public and thus will be feasible to implement (Rizzolo, 2021). Yet there is evidence (albeit in a UK sample) that a narrative of Covid-19 that emphasizes its origins in human–animal interaction elicits support for bans on the commercial trade of wildlife (Shreedhar & Mourato, 2020). This suggests that support for policies to protect wildlife and human health can still be harnessed even if research on the origins of Covid-19 is politicized or still in progress (Zhu et al., 2023). However, the current literature on China post-Covid-19 focuses on wildlife consumption patterns (Lin, 2021; Zhang et al., 2022) rather than support for particular regulations such as bans. More work needs to be done to investigate support for regulatory frameworks in China post-Covid-19 and specifically to model how perceptions of the relationship between wildlife consumption and zoonotic risk combine with other variables to influence support for wildlife policies.

Here we expand upon previous literature through an analysis of how support for wildlife policies in China differs according to taxa and whether traded individuals are wild-caught or farmed. Our objectives are two-fold: (1) to measure respondents' attitudes towards the current wildlife consumption ban in China as well as attitudes towards regulations of wildlife more broadly, and (2) to examine which variables correlate with support for bans on wild-caught and farmed wildlife for nine taxa. We discuss the implications of these results for conservation policies in China in the wake of Covid-19.

Methods

We recruited 974 adult respondents through the research firm Qualtrics (Provo, USA), which has experience in China-based sampling (Rizzolo, 2021) and offers a more representative sampling process compared to other online survey tools (Boas et al., 2020). We first wrote the survey in English and then a bilingual member of the research team translated it into Chinese. Before the full survey began, we conducted two pre-tests to ascertain translation clarity, data quality and survey validity. We recruited respondents from the Qualtrics panel and completed the survey online in June 2021 through the Qualtrics platform.

The sampling drew from a China-based panel of individuals recruited from diverse sources, such as website intercept recruitment, member referrals, targeted e-mail lists, gaming sites, customer loyalty web portals, permission-based networks and social media. Qualtrics validates the

names, addresses and dates of birth of panel members via third-party verification measures prior to their inclusion in a panel. Panellists are compensated through various mechanisms: they could be airline customers who choose to join to receive credits that can be applied to flights, retail customers who opt in to receive points at a retail outlet, or general consumers who participate to obtain cash or gift cards. Panel members are given an e-mail invitation or are prompted on the respective survey platform to participate in a given survey. Qualtrics utilizes quality control measures, such as tracking the amount of time a respondent spends on a survey, to ensure data quality. In addition, we employed quality checks that allowed for nuance in attitudes to be expressed but excluded respondents who answered the questions seemingly without reading or comprehending them. For example, these checks removed respondents who stated 'No, I have never consumed wild animals' but then indicated consumption in a subsequent question or respondents who selected an answer in addition to 'None of the above' within the same question.

The full survey (Supplementary Material 1) consisted of sections on demographic information, beliefs and behaviours related to the origins of Covid-19 and wildlife consumption, beliefs and behaviours that pertain to health and traditional Chinese medicine, and attitudes about the regulation of wildlife consumption and the prevention of potential zoonotic transfer through bans and other means. Here we present data from the last section of the survey; the other sections are discussed elsewhere (Rizzolo et al., unpubl. data; Zhu et al., 2023a,b).

We selected a total of nine taxa for assessment from the diverse taxa that are subject to wildlife farming and/or have been investigated as potential transmitters of Covid-19 or other zoonotic diseases or parasites: civets (Tu et al., 2004), frogs (Yang et al., 2007), the tiger (Zhang et al., 2008), bears (Li, 2004), bamboo rats (Ma et al., 2018; Li et al., 2020), mink (Liu et al., 2020a; Fenollar et al., 2021), snakes (Wang et al., 2011), bats (Giri et al., 2021) and pangolins (Gatti, 2020). These taxa differ with respect to the production system used (farmed/wild-caught) and perceptions of zoonotic risk. For most taxa we worded the questions to refer to the entire animal. However, for tigers and bears (as these animals are not consumed whole) we asked specifically about tiger bones and bear bile. We measured respondent attitudes towards the current wildlife ban in China with the following question (Q35 in the Supplementary Material): 'Do you think the ban on wild animal consumption is (a) adequate, (b) too strict, (c) not strict enough, (d) I don't know this policy or (e) other?'. Attitudes towards taxon-specific bans were measured using two questions (Q31 and Q32 in the Supplementary Material), which asked: 'Do you support a ban on the following animals if caught from the wild (a) yes or (b) no?' and 'Do you support a ban on farming the following animals (a) yes or (b) no?'. As this survey employed sampling quotas that were based upon membership in various demographic categories, we recorded gender, age, education and income.

We analysed the data using *SPSS 26* (IBM, 2019). Firstly, we generated descriptive statistics about attitudes towards the current wildlife ban in China. We did not detect collinearity; correlations between the consumption of various taxa were all < 0.7. Secondly, we modelled support for bans of consumption of wild-caught and farmed individuals of the nine taxa. Given that we modelled support for a ban as a dichotomous variable, we used binomial logistic regression. Independent variables were belief that a particular taxon was a probable transmitter of Covid-19 to humans (measured as yes/no), consumption patterns of reptiles, amphibians and mammals, and the demographic control variables of gender, age, education and income. The reference categories for the categorical variables were female (for gender), 70–79 years old (for age), middle school or below (for education), and < CNY 1,000 (for income).

Results

Sample

The sample included gender and age quotas representative of the adult population of China (National Bureau of Statistics of China, 2019) and was diverse in terms of gender, age, income, education and occupation (Table 1). The sample was predominantly urban (91%) but included respondents from all regions of China (Fig. 1).

Correlations indicated a moderate relationship between high earners and higher education levels. The correlation between the highest level of education (graduate degree) and the highest income bracket (> CNY 20,000 per month) was 0.236 and the correlation between the lowest level of education (middle school or less) and the lowest income bracket (< CNY 1,000 per month) was 0.146.

As measured using the Pearson χ^2 test ($\chi^2 = 2.864$, df = 1, P = 0.091), there was no difference between urban and rural respondents in the belief that the current wildlife ban in China is adequate. There was also no difference between rural and urban respondents in support of a ban on the consumption of farmed or wild-caught wildlife (Table 2).

Attitudes towards regulation

The results indicated broad support for many pathways of regulation. The majority of respondents supported regulations on imported products (78%), wild animal farms (76%), wet markets (75%), wild animal trade (69%) and virology research (62%). Furthermore, the majority of respondents supported bans on both wild-caught and farmed wildlife (Table 3). Although there was some variation between taxa, respondents supported bans on valuable taxa

TABLE 1 Demographic characteristics of the survey sample of 974 respondents.

Characteristic	%
Gender	
Male	52.3
Female	47.7
Age (years)	
20–29	17.6
30–39	16.5
40–49	23.4
50–59	20.9
60–69	14.9
70–79	6.7
Occupation sector[1]	
Agriculture	10.2
Construction	13.3
Education	12.6
Food service	9.2
Government	5.8
Healthcare	4.1
Technology	19.5
Other	25.3
Monthly personal income (CNY)	
< 1,000	1.9
1,000–5,000	23.6
5,001–10,000	37.3
10,001–20,000	21.6
> 20,000	15.6
Highest level of education	
Middle school or below	1.8
High school	15.5
College	74.2
Graduate degree	8.5

[1]The eight primary occupational categories in China.

(pangolins, tigers) and widely farmed taxa (bamboo rats, snakes).

When asked in particular about the ban on wild animal consumption that China issued after the outbreak of Covid-19, 75% of respondents thought that people were adhering to this ban (14% believed people were not in compliance and 11% were unfamiliar with the policy). Respondents had differential attitudes towards the adequacy of the current ban in China (Fig. 2) and towards overall policies governing wild animals (Fig. 3).

When asked which rationales would lead them to support a ban on wildlife consumption, respondents endorsed numerous rationales, with protection against future pandemics and protection of the environment being motivators for 80% of respondents (and protection of animal welfare and consumer health being motivators for 68% of respondents).

Support for taxon-specific bans

In the models of bans pertaining to wild-caught animals (Table 4), perceived zoonotic risk was a strong correlate for increased support for bans of all taxa except pangolins and bats. Although zoonotic risk was not significant in the bat and pangolin models, one variable that was significant in those models (as well as the models for other taxa) was belief that the current ban in China is adequate. Consumption of mammals increased the odds of supporting a ban on wild-caught tigers and bears. Furthermore, in these models being aged 60–69 years decreased the probability of support for such bans.

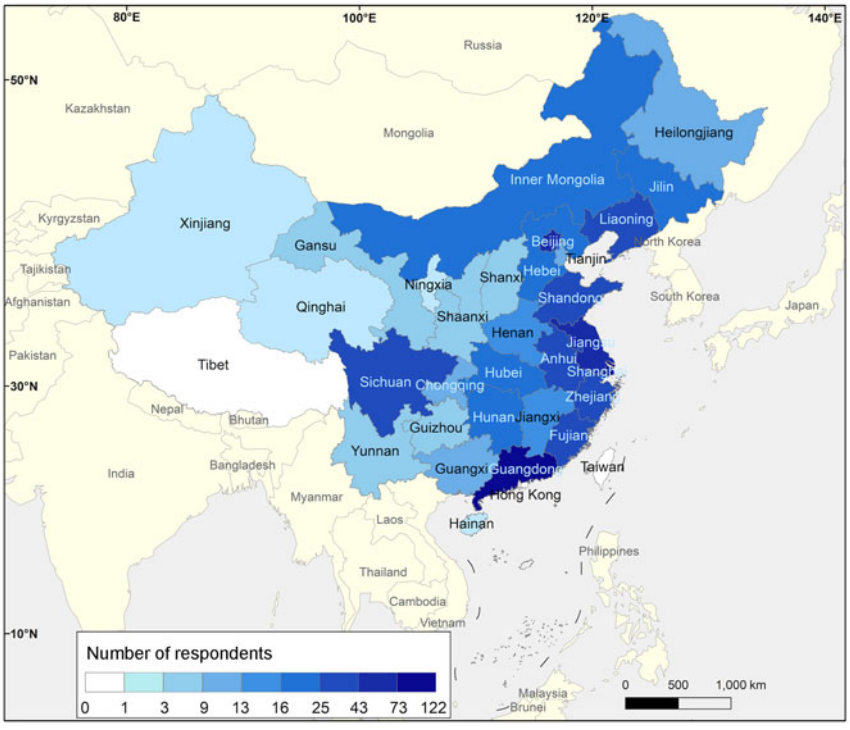

FIG. 1 The geographical distribution of the 974 respondents.

TABLE 2 Results of Pearson χ^2 tests comparing the support of rural and urban respondents of a ban on the consumption of farmed and wild-caught wildlife (df = 1 in all cases).

Taxon	χ^2	P
Farmed wildlife		
All farmed wildlife	2.589	0.108
Bamboo rats	0.568	0.451
Bats	0.939	0.333
Bears	3.757	0.053
Civets	2.447	0.118
Frogs	1.304	0.254
Mink	2.925	0.087
Pangolins	4.192	0.041
Snakes	1.355	0.244
Tiger *Panthera tigris*	1.731	0.188
Wild-caught wildlife		
All wild-caught wildlife	0.155	0.694
Bamboo rats	1.384	0.239
Bats	0.391	0.532
Bears	0.399	0.528
Civets	1.098	0.295
Frogs	0.024	0.877
Mink	2.550	0.110
Pangolins	0.621	0.431
Snakes	1.056	0.304
Tiger	0.723	0.395

TABLE 3 Per cent of the sample of 974 respondents who supported bans on the consumption of wild-caught wildlife and farmed wildlife.

Taxon/product	% supporting wild-caught ban	% supporting farmed ban
All wild animals	70.7	57.4
Bamboo rats	77.5	72.6
Bats	85.7	87.8
Bear bile	83.4	82.1
Civets	84.1	83.8
Frogs	75.2	64.8
Mink	80.5	68.4
Pangolins	85.1	73.8
Snakes	77.0	64.9
Tiger bone	83.7	80.0

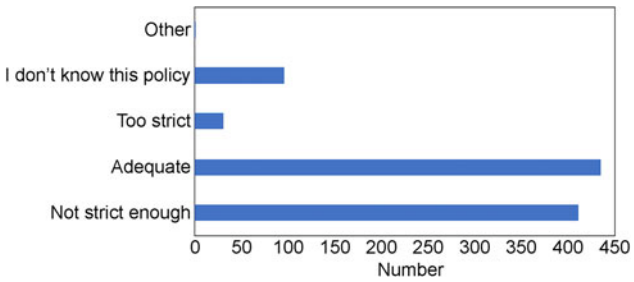

FIG. 2 Responses (of a total of 974 respondents) to the question 'China's ban on wildlife consumption is _____'.

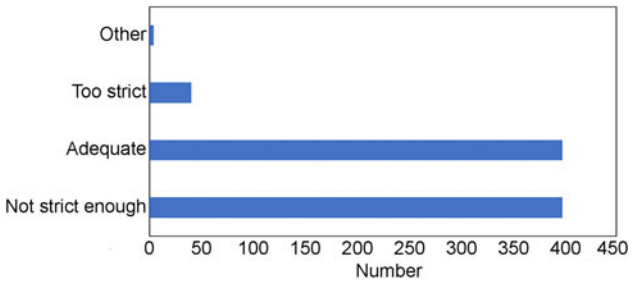

FIG. 3 Responses (of a total of 974 respondents) to the question 'Current policies governing wild animals in China are _____'.

The models of bans pertaining to farmed wildlife (Table 5) showed different results from those of bans on wild-caught taxa. Zoonotic risk was not a significant indicator for most taxa (the two exceptions being civets and frogs). In contrast to the models on bans concerning wild-caught animals, respondents aged 60–69 years were more likely to support bans regarding farmed wildlife of numerous taxa. Income had no effect in the models on bans concerning wild-caught animals, but was a significant factor in those regarding farmed wildlife: belonging to a higher-income group increased the probability of supporting a ban on farmed frogs, tigers, mink and pangolins.

Discussion

Our findings have several important implications for wildlife conservation interventions in China following the Covid-19 pandemic. The feasibility of the current wildlife ban in China and the potential for additional regulatory frameworks around wildlife consumption and zoonotic diseases have both been debated extensively in the conservation literature and policy arenas (Yang et al., 2020). Our results demonstrate both how the current wildlife ban in China is perceived and how support for wildlife consumption bans is contextualized and segmented by demographic variables, taxa, perceived zoonotic risk and whether animals are wild-caught or farmed. Such information is essential for the design and implementation of conservation initiatives such as demand-reduction efforts and/or enhanced regulation (Naidoo et al., 2021).

A crucial implication of our research is that, at least in an urban sample, there is widespread support for wildlife consumption bans in China post-Covid-19. Overall, the majority (70–90%) of respondents supported bans on wild-caught and farmed wildlife of several taxa. This support for bans extended to species of various taxa (amphibians, mammals and reptiles) and included threatened species used for lucrative products (tiger bone), widely farmed and consumed taxa (bamboo rats) and products used for medicine (bear bile). This suggests that now is an opportune moment to support efforts in China to regulate and limit

TABLE 4 Odds ratios (Exp(B) values) from models of support for bans on consumption of nine wild-caught taxa amongst the 974 respondents.

	Civets	Frogs	Tiger	Bears	Bamboo rats	Mink	Snakes	Bats	Pangolins
Zoonotic risk									
Believe likely to transmit Covid-19	7.098*	2.718*	12.657*	8.366*	6.391*	14.284*	2.662*	1.595	1.073
Consumption patterns									
Consume reptiles	0.781	0.470*	0.506	0.574	0.728	0.721	0.570	0.720	0.705
Consume amphibians	0.950	0.706	0.908	0.848	0.623	0.526	0.508	0.880	0.663
Consume mammals	1.346	0.773	4.321*	3.894*	0.462	0.909	0.684	3.389	2.703
Ban attitude									
Current ban adequate	2.189*	1.612	2.419*	2.176*	1.586	2.086*	1.932*	2.622*	2.405*
Gender[1]									
Male	0.810	1.016	0.654	0.637	0.870	0.943	1.034	0.743	0.814
Education[1]									
High school	0.587	4.802	1.555	1.733	1.733	0.401	3.286	0.829	0.935
College	0.507	2.888	0.881	1.002	1.312	0.536	1.677	0.511	0.591
Graduate degree	0.304	2.535	0.440	0.457	0.843	0.359	1.168	0.268	0.320
Age (years)[1]									
20–29	0.258	0.136*	0.162	0.154	0.162	1.039	0.145	0.222	0.207
30–39	0.603	0.154*	0.209	0.197	0.220	1.437	0.166	0.432	0.319
40–49	0.659	0.274	0.513	0.441	0.200	1.116	0.222	1.368	0.739
50–59	0.552	0.331	0.299	0.257	0.271	1.199	0.233	0.245	0.350
60–69	0.057*	0.034*	0.035*	0.026*	0.023*	0.139	0.029*	0.041*	0.037*
Monthly personal income (CNY)[1]									
1,000–5,000	2.200	2.183	1.286	1.288	4.491	2.289	2.299	1.744	2.055
5,001–10,000	2.227	1.866	1.535	1.515	3.709	1.621	2.325	1.658	1.798
10,001–20,000	6.331	2.976	4.066	4.082	7.030	3.300	4.567	6.165	4.939
> 20,000	3.220	0.955	1.975	2.316	1.844	0.913	1.183	2.270	2.679
Constant	5.420	3.501	14.527	19.103	3.673	3.521	5.197	11.759	15.823
Nagelkerke R^2†	0.424	0.262	0.350	0.334	0.381	0.401	0.305	0.376	0.331

*P < 0.001.

[1]For categorical variables, the reference categories are: female (for gender), middle school or below (for education), 70–79 (for age), and < CNY 1,000 (for income).

†Nagelkerke R^2 is a measure of model fit (< 0.2 indicates a weak relationship between the predictors and the outcome, 0.2–0.4 indicates a moderate relationship, and > 0.4 indicates a strong relationship).

wildlife consumption. Although it is important to replicate our study with a predominantly rural population, our analysis indicated no differences in support for bans (of either farmed or wild animals) between our urban and rural respondents. Furthermore, urban residents in China are significant consumers of wildlife products (Zhang et al., 2008; Zhang & Yin, 2014), so a high level of support for bans amongst this population is an important measure of the social acceptability of wildlife bans in China. Protection against future pandemics was not the only rationale given for the endorsement of wildlife consumption bans; c. 80% of respondents viewed protection of the environment as a valid reason for wildlife consumption bans. This could be because a large number of our respondents (62%) had protective attitudes towards wildlife (Zhang et al., 2008; Rizzolo, 2021), which could predispose them towards environmental rationales for policy decisions.

Comparisons with studies conducted prior to the outbreak of Covid-19 demonstrate that this pandemic could have contributed to a shift in such support. For example, a survey in 2011/2012, also with an urban Chinese sample, demonstrated that c. 63% of respondents supported tiger farms (Liu et al., 2015), whereas in our study 80% of respondents supported a ban on tiger farms. Although these samples are not directly comparable, they provide a snapshot of how views on wildlife consumption in China have shifted.

Our results also have significant implications for the differences in consumption of wild-caught and farmed wildlife in China. For almost all of the nine taxa, support for bans concerning wild-caught wildlife was greater than support for bans on the consumption of farmed wildlife (Table 3). In addition, the demographic correlates of support differed for bans regarding wild-caught and farmed wildlife. Income was a significant variable in the models concerned with farmed wildlife but not in those relating to wild-caught animals, with higher income increasing the probability that a person would support a ban on the consumption of farmed frogs, tigers, mink and pangolins. Farmed wildlife

TABLE 5 Odds ratios (Exp(B) values) from models of support for bans on consumption of nine farmed taxa amongst the 974 respondents.

	Civets	Frogs	Tiger	Bears	Bamboo rats	Mink	Snakes	Bats	Pangolins
Zoonotic risk									
Believe likely to transmit Covid-19	1.928*	2.477*	2.966	1.926	1.329	0.864	1.165	1.370	0.918
Consumption patterns									
Consume reptiles	0.848	0.430*	0.436*	0.444*	0.540	0.340*	0.453*	0.636	0.471*
Consume amphibians	0.583	0.481*	0.833	0.818	0.664	0.469*	0.432*	0.825	0.620
Consume mammals	1.165	0.377*	0.701	1.056	0.706	0.576	0.521	1.268	0.641
Ban attitude									
Current ban adequate	0.958	0.897	0.792	0.988	1.229	0.975	1.131	0.960	0.822
Gender[1]									
Male	0.729	0.655	0.713	0.708	0.856	0.702	0.633	0.917	0.662
Education[1]									
High school	0.693	0.596	1.010	2.276	1.835	0.396	0.622	0.00	0.558
College	0.625	0.309	0.691	1.824	1.109	0.257	0.304	0.00	0.320
Graduate degree	0.840	0.369	0.768	1.797	1.425	0.422	0.394	0.00	0.221
Age (years)[1]									
20–29	0.162*	1.947	0.308	0.044*	0.503	1.668	1.902	0.074*	1.888
30–39	0.159*	1.137	0.270	0.040*	0.609	1.418	1.458	0.103	1.083
40–49	0.272	1.488	0.485	0.083*	0.548	1.607	1.793	0.313	1.370
50–59	1.093	2.816	0.593	0.124	1.096	2.373	3.083	0.467	2.570
60–69	1.306	4.622*	1.286	0.603	2.202	4.073	4.907*	3.622	4.371*
Monthly personal income (CNY)[1]									
1,000–5,000	3.193	3.085	2.332	2.350	2.823	2.330	1.975	2.551	1.524
5,001–10,000	3.883	5.555*	4.434	3.288	2.732	4.736	3.398	2.171	3.586
10,001–20,000	5.961	8.512*	7.165*	4.983	3.467	7.765*	5.455	4.088	6.663*
> 20,000	5.589	6.692*	12.580*	6.796	2.826	5.361	3.390	3.169	13.263*
Constant	5.823	1.141	4.715	12.180	1.247	2.131	1.496	$1.419E+9\times10^{9}$	2.848
Nagelkerke R^2†	0.197	0.319	0.210	0.208	0.148	0.287	0.272	0.223	0.271

*P < 0.001.

[1]For categorical variables, the reference categories are: female (for gender), middle school or below (for education), 70–79 (for age), and < CNY 1,000 (for income).

†Nagelkerke R^2 is a measure of model fit (< 0.2 indicates a weak relationship between the predictors and the outcome, 0.2–0.4 indicates a moderate relationship, and > 0.4 indicates a strong relationship).

products are often perceived as less prestigious, effective or potent, whereas wild-caught wildlife is often viewed as nutritious, delicious and socially valued (Zhang et al., 2008; Coals et al., 2020). One possible explanation for this is that higher earners can afford the often more expensive wild-caught wildlife products and thus bans on farmed wildlife do not threaten their consumption patterns. Higher earners could also have achieved higher levels of education, which could make them more aware of the connections between wildlife consumption and health outcomes. However, it is also possible that members of higher income groups would have objections to wildlife farms that are not shared by lower income groups, such as concerns about animal welfare (You et al., 2014).

For those aged 60-69 years, age had the opposite effect on the support of bans concerning wild-caught vs farmed wildlife: these respondents were less likely to support bans on the consumption of wild-caught wildlife and more likely to support bans on wildlife farming. Although older respondents probably still use or consume wildlife, especially products such as tiger bones that are used for health ailments common in the elderly (Gratwicke et al., 2008), this segment of the population could view wild-caught species as more beneficial to their health and thus not object to farming bans.

Future research should aim to determine the reasons for these demographic variations between support for bans concerning wild-caught and farmed wildlife in terms of ethical concerns, perceived quality/price of the wildlife product, attitudes towards the expansion of wildlife farms or other possible explanations. However, the immediate indication is that interventions aimed at building support for bans should be tailored to different segments of the population depending upon whether the wildlife is farmed or wild-caught. Combining wild-caught and farmed wildlife (even of the same species) into a single category increases the risk of incorrect inferences regarding both the level of the support for bans and the segments of the population that are most receptive or resistant to a ban.

Our findings also indicate how differences between support for bans regarding wild-caught and farmed wildlife correlate with perceptions of zoonotic risk. In the models

on farmed wildlife, zoonotic risk was only significant for two taxa: civets and frogs. For civets, this could be because of their much-publicized role in the zoonotic outbreak of SARS as well as the detection of the virus in civets in wet markets in Wuhan in the early days of the Covid-19 outbreak (Wang & Eaton, 2007; Hassanin et al., 2021). For the models on wild-caught animals, however, zoonotic risk was significant (and by larger factors) for almost all taxa assessed. For both farmed and wild-caught wildlife, zoonotic risk (when significant) increased the support of bans. Therefore, these differences might be because of the increased tendency during Covid-19 in both the popular media and the scientific literature to discuss the wildlife trade in general terms rather than focusing on specific species or contexts (Wang et al., 2022). The term 'wildlife' could elicit conceptualizations of wild-caught wildlife, even though most wildlife markets include a mixture of wild-caught and farmed species (Xiao et al., 2021a,b). It is possible that this generalized framing of zoonotic risk leads consumers to underestimate the risks posed by farmed wildlife (and the associated incentives for bans on wildlife farming).

Another significant difference between the wild-caught and farmed wildlife models was that respondent attitudes towards the current ban in China were statistically significant only in the models concerning wild-caught animals. In these models, belief that the current ban was adequate increased the probability that a person would support a ban on products from wild-caught animals (but not a ban on farming of the same taxa). This might be because respondents evaluate the hypothetical feasibility of bans based on their beliefs about the effects of the current ban in China. In other words, if they think that the ban has been effective at protecting wildlife and human health, it makes sense that they would develop a generalized pro-ban attitude. However, in the models on farmed wildlife, respondent attitudes towards the current wildlife consumption ban in China had no effect. It could be that respondents view the current ban as applicable to wild-caught animals only and/or do not take the current ban into account when evaluating the feasibility of bans on farmed wildlife. This has important conservation implications because this ban applies to both wild-caught and farmed wildlife (You, 2020). However, respondents do not seem to consider this law when responding to hypothetical farmed wildlife bans. Others have noted the challenges of implementing the current wildlife consumption ban in China within the wildlife farming industry (Wang et al., 2020) because of public sympathy for the economic plight of wildlife farmers (Li, 2020). Prior research has identified the economic and logistical challenges faced by wildlife farmers and government authorities (You, 2020), and we found that consumer attitudes are an additional hurdle to compliance with a ban on wildlife farms. Although the current ban in China has substantially altered the legal context of wildlife farms (You, 2020), more education and outreach are needed concerning the zoonotic risks of wildlife farms to ensure that consumers are aware that farmed wildlife products are included in this ban.

Finally, our findings have several important implications for species-specific conservation and regulatory initiatives in the wake of Covid-19. Mammal consumption increased the probability that a person would support a ban on wild-caught tigers and bears. This requires follow-up research, as it could be a product of substitutability: it is possible that these respondents consume other mammals (perhaps more common or less threatened species) and thus have no need to consume tigers and bears. Although less than a quarter of our respondents perceived tigers (11%) and bears (11%) as probable zoonotic transmitters of Covid-19 (Rizzolo et al., unpubl. data), if a respondent believed this, then it greatly increased the odds (by 12- and 8-fold, respectively) of supporting a ban on wild-caught individuals of these species. This could be because of underlying attitudes that predispose certain people to view wildlife consumption as risky; in our sample, respondents with a protective attitude towards wildlife were more likely to view bears and tigers as probable sources of Covid-19 (Rizzolo et al., unpubl. data).

Both in this sample (Rizzolo et al., unpubl. data) and in the wider literature (Gatti, 2020; Giri et al., 2021) pangolins and bats are amongst the taxa that are most likely to be viewed as transmitters of Covid-19. Even though bats and pangolins are perceived as probable zoonotic transmitters overall, their status as presumed zoonotic vectors was not a factor in predicting support for wildlife consumption bans in this study. However, belief that the current ban was adequate increased support for a ban on wild-caught pangolins and bats. As they have received significant policy attention, it follows that support for bans on consumption of these taxa would be connected to attitudes towards the adequacy of the governmental response. Two taxa for which beliefs about the adequacy of the current ban did not have an effect were bamboo rats and frogs. Although additional research is needed to understand this, it is possible that these taxa (neither of which are generally perceived as particularly charismatic) have been a lower priority in the enforcement of the current ban and that respondents therefore do not see the ban as applicable to them.

One limitation of our research is that it is based on self-reporting, which in the case of wildlife consumption can be subject to a social desirability bias (i.e. the tendency to present oneself positively to the researcher; Nancarrow & Brace, 2000; Rizzolo, 2021). Although we attempted to address this by surveying respondents anonymously and not asking about illegal consumption, it remains a potential limitation. An additional limitation is that because Covid-19 was unexpected, we had to rely upon a cross-sectional rather than a longitudinal approach (although we complement

our cross-sectional data with longitudinal analysis of additional data sources; Zhu et al., 2023b).

Conclusion

The global outbreak of Covid-19 has brought increased attention to the zoonotic risks posed by wildlife trade and consumption. However, there is continuing debate about the role of regulations and wildlife bans in the reduction of high-risk wildlife consumption behaviours. We have noted the strong support in our sample for wildlife consumption bans, with the majority of respondents supporting bans concerning both wild-caught and farmed wildlife. Furthermore, although zoonotic risk is an important variable in determining support for wildlife consumption bans, the relationship between perceived zoonotic risk and support for bans differs depending on the taxa and whether the animal is wild-caught or farmed. This highlights both the feasibility of the current wildlife ban in China and opportunities to further mitigate the environmental and zoonotic risks of wildlife consumption.

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Conflicts of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards. The ethics committee of the Michigan State University institutional review board approved this research (study number 00005583) and all participants gave their informed consent to participate. Michigan State University was the primary affiliation of JBR at the time of research.

References

Aguirre, A.A., Catherina, R., Frye, H. & Shelley, L. (2020) Illicit wildlife trade, wet markets, and Covid-19: preventing future pandemics. *World Medical & Health Policy*, 12, 256–265.

Biggs, D., Caceres-Escobar, H., Kock, R., Thomson, G. & Compton, J. (2021) Extend existing food safety systems to the global wildlife trade. *Lancet Planetary Health*, 5, e402–e403.

Boas, T.C., Christenson, D.P. & Glick, D.M. (2020) Recruiting large online samples in the United States and India: Facebook, Mechanical Turk, and Qualtrics. *Political Science Research and Methods*, 8, 232–250.

Borzée, A., McNeely, J., Magellan, K., Miller, J.R., Porter, L., Dutta, T. et al. (2020) Covid-19 highlights the need for more effective wildlife trade legislation. *Trends in Ecology & Evolution*, 35, 1052–1055.

Cawthorn, D.M., Kennaugh, A. & Ferreira, S.M. (2021) The future of sustainability in the context of Covid-19. *Ambio*, 50, 812–821.

Chang, J. & Chang, J. (2020) China needs to establish a directory system of wildlife prohibited from hunting, breeding, transferring, or eating urgently. *Derecho Animal: Forum of Animal Law Studies*, 11, 59–64.

Chen, N., Li, X., Li, S., Xiao, Y., Ye, M., Yan, X. et al. (2020) How related is SARS-CoV-2 to other coronaviruses? *Veterinary Record*, 186, 496.

Coals, P., Moorhouse, T.P., D'Cruze, N.C., Macdonald, D.W. & Loveridge, A.J. (2020) Preferences for lion and tiger bone wines amongst the urban public in China and Vietnam. *Journal for Nature Conservation*, 57, 125874.

Daszak, P., Olival, K.J. & Li, H. (2020) A strategy to prevent future epidemics similar to the 2019-nCoV outbreak. *Biosafety and Health*, 2, 6–8.

Duonamou, L., Konate, A., Djossou, S.D., Mensah, G.A., Xu, J. & Humle, T. (2020) Consumer perceptions and reported wild and domestic meat and fish consumption behavior during the Ebola epidemic in Guinea, West Africa. *PeerJ*, 8, e9229.

Dutton, A.J., Hepburn, C. & Macdonald, D.W. (2011) A stated preference investigation into the Chinese demand for farmed vs. wild bear bile. *PLOS One*, 6, e21243.

Fenollar, F., Mediannikov, O., Maurin, M., Devaux, C., Colson, P., Levasseur, A. et al. (2021) Mink, SARS-CoV-2, and the human–animal interface. *Frontiers in Microbiology*, 12, 745.

Gatti, R.C. (2020) The pangolin's revenge: SARS-CoV-2 did not emerge from a lab but from wildlife exploitation. *GAIA – Ecological Perspectives for Science and Society*, 29, 79–82.

Giri, R., Bhardwaj, T., Shegane, M., Gehi, B.R., Kumar, P., Gadhave, K. et al. (2021) Understanding Covid-19 via comparative analysis of dark proteomes of SARS-CoV-2, human SARS and bat SARS-like coronaviruses. *Cellular and Molecular Life Sciences*, 78, 1655–1688.

Gratwicke, B., Mills, J., Dutton, A., Gabriel, G., Long, B., Seidensticker, J. et al. (2008) Attitudes toward consumption and conservation of tigers in China. *PLOS One*, 3, e2544.

Hassanin, A., Grandcolas, P. & Veron, G. (2021) Covid-19: natural or anthropic origin? *Mammalia*, 85, 1–7.

Hinsley, A., Wan, A.K.Y., Garshelis, D., Hoffmann, M., Hu, S., Lee, T.M. et al. (2022) Understanding why consumers in China switch between wild, farmed, and synthetic bear bile products. *Conservation Biology*, 36, e13895.

Huang, Q., Wang, F., Yang, H., Valitutto, M. & Songer, M. (2021) Will the Covid-19 outbreak be a turning point for China's wildlife protection: new developments and challenges of wildlife conservation in China. *Biological Conservation*, 254, 108937.

IBM (2019) *IBM SPSS statistics for windows* (Version 26.0). IBM Corp., Armonk, USA.

Jiao, Y. & Lee, T.M. (2021) China's conservation strategy must reconcile its contemporary wildlife use and trade practices. *Frontiers in Ecology and Evolution*, 9, 340.

Jiao, Y. & Lee, T.M. (2022) The global magnitude and implications of legal and illegal wildlife trade in China. *Oryx*, 56, 404–411.

Karesh, W.B., Cook, R.A., Bennett, E.L. & Newcomb, J. (2005) Wildlife trade and global disease emergence. *Emerging Infectious Diseases*, 11, 1000.

Koh, L.P., Li, Y. & Lee, J.S.H. (2021) The value of China's ban on wildlife trade and consumption. *Nature Sustainability*, 4, 2–4.

Li, P.J. (2004) China's bear farming and long-term solutions. *Journal of Applied Animal Welfare Science*, 7, 71–81.

Li, P.J. (2020) Reopening the trade after SARS: China's wildlife industry and the fateful policy reversal. *Environmental Policy and Law*, 50, 251–267.

Li, H., Daszak, F., Chmura, A., Zhang, Y., Terry, P. & Fielder, M. (2021) Knowledge, attitude, and practice regarding zoonotic risk in wildlife trade, southern China. *EcoHealth*, 18, 95–106.

Li, Z. & Wang, H. (2021) Consumer behavior and wild animal consumption in China. *The Chinese Economy*, 54, 389–401.
Li, F., Zhang, Z., Hu, S., Zhao, W., Zhao, J., Kváč, M. et al. (2020) Common occurrence of divergent *Cryptosporidium* species and *Cryptosporidium parvum* subtypes in farmed bamboo rats (*Rhizomys sinensis*). *Parasites & Vectors*, 13, 1–8.
Lin, J. (2021) Reflection: an update on China's wild meat consumption since Covid-19. *Food and Foodways*, 29, 213–222.
Liu, Z., Jiang, Z., Li, C., Fang, H., Ping, X., Luo, Z. et al. (2015) Public attitude toward tiger farming and tiger conservation in Beijing, China. *Animal Conservation*, 18, 367–376.
Liu, J., Li, Z., Cui, Y., Yang, H., Shan, H. & Zhang, C. (2020a) Emergence of an Eurasian avian-like swine influenza A (H1N1) virus from mink in China. *Veterinary Microbiology*, 240, 108509.
Liu, S., Ma, Z. F., Zhang, Y. & Zhang, Y. (2020b) Attitudes towards wildlife consumption inside and outside Hubei Province, China, in relation to the SARS and Covid-19 outbreaks. *Human Ecology*, 48, 749–756.
Ma, X., Wang, Y., Zhang, H.J., Wu, H.X. & Zhao, G.H. (2018) First report of *Giardia duodenalis* infection in bamboo rats. *Parasites & Vectors*, 11, 1–6.
Naidoo, R., Bergin, D. & Vertefeuille, J. (2021) Socio-demographic correlates of wildlife consumption during early stages of the Covid-19 pandemic. *Nature Ecology & Evolution*, 5, 1361–1366.
Nancarrow, C. & Brace, I. (2000) Saying the 'right thing': coping with social desirability bias in marketing research. *Bristol Business School Teaching and Research Review*, 3, 1–11.
National Bureau of Statistics of China (2019) *China Statistical Yearbook*. stats.gov.cn/sj/ndsj/2019/indexeh.htm [accessed April 2021].
Petrovan, S.O., Aldridge, D.C., Bartlett, H., Bladon, A.J., Booth, H., Broad, S. et al. (2021) Post Covid-19: a solution scan of options for preventing future zoonotic epidemics. *Biological Reviews*, 96, 2694–2715.
Rizzolo, J.B. (2021) Effects of legalization and wildlife farming on conservation. *Global Ecology and Conservation*, 25, e01390.
Sardana, S. & Fischer, C. (2021) *Implications of a Wildlife Trade Ban*. Asian Development Bank, Manila, Philippines.
Shreedhar, G. & Mourato, S. (2020) Linking human destruction of nature to Covid-19 increases support for wildlife conservation policies. *Environmental and Resource Economics*, 76, 963–999.
Tu, C., Crameri, G., Kong, X., Chen, J., Sun, Y., Yu, M. et al. (2004) Antibodies to SARS coronavirus in civets. *Emerging Infectious Diseases*, 10, 2244.
Van Kerkhove, M.D., Ryan, M.J. & Ghebreyesus, T.A. (2021) Preparing for 'Disease X'. *Science*, 374, 377.
Wang, L.F. & Eaton, B.T. (2007) Bats, civets and the emergence of SARS. In *Wildlife and Emerging Zoonotic Diseases: The Biology, Circumstances and Consequences of Cross-Species Transmission* (eds J.E. Childs, J.S. Mackenzie & J.A. Richt), pp. 325–344. Springer, Berlin, Germany.
Wang, H., Shao, J., Luo, X., Chuai, Z., Xu, S., Geng, M. et al. (2020) Wildlife consumption ban is insufficient. *Science*, 367, 1435.
Wang, Y., Tilley, H.B., Phalke, S., Andersson, A.A., Dingle, C., Hatten, C.E. et al. (2022) Discussion of wildlife trade before and during the Covid-19 pandemic in professional opinion pieces and scientific articles. *Global Ecology and Conservation*, 38, e02270.
Wang, W., Yang, L., Wronski, T., Chen, S., Hu, Y. & Huang, S. (2019) Captive breeding of wildlife resources – China's revised supply-side approach to conservation. *Wildlife Society Bulletin*, 43, 425–435.
Wang, F., Zhou, L., Gong, S., Deng, Y., Zou, J., Wu, J. et al. (2011) Severe infection of wild-caught snakes with *Spirometra erinaceieuropaei* from food markets in Guangzhou, China involves a risk for zoonotic sparganosis. *Journal of Parasitology*, 97, 170–171.
White, A. (2021) How China's wildlife trade legislation permits commercial trade in protected wild animal species. *China Quarterly*, 248, 1212–1225.
Whitfort, A. (2021) Covid-19 and wildlife farming in China: legislating to protect wild animal health and welfare in the wake of a global pandemic. *Journal of Environmental Law*, 33, 57–84.
Wikramanayake, E., Pfeiffer, D.U., Magouras, I., Conan, A., Ziegler, S., Bonebrake, T.C. et al. (2021) A tool for rapid assessment of wildlife markets in the Asia-Pacific region for risk of future zoonotic disease outbreaks. *One Health (Amsterdam, Netherlands)*, 13, 100279.
Worobey, M. (2021) Dissecting the early Covid-19 cases in Wuhan. *Science*, 374, 1202–1204.
Xiao, L., Lu, Z., Li, X., Zhao, X. & Li, B.V. (2021a) Why do we need a wildlife consumption ban in China? *Current Biology*, 31, R168–R172.
Xiao, X., Newman, C., Buesching, C.D., Macdonald, D.W. & Zhou, Z.M. (2021b) Animal sales from Wuhan wet markets immediately prior to the Covid-19 pandemic. *Scientific Reports*, 11, 1–7.
Yang, D., Dai, X., Deng, Y., Lu, W. & Jiang, Z. (2007) Changes in attitudes toward wildlife and wildlife meats in Hunan Province, central China, before and after the severe acute respiratory syndrome outbreak. *Integrative Zoology*, 2, 19–25.
Yang, N., Liu, P., Li, W. & Zhang, L. (2020) Permanently ban wildlife consumption. *Science*, 367, 1434.
You, M. (2020) Changes of China's regulatory regime on commercial artificial breeding of terrestrial wildlife in time of Covid-19 outbreak and impacts on the future. *Biological Conservation*, 250, 108756.
You, X., Li, Y., Zhang, M., Yan, H. & Zhao, R. (2014) A survey of Chinese citizens' perceptions on farm animal welfare. *PLOS One*, 9(10), e109177.
Yuan, J., Lu, Y., Cao, X. & Cui, H. (2020) Regulating wildlife conservation and food safety to prevent human exposure to novel virus. *Ecosystem Health and Sustainability*, 6, 1741325.
Zhang, L., Hua, N. & Sun, S. (2008) Wildlife trade, consumption and conservation awareness in southwest China. *Biodiversity and Conservation*, 17, 1493–1516.
Zhang, Z., Yang, T., Hu, Y., Cirella, G.T. & Xie, Y. (2022) Behavioral intention to resist the consumption of wild animals in China: Netizen survey. *Diversity*, 14, 343.
Zhang, L. & Yin, F. (2014) Wildlife consumption and conservation awareness in China: a long way to go. *Biodiversity and Conservation*, 23, 2371–2381.
Zhu, A., Chen, R., Rizzolo, J.B. & Li, Z. (2023a) The politicization of Covid-19 origin stories: insights from a cross-sectional survey in China. *Societies*, 13, 37.
Zhu A., Chen, R., Rizzolo, J.B, & Qian, J. (2023b). Perceptions of COVID-19 origins and China's wildlife policy reforms. *Global Ecology and Conservation*, 43, e02463.
Zhu, A. & Zhu, G. (2020) Understanding China's wildlife markets: trade and tradition in an age of pandemic. *World Development*, 136, 105108.