Using SMS surveys to understand songbird ownership and shark product consumption in Indonesia

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Abstract The unsustainable use of wildlife increases the risk of species extinction. In biodiversity-rich Indonesia, information on the scale of wildlife use is limited and requires further study. To address this, we explored the potential of text messaging (short message service; SMS) surveys to investigate levels and spatial patterns of domestic wildlife use, using songbird keeping and shark consumption as case studies because of their widespread occurrence in all 34 Indonesian provinces. We sent 340,000 messages for each survey during October–November 2018 and incentivized responses with a mobile data package as reward. We obtained survey response rates of 1.4% (songbird ownership) and 1.5% (shark consumption). Our results revealed an estimated 175.7 million songbirds being kept by 35% (80.4–86.6 million) of the Indonesian population and 33.5 million people (14% of the Indonesian population) to have consumed shark products in their lifetime. We identified hotspots of songbird ownership in several provinces in Java, corroborating previous findings, and new ones in the North Sumatra province, for example. The provinces of Maluku, Aceh and East Nusa Tenggara had the highest numbers of reported shark consumers per 1,000 people. Responses indicated a wide variety of shark products being consumed, highlighting the need for in-depth research to understand the explanatory factors behind these practices. These findings demonstrate the potential of SMS surveys to be a cost-effective approach for conducting large-scale studies on wildlife consumption patterns over a short period of time.

Keywords consumer behaviour, demand, Indonesia, shark fin, songbird, SMS survey, wildlife use

The supplementary material for this article is available at doi.org/10.1017/S0030605323000741

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Received 9 November 2022. Revision requested 21 December 2022. Accepted 19 May 2023.

Introduction

Wildlife trade (both legal and illegal) is a major global economic activity (CITES Secretariat, 2022) involving millions of people and being especially important to rural livelihoods (Roe, 2008; Robinson et al., 2018). Despite its socio-economic importance, wildlife trade poses a threat to a wide range of species through overexploitation (Maxwell et al., 2016), heightening the risk of species extinction and zoonotic disease transmission (Vora et al., 2022). This issue is prominent in Indonesia, a highly biodiverse country that plays a central role in the global wildlife trade as the largest exporter of wild-caught species (Nijman, 2010; Smith et al., 2017; Liew et al., 2021) as well as having an active domestic trade in native wildlife, which is often underreported (Nijman & Nekaris, 2014; Maulany et al., 2021). Songbird ownership and shark consumption are examples of this. Both groups are domestically traded in high volumes, yet information on patterns in this trade, including the spatial distribution and characteristic of domestic utilization that could drive overexploitation, is lacking (Jepson & Ladle, 2009; Muttaqin et al., 2019; Marshall et al., 2020b).

Indonesia is home to 1,818 bird species (Burung Indonesia, 2022). The country has a long tradition of keeping birds as pets (mainly wild sourced), to the detriment of wild populations across the Indonesian archipelago (Harris et al., 2017; Marthy & Farine, 2018). Consequently, several species, such as the Javan green magpie *Cissa thalassina*, the Bali myna *Leucopsar rothschildi* and the black-winged myna *Acridotheres melanopterus*, are now more abundant in captivity than in the wild, largely because of this trade (Nijman et al., 2018). It is therefore unsurprising that the 68 species identified as conservation priorities by the IUCN Species Survival Commission Asian Songbird Trade Specialist Group are native to Indonesia (IUCN SSC Asian Songbird Trade Specialist Group, 2022). Although trade data for sharks are limited, Indonesia lands > 100,000 t of shark catch annually, 13% of the global catch (Camhi et al., 2008; Lack & Sant, 2011). It is also the third largest national exporter of shark fins globally (Dent & Clarke, 2015; Shea & To, 2017). There is also widespread domestic consumption of sharks, notably in the provinces of Aceh (Abdullah et

al., 2020), West Nusa Tenggara (Muttaqin et al., 2019) and several provinces in Java (Simeon et al., 2015; Iskandar et al., 2019; Sjafrie et al., 2020).

Across Indonesia, information on the scale and patterns of the trade in these two wildlife groups is scarce (Jepson & Ladle, 2009; Chng et al., 2015; Booth et al., 2018; Marshall et al., 2020b). Research on domestic shark consumption has focused on several provinces, but only on the identification of species consumed (Muttaqin et al., 2019). The magnitude of this practice is unknown, but it is likely to be substantial (Booth et al., 2018). More extensive research has been conducted on the use of songbirds, especially in western Indonesia (the islands of Sumatra, Java and Kalimantan), through household, online and on-site market surveys (Jepson & Ladle, 2005; Burivalova et al., 2017, Miller et al., 2019; Marshall et al., 2020b). Other studies have focused on the socio-economic aspects and drivers of birdkeeping, such as the characterization of birdkeeping consumers or the evaluation of the dynamics of demand (Burivalova et al., 2017; Marshall et al., 2020a,b). There is little information on key drivers of demand at a wider scale in Indonesia for either species group, especially in terms of consumer behaviour. Knowledge of consumer motivation plays a pivotal role in developing demand-reduction interventions (Veríssimo et al., 2012) and in promoting changes in human behaviour (Liu et al., 2015). Having a thorough understanding of the characteristics of wildlife trade, built on knowledge of consumer behaviour, is crucial for prioritizing future demand management (Veríssimo et al., 2020a,b), including for designing consumer-focused initiatives (Nuno et al., 2018). To address this lack of information on shark consumption and to better understand songbird ownership in Indonesia, consumer research efforts are needed at a broader spatial scale.

Traditional methods, such as postal surveys, face-to-face interviews or phone calls, are costly and time-consuming to implement, particularly in a country such as Indonesia that comprises > 270 million people of > 1,300 ethnic groups living across 17,500 islands (Badan Pusat Statistik, 2021). Several new survey methods have emerged (Gibson et al., 2017) such as online or website-based surveys, which provide advanced features such as image, audio and video streams, although their limited ability to penetrate rural areas with poor access to the internet remains a significant barrier (Sue & Ritter, 2011). Short message service (SMS) surveys could potentially overcome this challenge (Hellström & Karefelt, 2012) because of their time-efficient nature (Alam et al., 2014; Lau et al., 2018; Patterson-Stein & Canavan, 2020) and their ability to cover rural areas with low internet coverage (Perosky et al., 2015). SMS surveys have been used to investigate a wide range of topics across large spatial scales, such as collecting data on farming practices (Giroux et al., 2019), patient health (Lee et al., 2013) and alcohol consumption (Kuntsche & Robert, 2009). However, the applicability of SMS surveys for obtaining a better understanding of conservation issues has yet to be ascertained. In this study we aimed to characterize the levels and spatial patterns of songbird ownership and shark consumption across all 34 Indonesian provinces and to assess the potential of using SMS surveys as a cost-effective tool for future consumer research in conservation.

Methods

When completing the questionnaire related to songbird ownership, despite us asking specifically about songbird ownership, some respondents also mentioned owning other non-songbird and domestic bird species. Therefore, we assigned respondents who were bird owners into one of the following four categories: (1) owners of any type of bird (i.e. the total number of people who own a bird of any kind, which consists of wild songbird and non-songbird species and domestic bird species such as chickens), (2) owners of wild songbirds (i.e. only species in the order Passeriformes; Sibley & Monroe, 1993; see Supplementary Table 1 for species list), (3) owners of wild non-songbird species (i.e. only wild non-songbird or non-passerine species) and (4) owners of all types of wild bird species (i.e. both wild songbird and wild non-songbird species). We defined shark products and their derivatives as either fin (e.g. fin soup, dried shark fin and shark lip soup), meat (e.g. meatball, dumpling, salted meat and satay) or other body parts used in traditional medicine and local food (e.g. capsules made from shark bone/cartilage and liver oil, shark skin used for crackers; Muttaqin et al., 2018).

Designing the SMS survey

Rewarding participants has been shown to increase survey response rates (Guo et al., 2016). To decide on the type of reward to be offered, we conducted a pilot study during 25 July–6 August 2018 in Jakarta and Banten provinces. We compared five incentive types: (1) post-survey airtime reward (i.e. the first 100 respondents to complete the survey would receive free airtime, to be spent on additional calls/SMS messages on their mobile phone) valued at IDR 20,000 (USD 1.4), (2) post-survey internet data reward (i.e. the first 100 respondents to complete the survey would receive 420 MB of internet data for use on their mobile phones), (3) pre-survey airtime reward (i.e. all respondents received an airtime reward valued at IDR 20,000 (USD 1.4) before filling out the survey), (4) pre-survey internet data reward (i.e. all respondents would receive 420 MB of internet data before filling out the survey), or (5) no reward, as a control group (i.e. we asked respondents to fill out the survey without any mention of a reward). We sent 25,000 SMS messages to each of the two provinces and

found that the pre-survey internet data reward resulted in the highest response rate (2%; Supplementary Table 2). We considered applying this incentive mechanism to the participants across Indonesia to be too expensive (an estimated USD 453,880 to contact 340,000 people). We therefore chose the post-survey internet data reward, which had elicited the second-highest response rate (0.7%).

To conduct the nationwide survey, we calculated the number of samples required in each province using the following formula (Dillman et al., 2014):

$$n = \frac{(N \times p \times q)}{\{(N-1) \times (MoE/z)^2 + (p \times q)\}}$$

where n = sample size required, p = proportion tested, $q = 1 - p$, MoE = desired margin of sampling error, z = the z-score for the desired level of confidence, and N = size of target population.

We expected to observe a conservative 50/50 split (Dillman et al., 2014) in responses to the yes/no question (yes or no songbird owned/shark consumed; $p = 0.5$), a margin of sampling error of 10% ($MoE = 0.1$) and a z-score for 95% CI of 1.96. We obtained information on the population sizes of people aged 15–74 years for each province from the 2010 National Census data, hereinafter referred to as the real population (comprising c. 165 million of people; Badan Pusat Statistik, 2012). This revealed that a minimum of 96 responses were required per province or a total of 3,361 respondents from all 34 provinces (Table 1, Supplementary Table 3). Given the low response rate in the pilot study, we sent 340,000 SMS messages for each species group survey, which required an effective response rate of just under 1% to reach our target sample.

Launching the SMS survey

We partnered with PT Telekomunikasi Selular (Telkomsel), the main network service provider in Indonesia, to implement the SMS survey during October–November 2018. Telkomsel has c. 163 million cellular data customers (Telkomsel, 2018; Supplementary Figs 1 & 2). Using their list of cellular data customers, after identifiable information was encrypted, Telkomsel sent 340,000 SMS messages for each survey, divided equally between male and female respondents and randomized at the sub-district level but proportional to the population size (with a maximum of 10,000 messages per province). The SMS messages were sent at the same local time (e.g. 9.00 in all regions) based on the location where customers actively used their phone, using the Mobile Station International Subscriber Directory Number database. Telkomsel established the participant sample prior to sending the SMS messages, and the listed numbers could participate only once. According to Ministerial Communication and Informatics Regulation No. 12 of 2016, a user should register themselves when they begin using their phone number by providing basic information including their identity number, which the provider then uses to validate data on name, age, gender and domicile. This reduced the possibility of the respondent pool being dominated by members of one or a few social networks that could disseminate the survey between them, which would violate randomization. It also reduced the possibility of respondents responding twice using a different phone number and of children and young people aged < 17 years responding to the survey. The survey used random sampling stratified by province (Supplementary Material 1).

Through the SMS survey we informed respondents of the incentive for replying, the time required to complete the survey and the number to dial to participate in the survey. Given the sensitivity of the issue being surveyed, respondents were also able to access the terms and conditions provided through a link, which consisted of their consent to the anonymous use of their data, their voluntary participation in the survey and the status of the collected data, deemed to be confidential, and that identifiable personal information would not be reported by the researchers, and no official investigations could therefore be instigated on the basis of the information provided. We included the official organization name in the messages to increase the credibility of the SMS messages received by the respondents. Once a respondent dialled the number to participate, they received a series of sequential SMS messages containing one of the surveys regarding either what species of birds they keep or the type of shark products they consume, the quantity, their purchasing frequency, the source of the products and their underlying motivation for such behaviours (Supplementary Material 2). To ensure the anonymity of respondents, their names, addresses and mobile numbers were not shared with the research team. We only used data regarding respondent location up to the sub-district level, and gender and age, for the demographic analysis. Each message comprised 10 questions regarding whether the respondent had owned songbirds/consumed shark products, their frequency of buying

TABLE 1 Results of the χ^2 tests of goodness of fit comparing our survey data on songbird ownership and shark product consumption in Indonesia (observed population) with the real population (Badan Pusat Statistik, 2012).

Survey	Observed population variable	χ^2	P
Songbird ownership	Province population	13,845	< 0.00001
	Age group	261.5	< 0.00001
	Gender	1.35	0.3
Shark product consumption	Province population	18,168	< 0.00001
	Age group	294.4	< 0.00001
	Gender	0.20	0.7

songbirds/consuming shark products, the market they used to buy songbirds/shark products and their motivation to own songbirds/consume shark products (Supplementary Material 2).

Data analyses

To assess sampling bias, we evaluated the demographics of our data (respondents who completed and did not complete the surveys) compared to the Indonesian population (15–74 years of age) using χ^2 tests for goodness of fit. We compared population by age group (within age ranges such as 15–19 or 20–24 years, although our respondents included only people ≥ 17 years of age), by gender and by province to data from the 2010 National Census (Badan Pusat Statistik, 2012). We applied the tests to both the songbird and shark survey data. If any of the population variables showed statistically significant differences, we used post-stratified weighting to make our results representative. Total owner/consumer data of unweighted vs weighted results for each province for both surveys (songbirds and sharks) are in Supplementary Fig. 3. Specifically, in North Kalimantan province, which was part of East Kalimantan province until 2012, the population in 2010 was estimated using the projected population proportion in 2020 (Badan Pusat Statistik, 2013), in which East Kalimantan province had 83% of the total population of East and North Kalimantan provinces. For weighting we used the package *survey* (Lumley, 2019) in *R 4.0.1* (R Core Team, 2020). We estimated the number of songbird owners/shark consumers based on Question 2 in the survey (Supplementary Material 2), where respondents could answer either yes or no. For questions on songbird ownership, we asked the respondents whether they 'keep or have had any songbird', implying present or past ownership. As this could cause bias during interpretation, we tested whether there is a correlation between the number of songbirds owned and age of respondents, with the assumption that there would be a positive correlation. However, the linear regression test produced a non-significant result ($P = 0.08$, coefficient value = −0.009), so we assumed the estimated number of owners is more likely to reflect current than past ownership. We estimated the number of songbirds currently owned from Question 4, which requested the respondents to state the number of songbirds they owned at the time of the survey.

We applied bootstrapping with 1,000 replications to estimate the standard error of both songbird ownership and shark consumption per province, corrected for age group, gender and provincial population (Wilcox, 2010). We then estimated the total number of people who owned songbirds and have consumed sharks in their lifetime, adjusted to the 2010 Indonesian population. We conducted all analyses using *R* and we created all maps using *ArcGIS 10.4.1* (Esri, Redlands, USA).

Results

We received 4,680 responses to the songbird survey (1.4% response rate) and 5,257 responses to the shark survey (1.5% response rate). We considered surveys to be valid if a respondent answered the first question (whether they owned a songbird or had consumed a shark product). The attrition rate for the songbird survey was higher (25.1%) compared to that of the shark survey (5.9%). The demographic data of the respondents only fit the expected Indonesian population in terms of gender (Table 1), so we corrected the estimates for age group and province.

Songbird ownership

We estimate that four provinces in Java and one in Sumatra had the highest numbers of bird owners (wild and domestic birds): West Java (15.9 million owners), Central Java (14.5 million owners), East Java (14.4 million owners), North Sumatra (4.7 million owners) and Jakarta (4.4 million owners; Fig. 1a, Supplementary Table 4). We found a similar pattern for the number of wild songbird owners nationwide (Fig. 1b, Supplementary Table 4). Regarding the top five provinces in terms of other bird owners (wild, non-songbird species), the top three provinces were in Java, followed by one in Sulawesi and one in Sumatra (Fig. 1c, Supplementary Table 4), and for owners of both wild songbird and non-songbird species, the top four provinces were in Java, followed by South Sumatra (Fig. 1d, Supplementary Table 4).

Adjusting for the number of owners per 1,000 people produced different patterns (Fig. 2, Supplementary Table 4). Provinces in Sumatra and Java had the highest numbers of all bird owners (wild and domestic birds) and of wild songbird owners per 1,000 people. The highest number of other wild bird (non-songbird) owners was in several provinces in eastern Indonesia and one province in Java. The number of wild songbirds and non-songbirds owned per 1,000 people was highest in Sumatra and Java.

We estimate that 182.4–206.6 million birds were kept in Indonesia (Supplementary Table 4, Supplementary Fig. 5). This number comprises 164.1–187.3 million wild songbirds (90.3%) and 15.5–22.1 million wild non-songbirds (9.7%). Birds were owned by an estimated 88.8–95.1 million people, including 80.4–86.6 million people who owned wild songbirds and 3.6–5.0 million people who owned wild non-songbirds. The number of people who owned both wild songbirds and non-songbirds was 3.4–4.9 million people (Supplementary Table 4, Supplementary Fig. 5). Each songbird owner had a mean of 2.1 ± SE 0.1 birds. The total number of bird owners corresponded to 37.2–39.9% of the total population or 53.7–57.6% of the Indonesian population aged 15–74 years (Badan Pusat Statistik, 2012).

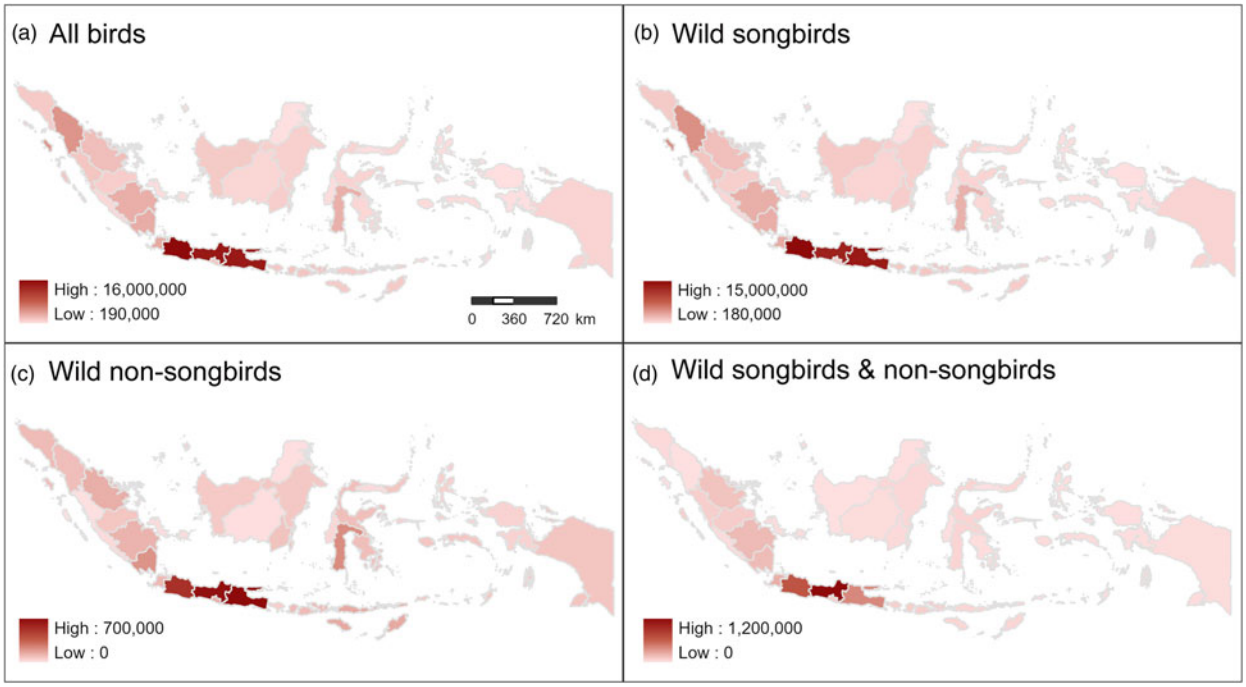

FIG. 1 Projection of the total numbers of (a) all bird owners (domestic and wild birds), (b) wild songbird owners, (c) wild non-songbird owners, and (d) wild songbird and non-songbird owners per province in Indonesia, weighted by the real population proportion per province and age group. The complete projection can be found in Supplementary Fig. 3.

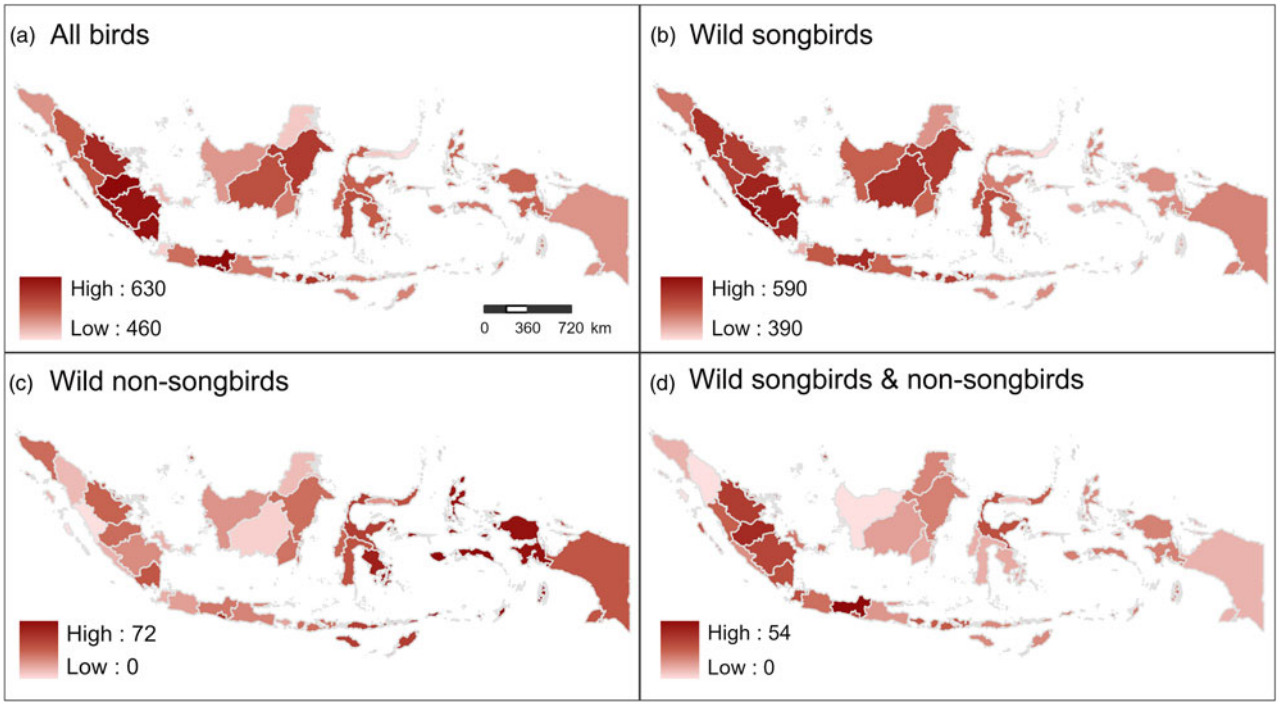

FIG. 2 Projection of the numbers of (a) all bird owners (domestic and wild birds), (b) wild songbird owners, (c) wild non-songbird owners, and (d) wild songbird and non-songbird owners per 1,000 people of the population in each of the provinces of Indonesia, weighted by the real population proportion per province and age group. The complete projection can be found in Supplementary Fig. 4.

Shark product consumption

The greatest numbers of people who had consumed shark products were centred in Java in the provinces of West Java (4.6 million consumers), East Java (3.8 million consumers), Central Java (3.4 million consumers), North Sumatra (2.6 million consumers) and Banten (1.3 million consumers;

Fig. 3a, Supplementary Table 5). We found a similar consumption pattern for shark meat consumers (Fig. 3b, Supplementary Table 5). For shark fin the top-ranked provinces were in Java, in North Sumatra and South Sulawesi (Fig. 3c, Supplementary Table 5). However, for other shark products the top five provinces were in Java along with North Sumatra (Fig. 3d, Supplementary Table 5).

Adjusting for the number of shark consumers per 1,000 people of the population, three provinces in eastern Indonesia and two provinces in Sumatra had the highest number of consumers (Fig. 4a, Supplementary Table 5). We found a similar pattern for shark meat consumers per 1,000 people, with Aceh province having the highest number of consumers (Fig. 4b, Supplementary Table 5). The numbers of shark fin consumers per 1,000 people were highest in eastern Indonesia provinces and West Kalimantan (Fig. 4c, Supplementary Table 5). However, the highest numbers of other shark products consumed per 1,000 people were in eastern Indonesia and in Central and North Kalimantan and West Sumatra provinces (Fig. 4d, Supplementary Table 5).

We calculated that an estimated 31.9–35.4 million people had consumed shark products in various forms (meat, fin and other products), which represents 13.3–14.8% of the total population or 19.2–21.3% of the Indonesian population aged 15–74 years (Badan Pusat Statistik, 2012). The highest level of consumption was of shark meat products, with an estimated 17.0–19.7 million consumers, followed by shark fin products (6.2–7.8 million consumers) and other shark products (4.6–6.0 million consumers; Supplementary Table 5, Supplementary Fig. 5).

Discussion

Our study reveals for the first time the nationwide patterns of songbird ownership and shark product consumption in Indonesia. Using an SMS survey and partnering with the largest telecommunications service provider in Indonesia enabled us to reach respondents across the country. We found that on average owners kept two birds, which equates to a nationwide ownership of 195 million birds kept by an estimated 88.7–95.1 million people (or c. 39% of the population). The SMS survey also revealed that an estimated 33 million people (or c. 14% of the Indonesian population) had consumed shark products in their lifetime. Collectively, our findings indicate the large scale of the domestic wildlife trade in these taxa and the need to monitor their wild populations to support future sustainable use whilst reducing demand.

Songbird ownership

Approximately 90.3% of the birds owned by an estimated 91.9 million people were songbirds. This finding highlights the urgency of managing the songbird trade for the conservation of this group, particularly regarding

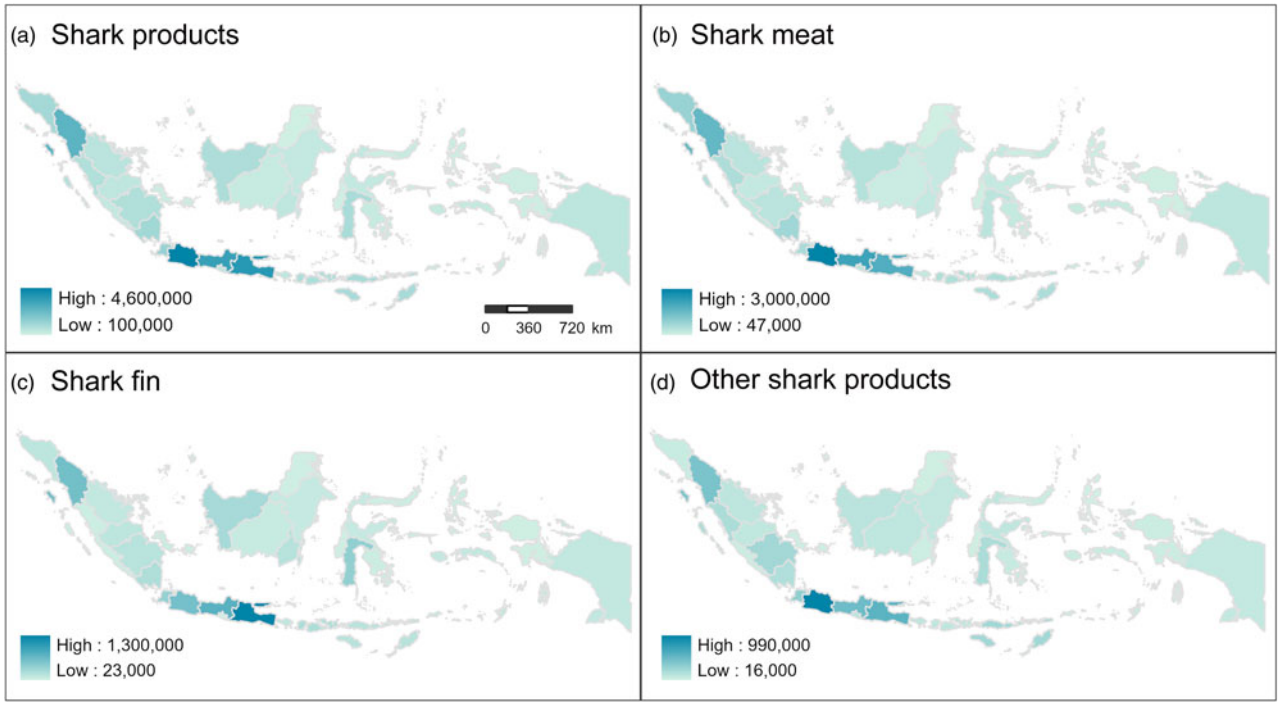

Fig. 3 Projection of the numbers of people that have (a) consumed shark products, (b) consumed shark meat, (c) consumed shark fins, and (d) consumed other shark products per province in Indonesia, weighted by the real population proportion per province and age group. The complete projection can be found in Supplementary Fig. 3.

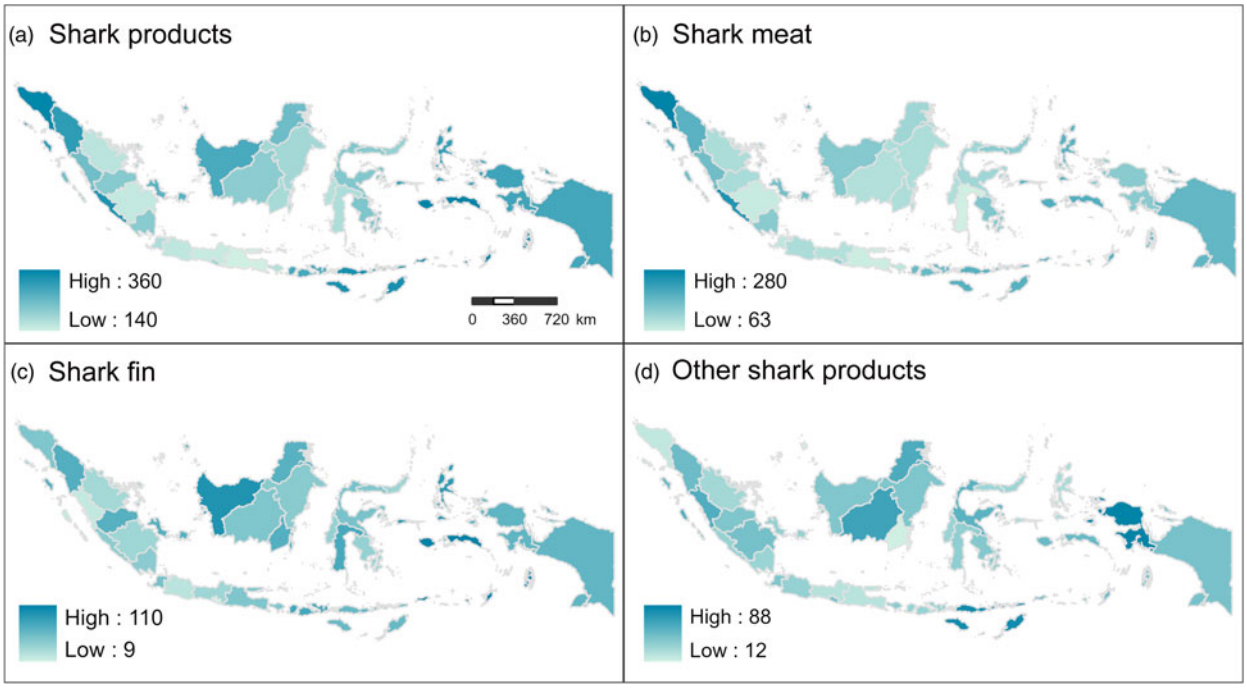

FIG. 4 Projection of the numbers of people that have (a) consumed shark products, (b) consumed shark meat, (c) consumed shark fins, and (d) consumed other shark products per 1,000 people of the population in each of the provinces of Indonesia, weighted by the real population proportion per province and age group. The complete projection can be found in Supplementary Fig. 4.

domestic demand in Java where most songbird owners are located. This is not unexpected as keeping songbirds at home is a well-known part of Javanese culture, with the Javanese representing the largest ethnic group (40%) in Indonesia (Ananta et al., 2015). Although there are currently large numbers of breeders and people who own birds for entering into singing contests, people who own birds primarily as pets (i.e. hobbyists) are still the largest proportion of bird owners (Iskandar & Iskandar, 2015; Marshall et al., 2020a). Previous research using structured household surveys calculated that 66–84 million cagebirds (not only songbirds) were owned by 36 million households in Java (Marshall et al., 2020b) compared to 105–129 million cagebirds (c. 56% more) owned by 51–57 million bird owners (c. 50% more) estimated in our study. This discrepancy could be attributed to the different survey methods used. Household surveys provide understanding of the socio-economic profiles of bird owners and their motivations for birdkeeping, and they are useful for identifying and verifying the specific species being kept in cages. Our SMS surveys provided information on the pervasiveness of songbird ownership in Java, which would be logistically prohibitive to obtain using household surveys.

Another challenge is addressing songbird ownership outside Java and the possession of parrots in eastern Indonesia (Maluku, North Maluku and West Papua). Our results corroborate previous findings that parrot-keeping is widespread on these islands (Lambert, 1993; Cottee-Jones et al., 2014). Four provinces in Sumatra were in the top five in terms of the numbers of songbird owners per 1,000 people of the population. Confiscations of illegally traded songbirds, which have been conducted intensely in Lampung (Indraswari et al., 2020), should be extended to other provinces in Sumatra to prevent wild-caught songbirds from entering the market. In addition, influencing consumer decisions through understanding their motivations could also be used to reduce demand (Veríssimo et al., 2020a,b).

Our SMS survey revealed 69.7 million songbirds were owned by 34.4 million people outside Java. However, the cultural and socio-economic context surrounding bird ownership needs to be further explored for these parts of Indonesia. Several hypotheses regarding the reasons underlying this scale of bird ownership have been offered, but it remains unknown whether such ownership is driven by the physical characteristics of the birds (e.g. colour, size), the financial needs of the local people (Sasaoka, 2003) or the acculturation of Javanese culture during a transmigration programme to other islands (Pangau-Adam & Noske, 2010). We found provinces in Sumatra, including Jambi, Lampung and South Sumatra, and in eastern Indonesia, such as West Papua, North Maluku and Maluku, to be the provinces outside Java that had the highest bird ownership levels after adjusting for population size. These provinces would therefore be suitable candidates for in-depth consumer research to provide further insights into the best approaches for managing consumer demand for these birds.

Shark consumption

The identified hotspots of shark meat consumption tended to be associated with shark landing sites. Java showed the highest shark product consumption, and, in a previous study, 17 large fishing ports that also landed sharks were found along the northern and southern coasts of Java compared to only 3–5 large fishing ports in each of Kalimantan, Sulawesi and Sumatra (Booth et al., 2018). The large human population of Java could also be a cause of the high demand, and surpluses of local products from Sumatra, Kalimantan, Sulawesi, West Nusa Tenggara, East Nusa Tenggara and Maluku are used to meet this demand (Muttaqin et al., 2018). Large cities in Java, such as Jakarta, Semarang, Surabaya and Tangerang, are also the largest collectors of shark products for export to other countries (Ali & Isa, 2003; Dent & Clarke, 2015; Muttaqin et al., 2018).

Provinces in Java had the highest absolute numbers of shark product consumers, but in terms of the numbers of consumers per 1,000 people of the population, Maluku, Aceh and East Nusa Tenggara were amongst the top five provinces. This result suggests that shark consumption differs based on location, the types of products consumed and social and demographic factors. Shark product consumers can be grouped into luxury consumers (those who consume high-value shark food products; Shea & To, 2017), traditional consumers (consumption associated with shark-fishing communities; Muttaqin et al., 2019) and consumers unaware that the products originated from sharks (Booth et al., 2018). As a luxury product, shark is usually consumed as fin soup in hotels in large cities such as Jakarta, Surabaya, Makassar, Medan and Semarang (Ali & Isa, 2003; Booth et al., 2018; Vallianos et al., 2018). Traditional shark product consumers usually inhabit coastal areas and have livelihoods associated with shark fishing. In these areas, shark meat provides a source of cheap, readily available protein and therefore plays a role in food security, but some such consumers also believe that shark consumption is beneficial to health and provides wellness benefits (Booth et al., 2018; Muttaqin et al., 2019). Passive shark product consumption could occur because shark products are often processed through drying or salting and marketed as generic fish (called salted fish, *ikan asin*; Dharmadi & Sumardhiharga, 2008; Muttaqin et al., 2019). Further investigation of the factors underlying shark product consumption in areas such as West Java and Maluku is needed to better support shark conservation actions and the legal trade in shark species.

Caveats and benefits of SMS surveys

Our research shows the potential of using SMS surveys for scoping studies conducted at a large scale and over a short period of time. The main challenge we encountered was the low response rate, although this is common for this type of survey (Li et al., 2013; Lau et al., 2018). We tried to mitigate this by providing an incentive to respond, asking a small number of short questions, using the identification label of our official organization name as the sender ID and sending a reminder SMS, but the response rate remained low. The response rate obtained by other studies using SMS surveys has varied greatly (1–71%), potentially being affected by many factors beyond incentive type, such as the length of the message (which was limited to 160 characters), the way in which the questions were structured and the sensitivity of the issues being investigated (Berman et al., 2017; van der Heijden, 2017; Leidich et al., 2018; Lau et al., 2019). In the context of this research, we learnt from the network provider that users regularly receive advertisements, which could affect their willingness to engage with SMS and therefore the response rate. Issues of sensitivity could also arise because of the protected status of some of the kept birds, which could introduce a non-response bias to the sample. We put in place several measures to reduce this possibility, including providing the terms and conditions ensuring the anonymity of any data provided. However, there was a higher attrition rate for the songbird survey than for the shark survey. Our question on the number of birds owned might also have introduced bias as it questioned current and past ownership of songbirds as pets. Although this might not be the case, this is also why further study to verify our estimates using ground-truthing and direct interviews is important.

Future research using SMS surveys should consider the use of simple questions with randomized and single responses (Lau et al., 2019) and explore platforms such as WhatsApp (Meta, Menlo Park, USA) or other popular cross-platform software. These allow the use of different data formats, although an internet connection is necessary, which could limit access. We also encourage future research focused on understanding where songbirds/shark products are usually bought and understanding motivations for songbird ownership/shark product consumption, which could help with the design of targeted behaviour change campaigns.

In this research we demonstrated that SMS surveys are useful for examining the scale of the patterns and demands for wildlife. We urge the conservation science community to explore and leverage this technology further to help match the scale of research effort to that of the threat processes being studied. We also call on conservationists to strengthen evidence-based conservation efforts by engaging and partnering with telecommunication companies.

Acknowledgements We thank USAID for funding this research; Telkomsel (A. Mario, A. Winanda and V. Pramusanto) for facilitating the SMS survey; J. Glikman for support regarding the research ethics approval; the WCS Indonesia team (M. Linkie, N. Andayani, H. Booth,

H. Pramono, F. Amama and P. Lestari) and E.J. Milner-Gulland for feedback during the development of both the research and article; and two anonymous reviewers for their valuable input.

Author contributions Study design: NU, EM, SM, ML, DV; data collection: NU, AM; data analysis: UM, S, AM, SS, EM, ML, DV; map development: SS; writing: NU, UM, S, EM, SM, ML, DV, DW, CR.

Conflicts of interest None.

Ethical standards This study was approved by Miami University (ID 03091e) and otherwise abided by the *Oryx* guidelines on ethical standards.

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