



Demand reduction campaigns could reduce the domestic trade in illegal wildlife in Peru

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ABSTRACT

Wild animals are captured and traded across Peru to meet urban demand for wild meat, zoothapeutic remedies, decorative items or amulets, and as wild animal pets. This study comprised an experimental survey aiming to reveal prior consumption or ownership of wildlife-origin products in urban Peru, and to test the effectiveness of consumer-focused approaches to reduce demand for illegal wild animal-origin products. We presented 501 respondents with 52 items (wild pets, meat and cultural, medicinal and decorative artefacts) to ascertain if respondents had owned or consumed them. Of our respondents 77.4 % had purchased, owned or consumed at least one product: 39.9 % wild pets, 63.1 % wild-sourced meat, and 41.5 % wildlife-derived artefacts. We then presented a separate 2005 respondents with 15 items (five wild pets, five wild meats and five wildlife-derived medicines/artefacts), each accompanied by a different type of information, and asked them to indicate how likely they would be to buy each. Accompanying information was either neutral (control), or one of four pieces of treatment information describing the zoonotic disease, animal welfare, legal, and conservation risks associated with the purchase. Treatment information made respondents between 1.47 and 1.86 times less likely to select higher probabilities of purchase for any item. We conclude that consumption of wildlife-origin items is commonplace in urban Peru, but social norms surrounding the acceptability of ownership of these will be amenable to alteration through repeated demand reduction campaigns, especially if these highlight the zoonotic disease potential of such purchases and the need to conserve native Peruvian species.

1. Introduction

The global trade in wildlife is a substantial, and growing, threat to global biodiversity, species conservation, animal welfare (Grieser-Johns and Thomson, 2005; Pires and Moreto, 2011; Fernandes-Ferreira et al., 2012; Baker et al., 2013; Dutton et al., 2013; Challender and MacMillan, 2014), human health (e.g. Espinosa et al., 2020; Macdonald et al., 2021) and financial stability (e.g. Macdonald et al., 2021; D'Cruze et al., 2021).

Peru is a mega-diverse country (Rodríguez and Young, 2000; MINAM, 2021) and a key source of wildlife traded both across the Latin American region (Reuter et al., 2018) and internationally to meet consumer demand (Can et al., 2019; Mendoza et al., 2022). In addition to its international and regional significance, Peru has a substantial domestic market for wildlife (Daut et al., 2015). This domestic trade encompasses an array of taxa, including mammals (Bodmer and Lozano, 2001), birds

(Daut et al., 2015), reptiles (Pineda-Catalan et al., 2012), amphibians (Quevans et al., 2013) and invertebrates (SERFOR, 2017; Delgado et al., 2019). Wild animals are captured and traded across Peru to meet demand arising from four principal uses: as a source of meat, fats and nutrients (Bodmer et al., 2004; Asprilla-Perea and Díaz-Puente, 2019); as a source of zoothapeutic remedies; for use as decorative items and in magico-religious rituals in the form of amulets and charms (Venero, 1998), and; as pets (i.e. wild animals as pets; Bodmer and Lozano, 2001; D'Cruze et al., 2021). The harvest and trade of wild animals therefore plays important nutritional, medicinal, luxury and socio-cultural roles for Peruvian nationals, and also represents an important source of financial security for Peruvian rainforest residents (Espinosa, 2008; D'Cruze et al., 2021).

The wildlife trade within Peru comprises a large number of species – for example, Mendoza et al. (2022) recorded at least 430 different species confiscated by Peruvian authorities between 2001 and 2019 –

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and relies on a structured network of trafficking routes. The trade typically originates in small open-air markets local to the Amazon which have few to no health/safety precautions or sanitation and which exclusively sell species that have been sourced from the surrounding locale (Mendoza et al., 2022; Gastañaga et al., 2011). From these markets species feed into larger markets and are traded to larger cities in which the proportions of local species sold vary significantly, such that markets in large urban centres provide consumers with a diverse selection of species sourced from across the whole of Peru (Mendoza et al., 2022). Pires (2015) characterised wildlife markets in Peru and Bolivia as local, regional or “feeder” markets, with the latter responsible for distributing commodities to other markets, allowing purchase by middlemen to become an important component of the local demand. Urban consumers in Peru, therefore, can act as a key source of demand for species sourced at the local level (Mendoza et al., 2022). In addition, there is a substantial, and increasing online trade in wild animals - with adverts across a number of different social media and online platforms - across Andean Amazonian countries, including Peru, which plays an increasingly important role in supplying demand for wildlife in urban areas (WCS, 2021).

Peru's domestic wildlife trade represents a series of severe risks, to wildlife populations through overexploitation, to the ecosystems from which they are extracted (Gardner et al., 2019), to the welfare of individual animals at each point of the trade chain (Baker et al., 2013; D'Cruze et al., 2021) and to the human population, both through the potential for the transmission of zoonotic disease (e.g. Watsa et al., 2020), and through unsustainable harvests that threaten the long term future financial security of the region's poorest citizens (van Halle, 2002). (N.B. under Peru's national legal framework, wildlife is understood as comprising only animals that carry out all or part of their life-cycle on land, and different regulations apply to fish, which are considered a hydrobiological resource; Law No 29763. In this study, however, our results incorporate fish as wildlife in order to provide an integrated approach to consumption of wild animals.)

The commercialisation of wildlife products in Peru is forbidden unless those products have a legal origin (e.g. captive breeding sites or managed areas) (Law No 29763). The prohibition, however, is currently ineffective at preventing illegal trade of wildlife-sourced products (D'Cruze et al., 2021; Mendoza et al., 2022; Mayor et al., 2022; WCS, 2016). Enforcement is hindered by a number of factors including logistical limitations, financial constraints, and on-going consumer demand (Mayor et al., 2022), as well as a prevailing assumption among citizens that possession of prohibited animals and products is both socially permissible and unlikely to lead to sanction by the authorities (WCS, 2016). As an example, Belen market in Iquitos is the largest and most important open market selling wildlife in the Peruvian Amazon (Mayor et al., 2022) and previous work found 99 vendors willing to admit to involvement with forbidden trade of wildlife when interviewed (D'Cruze et al., 2021). Similarly, of 554 citizens surveyed while visiting markets in Peruvian cities, 282 (71.4 %) reported having, or having had, a wild animal as a pet at home, but <5 % stated that it was allowed (WCS, 2016).

Global efforts to stem illegal and/or unsustainable wildlife trade have traditionally focussed on tackling the supply of products, through enforcement and regulation (Challender and MacMillan, 2014; Veríssimo et al., 2012). In addition, however, measures are increasingly implemented to reduce consumer demand through educational and public awareness campaigns (Courchamp et al., 2006; Dalberg, 2012; Baker et al., 2013; Veríssimo and Wan, 2019). At present, however, the relative effectiveness of consumer approaches often remains untested and under-reported (Olmedo et al., 2018; Veríssimo and Wan, 2019; Veríssimo et al., 2018). A recent study concluded that of 236 such campaigns, only a quarter reported on outcomes (e.g. changes in the target audience regarding, for example, knowledge, attitudes or behaviour) and < 9 % reported on conservation impacts (Veríssimo and Wan, 2019). Many campaigns lack a theory of change for how

interventions could influence consumers' behaviour (Olmedo et al., 2018; Wallen and Daut, 2018) or have project designs that are not adequate to test the effect of interventions on the target audience (Veríssimo and Wan, 2019).

Creating positive outcomes for conservation and animal welfare through changing consumers' choices will often require removing barriers that prevent environmentally desirable behaviours (Wallen and Daut, 2018). Wallen and Daut (2018) state that such barriers may occur at the level of individuals (e.g. ignorance that a purchase is illegal or that there is a legal alternative), or be embedded within broader sociocultural or political contexts (e.g. consumption that is considered traditional, or which denotes status within a culture) (Wallen and Daut, 2018; Hauser et al., 2018). Targeting individuals' barriers/beliefs may alter their behaviour if they have received incorrect information, and would change their mind if provided with accurate information. A lack of information can be a barrier to changing behaviour (Schultz, 2002), but information alone will not necessarily motivate individuals to alter their behaviour (Stern, 2000), especially if the barrier is embedded within wider society (e.g. Rizzolo, 2021; Hinsley et al., 2022). Marketing and behavioural economics approaches may therefore be required to test which, if any, messages or interventions are likely to be effective on the target population (e.g. Moorhouse et al., 2017; Olmedo et al., 2018). Interventions to reduce demand for animal-origin products could involve, for example, disseminating information to consumers about the animal welfare (e.g. Hauser et al., 2018) or conservation (e.g. Davis et al., 2016; Liu et al., 2016) impacts of their consumption, as well as informing consumers about the legal or potential zoonotic disease risks (e.g. WCS, 2016).

In this study, we present an experimental survey with two main goals. We first investigate levels of prior ownership/consumption of wildlife-origin products in urban Peru, and ascertain the most commonly consumed species/products. We then test, using these commodities, the potential effectiveness of consumer-focused approaches to reduce the size of the demand for these illegal wild animal-origin products. We provide initial tests of the effectiveness of information campaigns aimed at demand reduction by highlighting impacts on species conservation, animals' welfare, human health and legal consequences, and gauging the effects of these messages on respondents' likelihood of purchasing wild-animal-derived products.

2. Methods

2.1. Study design, rationale and overview

To meet our study objectives we employed two separate surveys. The first (Survey A) sought to establish prior levels of consumption of illegal wildlife-origin products in urban Peru, and identify those most commonly consumed. Initial research indicated this information was largely absent, with two broad implications: that demand reduction campaigns would be uncertain which species/products to target, and that our tests of demand reduction strategies in the second survey would risk targeting unpopular or infrequently consumed products. Our second survey (Survey B) aimed to assess the potential for demand reduction campaigns to reduce the future likelihood of urban Peruvians from consuming the most common products, as identified in the first survey. Our methodology in this survey aimed to minimise biases that can arise from surveys on issues considered to be sensitive (e.g. social desirability bias whereby respondent attempt to present themselves positively to researchers; Nederhof, 1985). Rather than asking respondents about illicit behaviours we presented them with a series of wildlife-origin products and for each asked them to state their likelihood of purchasing it. Any given product was accompanied by either “treatment” demand reduction messaging or neutral “control” messaging (e.g. Moorhouse et al., 2017; Moorhouse et al., 2020; see below). This approach encourages respondents to think like consumers, and allows direct comparison of the effect of messaging on the desirability of

products. Moreover it minimises the likelihood of respondents comprehending that an array of messages was tested for each item, as opposed to viewing a given message as describing an intrinsic property of a given item (e.g. Moorhouse et al., 2020; see below).

Survey A comprised direct questions. Survey B had an experimental setup, comprising two principal sections. **Section 1** contained questions seeking to understand respondents' history of owning different types of illegal wildlife origin products, and to gauge their intention of owning such products in the future. **Section 2** presented respondents with images of the fifteen most popular illegal wildlife-origin items identified from Survey A, each accompanied by a statement that provided either neutral information about the product (control information), or described one of four types of potential negative impacts of purchasing the item (treatment information; see Table 1; Fig. 1a, b; details below). The design of Survey B incorporated two methods for assessing the degree to which the treatment messaging in **Section 2** influenced consumers. First, within **Section 2** we compared respondents' stated likelihood of purchase of a given item when presented with a treatment message (see details below) versus when presented with neutral, control messaging. Second, we randomised the order in which respondents were presented with **Section 1** and **Section 2** of Survey B. If respondents who had previously completed **Section 2** (and therefore read all of the types of treatment messaging) selected lower likelihoods of future purchase of different types of items than those who viewed **Section 1** first, this would indicate an overall effect of the treatment messaging.

Both surveys were professionally translated into Spanish and the translated version was then screened by in-country collaborators (Sociedad Peruana de Derecho Ambiental (SPDA) and Instituto de Investigaciones de la Amazonía Peruana (IIAP)) to ensure that the terminology for given products was appropriate for, and easily recognisable by, the intended recipients. Both surveys were designed in collaboration with, and conducted by, market-research professionals (Touchstone Partners Limited, <http://www.touchstonepartners.co.uk>) who coordinated respondent recruitment through proprietary market research panels. Panellists were familiar with surveys but not contacted so frequently as to have become unrepresentative of the wider population. Surveys were conducted via questionnaires accessed online. Survey A ran from 21/09/2022 to 27/09/2022. Survey B ran from 08/01/23 to 13/01/23.

2.2. Survey A, initial background survey

We constructed a survey with the objective of deriving 500 full responses from urban residents in Peru to ascertain which wildlife-origin products they had consumed. Potential respondents were asked initial screening questions to establish respondents' sex and age and two questions to exclude respondents who lived in rural, as opposed to urban locations. These latter questions asked, "What is the name of the nearest big city to you?", with open responses, and "And how would you describe where you live" with response options being "Rural" or "Urban".

Respondents were then asked two sets of survey questions. The first set sought to establish which wildlife or wildlife-origin products respondents had owned or bought in the past. The question set comprised questions on three product types: wild animals as pets; wild meat or fish; products made from wildlife for cultural, decorative or medicinal purposes (Table 1). The products selected were drawn from the most common species and usages in D'Cruze et al. (2021, Appendix 4), WCS (2021, Tables 6–9), Delgado et al. (2019) and Mendoza et al. (2022, Table A4). The number of species/products of any type was limited to 21 to prevent respondent fatigue.

For wild animals as pets, respondents were shown a statement that read "Please find below a list of wild animals, for each of them please add all the options that apply", with response options of "I bought this animal as a pet for myself", "I was given this animal as a gift for a pet", "I bought this animal as a pet for someone else", "I know someone who has

this animal as a pet", "I do not have this animal but I would like to have it as a pet", "I do not have this animal and would not like to have it as a pet", "I don't know what this is". Respondents were then asked "Where, typically, do people get animals like these as pets?", with response options of "Shop", "Market", "Street Fair", "Found/captured in the wild", "Found on the street", "Social media (e.g. Facebook/Instagram advertisements)", "WhatsApp", "Don't know".

For wild meat, respondents were asked "We're going to show you a list of types of meat. For each one, please choose as many of the options as apply to you", with response options of "I have bought this meat to eat at home", "I have eaten this meat at someone else's house", "I have eaten this meat at a restaurant", "I know somebody who has eaten this meat", "I haven't eaten this meat but would like to", "I haven't eaten this meat and don't want to" and "I don't know what this is". Respondents were then asked "Where, typically, do people get meat like this?", with response options of "Shop", "Market", "Street Fair", "Restaurants", "Bought direct from hunter", "Social media (e.g. Facebook/Instagram advertisements)", "WhatsApp", "Don't know".

For cultural, decorative or medicinal artefacts, respondents were asked: "We're going to show you a list of products that are made from animals for cultural, decorative or medicinal purposes. For each one, please choose as many of the options as apply to you", with response options of "I have bought this to use myself", "I have bought this as a gift", "I have received this as a gift", "I know somebody who owns/uses this", "I haven't owned/used this but would like to", "I haven't owned/used this and don't want to", "I don't know what this is". Respondents were then asked "Where, typically, do people get products like these?" with options of "Shop", "Market", "Street Fair", "Social media (e.g. Facebook/Instagram advertisements)", "WhatsApp" and "Don't know".

The second question set sought to establish respondents' levels of knowledge concerning the legality of owning the above products, and intentions regarding owning or consuming these products in the future. The first question asked "As far as you know, is it legal to buy or possess:" with two options of "wild animals as pets" and "products made from wild animals", with response options of "Yes, it's legal", "No, it's illegal" and "I don't know". Respondents were then asked "How would you feel about:" a) "Owning a wild animal as a pet in the future", b) "Eating meat from wild animals in the future", c) "Taking remedies made from wild animals in the future", and d) "Owning items made from wild animals in the future", with response options of "I would definitely like to", "I would very much like to", "I am not sure", "I most likely would not", "I definitely would not want to". Respondents were then asked "In Peru it is illegal to buy, sell or possess many types of wild animal and products made from them. To what extent do you think this stops people from buying or possessing them?" with response options of "It stops people from buying them", "It makes people much less likely to buy them", "It makes people somewhat less likely to buy them", "It makes no difference", "It encourages people to buy them".

Following these questions, respondents were asked four further questions regarding their household composition, occupation, income and ethnicity.

2.3. Survey B, experimental survey

We constructed an experimental survey with the objective of deriving full responses from 2000 urban Peruvians to ascertain the potential for demand-reduction messaging to reduce the desire to purchase wildlife-origin products. Potential respondents were asked initial screening questions to establish their sex and age and two questions to exclude respondents who lived in rural, as opposed to urban locations. These latter questions asked, "What is the name of the nearest big city to you?", with open responses, and "And how would you describe where you live" with response options being "Rural" or "Urban". Qualifying respondents were then directed to either **Section 1** or **Section 2** of the main survey.

Section 1 comprised four sets of questions on different wildlife-origin

Table 1

The list of species and products presented to respondents in Surveys A and B. For full details of all statements presented to respondents in Survey B, please see Supplementary Table A.

Number	Survey A				Survey B		
	Wildlife origin pets	Wildlife origin meat/ fish	Wildlife origin artefacts/remedies	Wildlife origin medicines/ remedies	Wildlife origin pets	Wildlife origin meat/ fish	Wildlife origin artefacts/remedies
1	Poison dart frog (Class: Amphibia; Order: Anura)	Tinamou (Class: Aves; Order: Tinamiformes)	Items made from anaconda skin (Class: Reptilia; Order: Squamata)	Medicine made from mantona (boa) (Class: Reptilia; Order: Squamata)	Parakeet (Class: Aves; Order: Psittaciformes)	Amazonian fish (e.g. Class: Actinopterygii; Order: Osteoglossiformes)	Parrot artefact (decorative) (Class: Aves; Order: Psittaciformes)
2	Parrot (Class: Aves; Order: Psittaciformes)	Spix's guan (Class: Aves; Order: Galliformes)	Items made from mantona (boa) (Class: Reptilia; Order: Squamata)	Remedies made from caimans (Class: Reptilia; Order: Crocodylia)	Parrot (Class: Aves; Order: Psittaciformes)	Brocket deer (Class: Mammalia; Order: Artiodactyla)	Parrot artefact (spiritual) (Class: Aves; Order: Psittaciformes)
3	Parakeet (Class: Aves; Order: Psittaciformes)	Amazonian fish (e.g. Class: Actinopterygii; Order: Osteoglossiformes)	Items made from caiman parts (Class: Reptilia; Order: Crocodylia)	Remedies made from anaconda/ alligator oil (Class: Reptilia; Order: Crocodylia)	Dove (Class: Aves; Order: Columbiformes)	Tinamou (Class: Aves; Order: Tinamiformes)	Crocodile tooth necklace (Class: Reptilia; Order: Crocodylia)
4	Dove (Class: Aves; Order: Columbiformes)	South American Palm Weevil (Suri) (Class: Insecta; Order: Coleoptera)	Items made from caiman skin (Class: Reptilia; Order: Crocodylia)	Remedies made from river dolphins (Class: Mammalia; Order: Artiodactyla)	Tortoise/turtle (Class: Reptilia; Order: Testudines)	Caiman (Class: Reptilia; Order: Crocodylia)	Bufo (Amazonian river dolphin) remedies (Class: Mammalia; Order: Artiodactyla)
5	Song bird (Order: Passeriformes)	Tapir (Class: Mammalia; Order: Perissodactyla)	Crocodile tooth necklace (Class: Reptilia; Order: Crocodylia)	Suri oil (Class: Insecta; Order: Coleoptera)	Monkey (Class: Mammalia; Order: Primates)	Lowland paca (Class: Mammalia; Order: Rodentia)	Mantona (boa) remedies (Class: Reptilia; Order: Squamata)
6	Monkey (Class: Mammalia; Order: Primates)	Lowland paca (Class: Mammalia; Order: Rodentia)	Items made from jaguar parts (Class: Mammalia; Suborder: Feliformia)				
7	Sloth (Class: Mammalia; Suborder: Folivora)	Peccary (Class: Mammalia; Order: Artiodactyla)	Items made from jaguar skin (Class: Mammalia; Suborder: Feliformia)				
8	Agouti (Class: Mammalia; Order: Rodentia)	Armadillo (Class: Mammalia; Order: Cingulata)	Items made from mata mata (Class: Reptilia; Order: Testudines)				
9	Coati (Class: Mammalia; Order: Procyonidae)	Capybara (Class: Mammalia; Order: Rodentia)	Decorative items made from parrot/ macaw feathers (Class: Aves; Order: Psittaciformes)				
10	Jaguar (Class: Mammalia; Suborder: Feliformia)	Agouti (Class: Mammalia; Order: Rodentia)	Spiritual items made from parrot/macaw feathers (Class: Aves; Order: Psittaciformes)				
11	Manntona (<i>Boa constrictor</i>) (Class: Reptilia; Order: Squamata)	Amazon river dolphin (Class: Mammalia; Order: Artiodactyla)	A sloth claw (Class: Mammalia; Suborder: Folivora)				
12	Caiman (Class: Reptilia; Order: Crocodylia)	Sloth (Class: Mammalia; Suborder: Folivora)	A monkey hand (Class: Mammalia; Order: Primates)				
13	Iguana (Class: Reptilia; Order: Squamata)	Coati (Class: Mammalia; Order: Procyonidae)					
14	Tortoise or turtle (Class: Reptilia; Order: Testudines)	Jaguar (Class: Mammalia; Suborder: Feliformia)					
15		Manatee (Class: Mammalia; Order: Sirenia)					
16		Brocket deer (Class: Mammalia; Order: Artiodactyla)					
17		Monkey (Class: Mammalia; Order: Primates)					

(continued on next page)

Table 1 (continued)

Number	Survey A				Survey B		
	Wildlife origin pets	Wildlife origin meat/ fish	Wildlife origin artefacts/remedies	Wildlife origin medicines/ remedies	Wildlife origin pets	Wildlife origin meat/ fish	Wildlife origin artefacts/remedies
18	Turtle or tortoise (Class: Reptilia; Order: Testudines)						
19	Caiman (Class: Reptilia; Order: Crocodylia)						
20	Mantona (<i>boa</i> <i>constrictor</i>) (Class: Reptilia; Order: Squamata)						
21	Iguana (Class: Reptilia; Order: Squamata)						

¿Qué probabilidad hay de que compre...?

a)



Objeto de decoración hecho con plumas de loro

Muchos loros silvestres están en peligro de extinción. La captura para fabricar objetos de decoración es una gran amenaza para su conservación.

- Definitivamente lo compraría.
- Muy probablemente lo compraría.
- No estoy seguro.
- Es muy poco probable que lo compre.
- Definitivamente no lo compraría.

¿Qué probabilidad hay de que compre...?

b)



Un periquito como mascota

Estos periquitos son nativos de Sudamérica. En su hábitat natural, se alimentan principalmente de frutas, frutos secos y semillas.

- Definitivamente lo compraría.
- Muy probablemente lo compraría.
- No estoy seguro.
- Es muy poco probable que lo compre.
- Definitivamente no lo compraría.

Fig. 1. Examples of items with treatment messaging as presented to respondents in the survey, showing: a) decorative items made from parrot feathers, accompanied by conservation risk (treatment) messaging, and; b) parakeets as pets, accompanied by neutral (control) messaging.

products. The first question set asked: “What do you think of wild animals as pets? (By “wild animals as pets,” we mean wild animals that are not traditionally domesticated for livestock farming or bred to be kept at home near humans, e.g., parrots, turtles, boas, and monkeys.) Select one of the following options”, with response options of “I own at least one wild animal pet”, “I have previously owned a wild animal pet but don’t at the moment”, “I have never owned a wild animal pet, but have bought one for someone else”, “I have never owned a wild animal pet but would like to” and “I have never owned a wild animal pet and don’t want to”. This was followed by: “How likely are you to buy a wild animal pet in the next 2 years?” with response options of “Very likely”, “Quite likely”, “Neither likely nor unlikely”, “Quite unlikely”, “Very unlikely”.

The second question set asked “What do you think about eating bush meat? (By ‘bush meat’, we mean the meat of wild animals caught in their natural habitats, for example, deer meat, alligator meat and partridge meat). Choose one of the following options” with responses of “I regularly eat bush meat”, “I have previously eaten bush meat, but not recently”, “I have never eaten bush meat, but would like to” and “I have

never eaten bush meat, and don’t want to”. This was followed by: “How likely are you to buy or consume bush meat in the next few months?” rated on the above five point scale from “Very likely” to “Very unlikely”.

The third question set asked “What do you think about products made with wild animals? (For example, decorative and spiritual items made from parrot feathers, items made from alligator skin, or items made from jaguar). Choose one of the following options”, with response options of “I have owned an object made from a wild animal but don’t now”, “I currently own an object made from wild animals”, “I don’t own any objects made from wild animals, but would like to”, “I don’t own any objects made from wild animals, and don’t want to”. This was followed by: “How likely are you to buy items made from wild animals in the next few months?”, rated on the above five point scale.

The fourth question set asked, “What do you think about remedies made with wild animals? (For example, suri oil, iguana oil or pusanga). Choose one of the following options”. [N.b. Suri oil is derived from the larvae of palm weevils, *Rhynchophorus palmarum* (Delgado et al., 2019) and pusanga is an aphrodesiac perfume derived from ‘Amazon river

dolphin', *Inia geoffrensis* (D'Cruze 2021).] Response options were: "I regularly buy remedies made from wild animals", "I sometimes buy remedies made from wild animals", "I don't buy remedies made from wild animals, but would like to", "I don't buy remedies made from wild animals, and don't want to". This was followed by "How likely is it that you will buy or consume medicinal products, remedies and supplements made from wild animals in the coming months?", rated on the above five point scale.

Section 2 comprised one question that stated "We will show you some wild animals that are usually kept as pets, some types of wild meat and some products and medicines made from wild animals. For each, indicate how likely it is that you would buy it, if it were easily obtainable". Respondents were then shown fifteen animals or products, accompanied by a treatment message, and rated each on a five point Likert-type scale of "I would definitely buy it", "I would be very likely to buy it", "I am not sure", "I would be very unlikely to buy it", "I would definitely not buy it" (Fig. 1). The animals/products shown to respondents were selected from the most popular wild-origin pets, wild-origin meats and wildlife-origin artefacts and remedies revealed by responses to Survey A. These items are presented in Table 1, and full details of the statements used are given in Supplementary Table A. The appearance of the survey to respondents is represented in Fig. 1. Each item was shown to each respondent in random order, but grouped within their product types (e.g. five wildlife-origin pets were shown to respondents consecutively, but in random order, and either comprised the first five, second five or third five items shown to any given respondent). Each item was accompanied by a random selection of one of five types of experimental statement (for full details of all statements see Supplementary Table A. These statements were neutral (control) information concerning the provenance or constitutions of a given item, treatment information describing the zoonotic disease risks associated with the purchase of the item, treatment information describing the animal welfare risks associated with the purchase, treatment information describing the legal risks of the purchase and treatment information describing the conservation risks of the purchase. These types of statements have been used in prior research into conservation marketing messaging (Moorhouse et al., 2017; Moorhouse et al., 2020). All statements presented to respondents were factually correct. Any given item was shown to any respondent only once. A set of example control and treatment statements are provided in Table 2.

2.4. Statistical analysis

For Survey A, analysis of respondents' level of desire to purchase wildlife origin items in the future was conducted via ordinal logistic regressions, implemented in Program R (R Core Team, 2022) using the ordinal package (Christensen, 2015; Christensen, 2022), with respondents' stated likelihood of purchase as the response variable. Available explanatory variables were respondents' age, sex, previous ownership/consumption of wildlife-origin items, and respondents' level of belief that ownership/consumption of wildlife-origin items was legal. Where appropriate illustrative odds ratios were calculated from the regression coefficients for each variable factor of interest, as exp

(coefficient) (Christensen, 2015; Christensen, 2022).

For Survey B, analysis of the impact of treatment messaging on respondents' desire to purchase each of the fifteen wildlife-origin items in Section 2 was conducted using repeated measures ordinal logistic regression for which the response variable was respondents' selected likelihood of buying a given product. Available explanatory variables were the type of message shown (control, disease, welfare, legality, conservation; Table 2), the identity of the item in question (e.g. lowland paca meat, decorative item made from parrot feathers, etc.) respondents' age, sex, level of education and income, the order in which the two Sections were presented (i.e. whether respondents had already answered Section 1 or not) and the order in which each item was presented to a given respondent (i.e. whether the respondent viewed the item first, second etc., up to fifteenth, to test of a cumulative effect of messaging with repeated exposure).

In Survey B, we also assessed the effect of treatment messaging by testing for an effect of section order (i.e. whether respondents were shown questions in Section 1 or Section 2 first) on responses to questions in Section 1. Available response variables were respondents' stated past ownership of each type of item (i.e. wildlife-origin pets, meat, and cultural, decorative or medicinal artefacts) and their stated future likelihood of purchase. To analyse past ownership, each item type was analysed separately using single-measures ordinal logistic regression, with survey responses reduced to a binary response variable (whether a given respondent had owned the item or not). Future likelihood of purchase was analysed separately for each item type using single measures ordinal logistic regression. For both sets of analyses available explanatory variables were respondents' age, sex, education and income, as well as treatment (control respondents received Section 1 first, treatment respondents received Section 2 first), and the order in which each item type was presented to respondents (i.e. whether a given item type was the first, second, third or fourth viewed).

3. Results

3.1. Current levels of consumption of illegal wildlife in urban Peru

In Survey A we gained full responses from 501 residents of urban areas in Peru, of which 249 identified as male, 249 identified as female and three preferred not to say. Respondents were drawn from 57 urban locations overall, but with the majority responding from Lima (247 respondents), Trujillo (40), Arequipa (29), Callao (17) Ica (15), Piura (14), Chiclayo (12) and Huancayo (10). These respondents were presented with a total of 14 Amazonian wild animals kept as pets, 21 types of wild meat derived from Amazonian animals and 17 cultural, medicinal and decorative artefacts derived from Amazonian wild animals (Table 1), and for each we ascertained whether the respondents had owned, gifted or consumed that wild animal or product. Of 501 respondents only 113 had not bought, consumed or possessed any of the products. Therefore 77.4 % of our sample had purchased, owned or consumed at least one product derived from Amazonian wildlife: 39.9 % had purchased or owned at least one wild animal pet, 63.1 % had consumed wild-sourced meat at least once, and 41.5 % had purchased or possessed at least one

Table 2

An example set of treatment statements for parakeets kept as pets.

Initial question	Treatment statements				
	Control statement	Human disease/harm message	Welfare message	Legality message	Conservation message
How likely would you be to buy...	Neutral information				
A parakeet as a pet	These parakeets are native to South America. In the wild they eat mostly fruits, nuts and seeds.	Parakeets can carry diseases that infect humans, including psittacosis, tuberculosis and paramyxovirus.	Parakeets are often captured and transported in conditions that cause severe welfare issues and deaths	Wild parakeets are often traded illegally. It can be impossible to tell if an individual is legal to own	Many wild parakeets are vulnerable to extinction. Capture for sale as pets is a major threat to their conservation.

wildlife-derived artefact. Every one of our 52 animals and products had been owned or purchased by multiple respondents.

Of the owned pets, 48.3 % comprised parakeet (27.2 %) and parrot (21.1 %) species, with a further 25.3 % comprising species of doves and tortoises (12.6 % each). The remaining 26.4 % of species comprised approximately equal quantities of the remaining 10 animals (Table 1). Of the types of wild meat consumed, the largest proportions comprised Amazonian fish (19.5 %), Brocket deer (12.0 %) tinamous (9.1 %), South American palm weevil (suri, 7.4 %) and lowland paca (5.3 %). The remaining 46.8 % comprised approximately equal proportions of the sixteen remaining species. Of the artefacts presented, the largest proportions owned or bought comprised decorative items made from parrot feathers (17.9 %), spiritual items made from parrot feathers (14.4 %), necklaces made from crocodilian teeth (8.8 %), artefacts made from jaguar parts (6.0 %) and caiman skin (5.6 %), medicine made from boa (5.6 %) and anaconda (5.5 %). The remaining 36.0 % comprised small proportions of the remaining 10 types of artefact.

We tested the extent to which consumption of each product type

varied with respondents' location by comparing the proportion of the survey population living in the eight cities that housed the majority of respondents (listed above), with the percentage of consumption of a given type of product stemming from that city. Proportions of total wild meat consumption at each location approximately matched the proportion of respondents from those locations (Fig. 2a). For example, Lima contained 49.3 % of the survey respondents, and respondents from Lima accounted for a mean of 53.0 % of those who stated that they had eaten a given type of wild meat (range 38.5–69.2 % of consumption across all meats; Fig. 2b). By contrast levels of pet ownership and ownership of wildlife-origin artefacts/remedies were strongly biased toward respondents from Lima (Fig. 2a,c). A mean of 72.0 % of all pets were owned or bought by residents in Lima (range 51.0 % - 100 % of ownership across all pets) (Fig. 2c). Similarly, a mean of 70.7 % across all artefacts/remedies were bought or owned by residents of Lima (range 61.5 %–81.8 %).

When asked about the legality of owning wild animals as pets, 78.2 % of respondents stated that it was illegal to do so, with 11.4 % stating

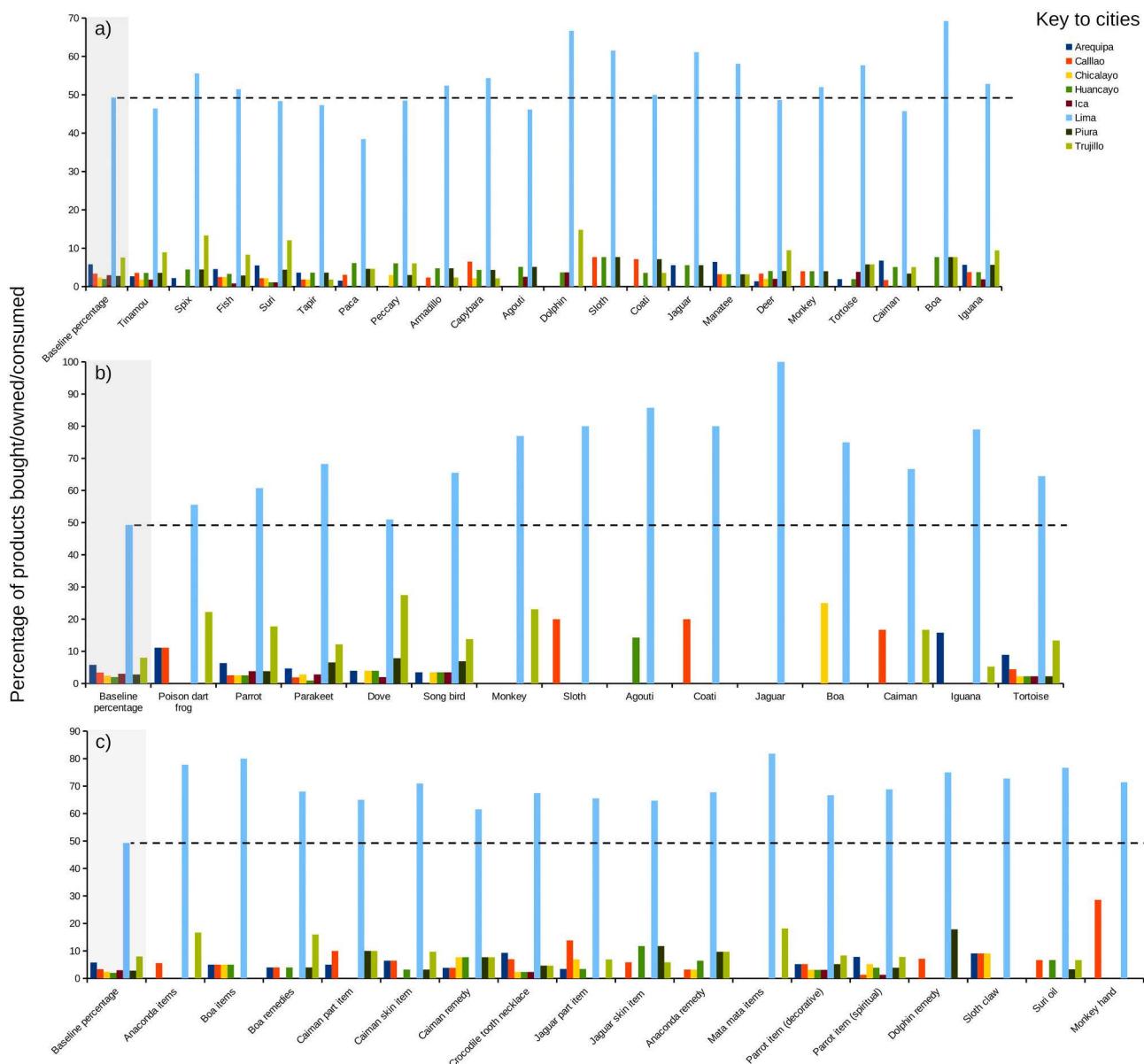


Fig. 2. Comparison of the proportion of the survey population living in the eight cities that housed the majority of respondents (baseline percentage), with the percentage of consumption of an each type of product stemming from that city for a) wild meats b) wildlife as pets and c) wildlife-origin artefacts and remedies. Dotted reference lines indicate the baseline percentage for Lima.

that they were unsure and 10.4 % stating that it was legal to do so. A smaller proportion of respondents, 61.1 %, stated that it was illegal to own products made from wild animals, with 20.4 % stating that they were unsure, and 18.5 % stating that it was legal to do so.

When asked about future ownership intentions, the overall percentages of respondents who selected that they would “definitely like to” or “very much like to” (hereafter “high likelihoods”) own each item was 12.9 % (wild animals as pets), 11.8 % (wild origin meat), 8.8 % (artefacts from wild animals) and 14.2 % (remedies from wild animals). The percentages selecting “I most likely would not” and “I definitely would not want to” (hereafter “low likelihoods”) were 71.1 %, 70.3 %, 73.3 % and 63.1 %, respectively. In all analyses intention to own/purchase each product increased with previous ownership and also with belief that the product was legal to possess (Table 3). The percentage of respondents selecting high likelihoods of future purchase/ownership was 5.3 %, 2.7 % 4.1 % and 5.1 % for non-owners but 24.4 %, 17.3 %, 15.6 % and 27.3 % for previous owners, for pets, meat, artefacts and remedies, respectively. Odds ratios derived from Wald tests of the effect of previous ownership demonstrated that previous owners of wildlife-origin pets, meat, artefacts and remedies/supplements were respectively 3.43, 2.88, 3.14 and 3.79 times more likely to pick high likelihoods of future purchase than non-owners. The effect of believing that these items were legal to possess, was to make respondents 2.17, 2.79, 4.13 and 3.97 times more likely to state high likelihood of future purchase, respectively, compared with those who believe they were illegal (the reference level) (Fig. 3). The effect of being uncertain regarding a given product’s legality was to make respondents 2.46, 1.77, 1.90 and 1.51 times more likely to pick high likelihoods of future purchase (Fig. 3).

Across all products male respondents were between 1.35 and 2.17 times more likely than female respondents to pick higher likelihoods of future purchase.

In response to the statement “In Peru it is illegal to buy, sell or possess many types of wild animal and products made from them. To what extent do you think this stops people from buying or possessing them?” 81.4 % of respondents were of the opinion that illegality would have some negative impact on purchase and ownership rates: 19.2 % of respondents stated that this stops people from buying them; 27.1 % stated that it makes people much less likely to buy them, and 35.1 % stated that it makes people somewhat less likely to buy them. Of the remainder, 17.0 % stated that it makes no difference and 1.6 % that it encourages people to buy them.

3.2. Effectiveness of demand reduction messaging on respondents’ stated likelihood of purchasing wild animal-origin pets and products

For Survey B we gained full responses from 2005 respondents, of whom 1004 identified as male, 992 identified as female and 9 preferred not to say or identified as binary. Respondents came from 124 urban locations in Peru. The majority were located in Lima (1075), Arequipa (128), Trujillo (97), Piura (50), San Juan de Lurigancho (48) Chiclayo (44), Cuzco (43), Ica (40), Huancayo (37), Callao (34). Overall, of respondents whose locations were able to be categorised, 77.7 % lived in coastal cities, 15.4 % in Andean cities and 6.9 % in cities bordering forested areas.

All experimental treatments in Section 2 were effective at lowering

respondents’ stated desire to purchase any given animal or product (Table 4, Fig. 4). Across all animals and products, a mean of 22.8 % of respondents stated that they were “definitely” or “very likely” (hereafter “high likelihoods of purchase”) to buy each item when shown control (neutral) statements. When shown information regarding the conservation, disease, legal and welfare consequences of the purchase, the percentage of respondents selecting high likelihoods of purchase were 15.6 %, 15.9 %, 16.4 % and 16.5 %, respectively (Table 4, Fig. 4). Similarly, when shown control information, the mean percentage of respondents stating that they would “be very unlikely to” or “definitely not” buy an item was 62.6 %. This percentage was 72.2 %, 72.4 %, 70.49 % and 70.2 %, respectively, for respondents shown conservation, disease, legal and welfare statements (Fig. 4). Odds ratios for the effect of each type of treatment information were 0.54, 0.54, 0.68 and 0.60 - for conservation, disease, legality and welfare, respectively – indicating that overall respondents shown conservation and disease information were 1.84 and 1.86 times less likely to select higher probabilities of purchase, respectively, while those responding to legality and welfare information were 1.47 and 1.68 times less likely to select higher probabilities of purchase.

The effect of treatment information varied between items (LRT effect of treatment * item = 136.12, d.f. = 52, $P < 0.001$; Table 4). Relative to the reference level, Wald tests reveal an increased effect of the following: disease information for Brocket deer; conservation, disease and welfare information for Arapaima fish; conservation and disease information for lowland paca, and; conservation information for parrot (as a pet) (Fig. 4; reference level was caiman in this analysis). In each case the effect size was greater than reference and so the interaction term therefore did not invalidate the conclusion that all experimental treatments lowered respondent’s desire to purchase for all items, but indicates an additive effect for some items.

There was a cumulative effect of repeated messaging on responses (LRT effect of the order in which a given message was presented to respondents (1–15) = 22.038, d.f. = 1, $P < 0.001$; Table 4). Wald tests reveal that this effect was relatively minor, with the odds ratio for the fifteenth message indicating that the repetition led to respondents being 1.22 times less likely to select high likelihoods, compared with when seeing the first message. Male respondents were twice as likely as female respondents to select high likelihoods of purchase (odds ratio 0.50), and respondents became substantially less likely to select high likelihoods of purchase with increasing age (odds ratio 1.50 for every 10 year increase in age beyond 18, the minimum age in our survey) (Table 4).

To mimic the likely effect of viewing a single-message demand reduction campaign on respondents, we conducted a separate analysis, limited to only data from the first message shown. The results were highly consistent with those from the above repeated-measures analyses (LRT effect of treatment = 219.61, d.f. = 3, $P < 0.001$, in a model containing effects of age, sex, section order and species). The odds ratios for the effect of treatment messages were 0.65, 0.64, 0.73 and 0.71 for conservation, disease, legality and welfare messages, respectively – indicating that overall respondents shown conservation and disease information were 1.5 and 1.6 times less likely to select higher probabilities of purchase, respectively, while those responding to legality and welfare information were 1.36 and 1.41 times less likely to select higher probabilities of purchase.

Table 3

Likelihood ratio tests of factors effecting future likelihood of purchasing items within each category (pets, meat, artefacts and remedies) in Survey A. Analyses for each category were conducted separately.

Source	d.f.	Wildlife origin pets		Wildlife origin meat/fish		Wildlife origin artefacts		Wildlife origin supplements/remedies	
		LRT	P	LRT	P	LRT	P	LRT	P
Age	1	2.081	0.1491	0.053	0.819	0.153	0.696	3.195	0.0739
Sex	1	21.411	<0.001	17.319	<0.001	11.973	<0.001	3.599	0.0578
Previously owned/Consumed? (Y/N)	1	47.970	<0.001	36.512	<0.001	40.675	<0.001	56.817	<0.001
Legal belief (Legal, illegal, uncertain)	2	17.023	<0.001	24.529	<0.001	38.815	<0.01	35.589	<0.001

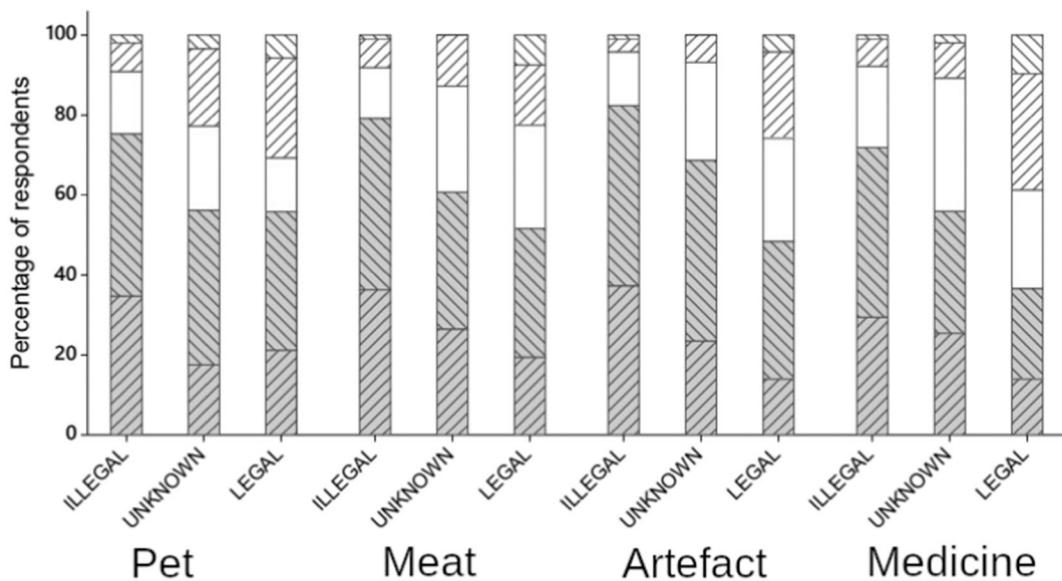


Fig. 3. The effect of respondents' beliefs about the legality of possessing items on stated likelihood of purchase in the future. From top to bottom, bars represent the responses "Very likely" (unshaded, hashed) "Quite likely" (unshaded, hashed) "Neither likely nor unlikely" (unshaded, no hashing) "Quite unlikely" (shaded, hashed) "Very unlikely" (shaded, hashed) in response to the question of how likely they would be to purchase each type of item in the future.

Table 4

Likelihood ratio tests of the effects of the treatment messages on stated likelihood of purchase of each item in Survey B, [Section 2](#).

Source	df	LR statistic	P
Treatment	4	339.23	<0.001
Order	1	22.038	<0.001
Sex	1	63.824	<0.001
Age	1	110.860	<0.001
Item	14	3070.00	<0.001
Treatment * Item	56	136.12	<0.001
Section order	1	0.955	0.328
Education	1	3.469	0.0625
Income	1	1.195	0.274

There was no evidence of an effect on stated likelihood of purchase of respondents' education or income, or the section order in the survey (i.e. whether we had previously asked respondents about their prior ownership of items derived from wild animal) ([Table 4](#)). Similarly, in a separate model, there was no effect of whether a given respondent's city was coastal, Andean or bordered forest (LRT effect of location = 0.547, d.f. = 2, $P > 0.76$).

3.3. Overall impact of demand reduction messaging on respondents' stated future likelihood of purchase

Of the 2005 respondents in Survey B, 1000 were first presented with [Section 1](#) (in which we asked respondents about their prior ownership of items derived from wild animals), followed by [Section 2](#) (which contained the demand-reduction messaging), and 1005 saw [Section 2](#) first, followed by [Section 1](#). In contrast to the above absence of a significant effect of section order on the responses to [Section 2](#), we detected a substantial effect of section order on respondents' answers in [Section 1](#) ([Table 5](#), [Fig. 5](#)). Compared with respondents who received [Section 1](#) first, and so had not read any treatment messages (hereafter 'control' respondents), respondents who received [Section 2](#) first ('treatment' respondents) selected substantially reduced likelihoods of purchasing wild animal-origin items in the future (LRT effect of treatment >111.97, d.f. = 1, $P < 0.001$ for all items; [Table 5](#); [Fig. 5](#)). The percentage of control respondents selecting high likelihoods of future purchase was 22.2 %, 23.2 %, 18.6 % and 27.1 % for wild animals as pets, wild meat, wildlife-

origin artefacts and wildlife-origin supplements/remedies, respectively. For treatment respondents these percentages were respectively 9.6 %, 7.4 %, 7.8 % and 10.0 % ([Fig. 5](#)). The percentages of control respondents selecting low likelihoods of future purchase were 57.2 %, 53.7 %, 60.7 % and 49.0 %, compared with 79.8 %, 80.3 %, 81.0 % and 75.0 % for treatment respondents ([Fig. 5](#)).

Odds ratios for the effect of treatment on likelihood of purchasing wild animals as pets, wild meat, wildlife-origin artefacts and wildlife-origin supplements/remedies were 0.36, 0.32, 0.40 and 0.33, respectively, indicating that treatment respondents were between 2.75 and 3.2 times less likely to select high likelihoods of purchase than were control respondents ([Fig. 5](#)).

Stated likelihood of future purchase varied with respondents' sex ([Table 5](#)). Odds ratios for male respondents were between 1.61 and 1.99 for all items, indicating that male respondents were one-and-a-half to twice as likely to select higher likelihoods than were female respondents. Stated likelihood of purchase decreased with increasing age of respondents ([Table 5](#)), with odds ratios falling between 0.69 and 0.78 for every 10 years of age increase, such that respondents became between 1.3 and 1.5 times less likely to select higher likelihoods of purchase with every 10 years aged. The order in which respondents saw questions about each item (i.e. whether they were, for example, shown questions on wild animals as pets first) influenced likelihood of future purchase for wild meat, wildlife-origin artefacts and wildlife-origin supplements/remedies ([Table 5](#)). In each case respondents' stated likelihood of purchase was lower the more questions they had previously answered. Odds ratios indicated that being asked a given question last made respondents between 1.33 and 1.77 times less likely to select higher likelihoods of purchase in the future.

There was no indication that a respondent's income, level of education influenced their desire to purchase any of the items in the future ([Table 5](#)). There was also no indication from separate analyses of an effect of whether a given respondent's city was coastal, Andean or bordered forest (LRT effect of location in all analyses <5.326, d.f. = 2, $P > 0.0697$).

3.4. Impact of demand reduction messaging on proportion of respondents stating they had previously consumed wildlife-origin products

Section order in Survey B had a significant effect on the proportion of

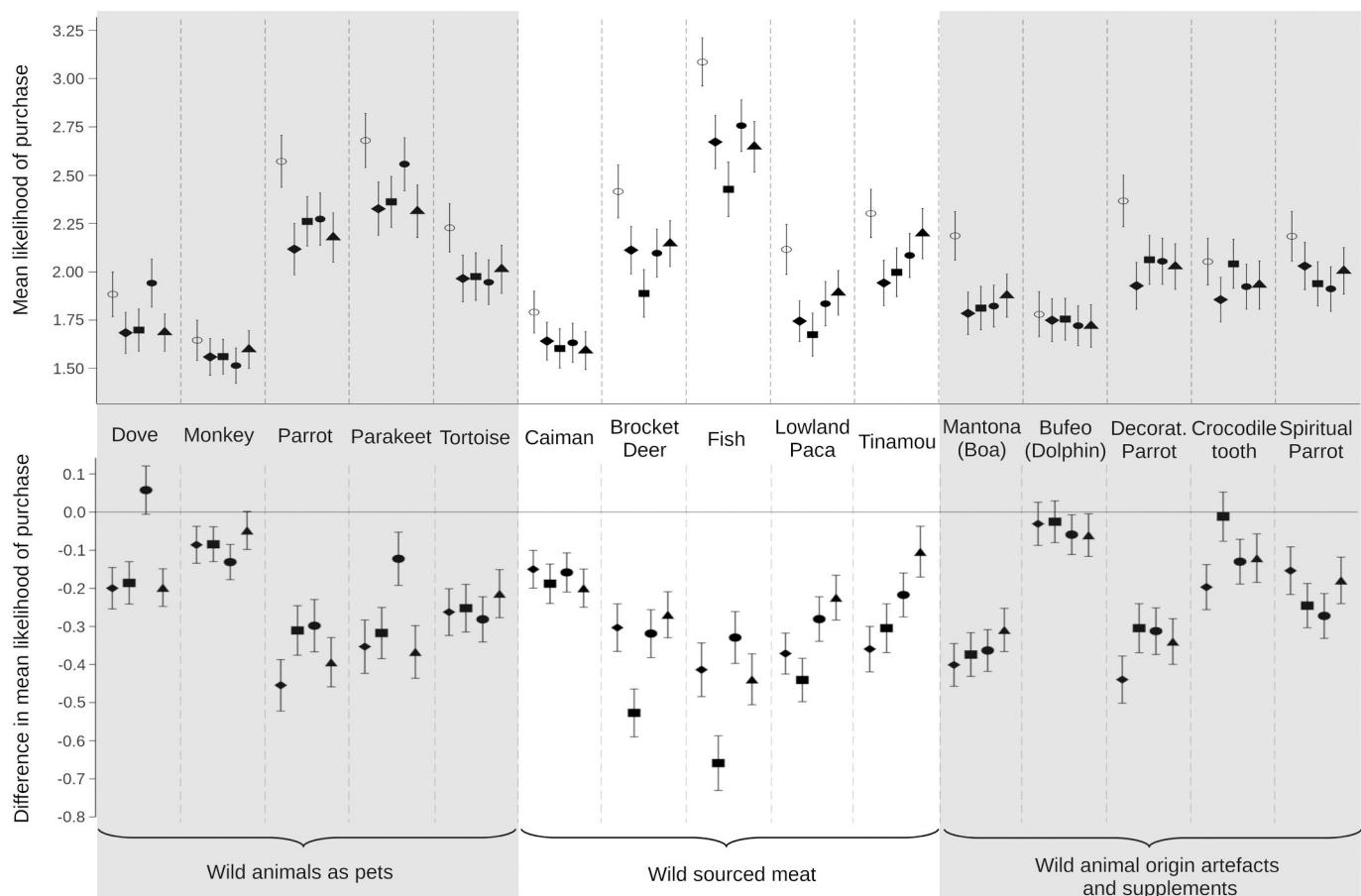


Fig. 4. Effect of treatment messaging on mean desire to purchase within Survey B, Section 2. For each item neutral (control) information is represented by open circles, with treatment information represented by filled, black shapes representing disease messaging (rhomboids), welfare messaging (squares), legality messaging (circles) and conservation messaging (triangles). Results are shown as mean selected likelihood (1–5 scale) for all control and treatment messages (above) and (below) only treatment messages, presented as a deviation from the control information.

Table 5

Likelihood ratio tests of factors effecting future likelihood of purchasing items within each category (pets, meat, artefacts and remedies) in Survey B, Section 1. Analyses for each category were conducted separately.

Source	Df	Wildlife origin pets		Wildlife origin meat/fish		Wildlife-origin artefacts		Wildlife-origin supplements/remedies	
		LRT	P	LRT	P	LRT	P	LRT	P
Age	1	101.296	<0.001	48.770	<0.001	76.246	<0.001	58.19	<0.001
Sex	1	38.953	<0.001	66.550	<0.001	45.075	<0.001	32.54	<0.001
Treatment (section order)	1	138.254	<0.001	181.719	<0.001	111.971	<0.001	180.543	<0.001
Question order	1	3.542	0.0599	13.882	<0.001	5.711	0.0169	6.745	0.009
Education	1	0.121	0.728	2.083	0.149	0.556	0.456	3.197	0.074
Income	1	1.485	0.223	3.331	0.068	1.225	0.268	0.021	0.885

respondents stating that they had previously owned wild animals as pets, or wild animal-origin items, consumed wild animal-origin meat or bought wild animal-origin supplements/remedies. A higher percentage of control respondents (who received Section 1 first) than treatment respondents (those who received Section 2 first) indicated that they had consumed any of the wild animal-origin items (LRT effect of treatment >16.30 , d.f. = 1, $P < 0.001$ for all items; Table 6). The percentage of control respondents stating they had owned or consumed each of the items was 33.3 %, 39.8 %, 22.0 % and 25.6 % for wild animals as pets, wild meat, wildlife-origin artefacts and wildlife-origin supplements/remedies, respectively (Fig. 6). For treatment respondents these percentages were respectively 20.9 %, 23.2 %, 14.7 % and 13.9 % (Fig. 6). The percentages of control respondents stating that they had never consumed any of the items were 63.2 %, 60.2 %, 78.0 % and 74.4 %,

compared with 76.1 %, 76.8 %, 85.3 % and 86.1 % for treatment respondents (Fig. 6).

Odds ratios for the effect of treatment on respondents stating they had consumed wild meat, wildlife-origin artefacts and wildlife-origin supplements/remedies were 0.52, 0.46,

0.62 and 0.47, respectively, indicating that treatment respondents were between 1.62 and 2.19 times less likely to state they had previously consumed any of these items than were control respondents.

The proportion of respondents stating they had previously consumed any of the types of items varied with respondents' sex (Table 6). Odds ratios for male respondents were between 1.25 and 2.05 for all item types, indicating that male respondents were one-and-a-quarter to twice as likely to state that they had previously consumed than were female respondents. Older respondents were more likely to have stated that

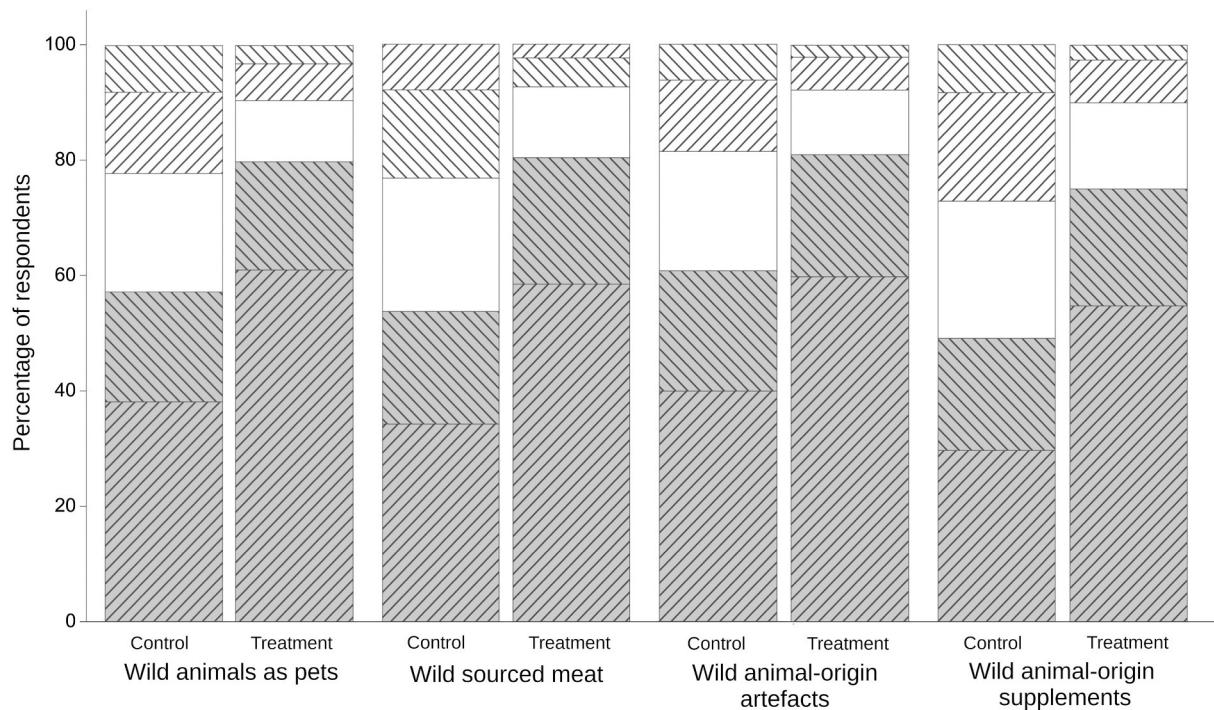


Fig. 5. The effect of respondents having viewed Section 2 (treatment respondents) prior to Section 1, versus having viewed Section 1 first (control respondents) on their stated likelihood of purchasing items of each type in Section 1. From top to bottom, bars represent the responses “Very likely” (unshaded, hashed) “Quite likely” (unshaded, hashed) “Neither likely nor unlikely” (unshaded, no hashing) “Quite unlikely” (shaded, hashed) “Very unlikely” (shaded, hashed) in response to the question of how likely they would be to purchase each type of item in the future.

Table 6

Likelihood ratio tests of factors effecting likelihood of respondents stating they had previously owned items within each category (pets, meat, artefacts and remedies) in Survey B, Section 1. Analyses for each category were conducted separately.

Source	Df	Wild animals as pets		Wild meat		Wildlife-origin artefacts		Wildlife-origin supplements/remedies	
		LRT	P	LRT	P	LRT	P	LRT	P
Age	1	12.585	<0.001	7.056	<0.0079	49.771	<0.001	29.410	<0.001
Sex	1	5.016	<0.025	51.86	<0.001	22.308	<0.001	13.456	<0.001
Treatment (section order)	1	39.242	<0.001	62.356	<0.001	16.296	<0.001	42.411	<0.001
Question order	1	7.060	0.0079	4.620	0.0316	0.328	0.567	0.153	0.696
Education	1	1.557	0.212	11.887	<0.001	7.088	0.0078	0.309	0.578
Income	1	1.191	0.275	6.558	0.0102	4.197	0.0405	0.300	0.584

they had not consumed any of the items, with odds ratios falling between 0.69 and 0.89 for every 10 years of age increase, such that respondents became between 1.12 and 1.45 times more likely to indicate that they had not consumed any of the items with every 10 years aged. The order in which respondents saw questions about each item type influenced the proportion stating they had consumed it for wildlife as pets and wild meat (Table 6). For these items being asked a given question last made respondents 1.63 and 1.47 times less likely to state that they had consumed the item type, respectively.

In separate models there was a significant effect of a respondent's income and level of education upon their likelihood of stating they had consumed wild -origin meat or wildlife-origin artefacts (both increased the probability), but no such effect on wild animals as pets or wildlife origin remedies/supplements (Table 6). There was no indication from separate analyses of an effect of whether a given respondent's city was coastal, Andean or bordered forest (LRT effect of location in all analyses <2.588, d.f. = 2, P > 0.274).

4. Discussion

Our intention in this study was to establish patterns of consumption of different classes of illegal wildlife-origin products in urban Peru, to

establish respondents' future intentions regarding their consumption and to then test whether different types of demand-reduction messaging would be sufficient to lower respondents' desire to purchase the most commonly consumed (and therefore most popular) illegal wildlife-origin items.

Survey A revealed widespread consumption of wildlife species and wildlife-origin products. Over three quarters (77.4 %) of 501 respondents had purchased, owned or consumed at least one of the 52 pets, meats or products with which they were presented. Wild meat was the most commonly consumed item type, consumed by approximately two thirds of respondents, and approximately 40 % of respondents had owned each of the wildlife-derived remedies, artefacts (spiritual and decorative items) or wild animals as pets. Intentions of owning items in the future were lower, with between 8.8 and 14.2 % of respondents selecting high likelihoods of owning in the future, but were 2.88 to 3.79 times higher among respondents who had previously owned one.

Taken overall these figures suggest a considerable market existing for illegal wild-animal origin items in urban regions of Peru. In particular our analysis of the data in Fig. 2, although revealing coarse trends, strongly implies that while levels of wild meat consumption were relatively consistent across all the cities we studied, demand for wildlife as pets and wildlife-origin artefacts/remedies appeared to be

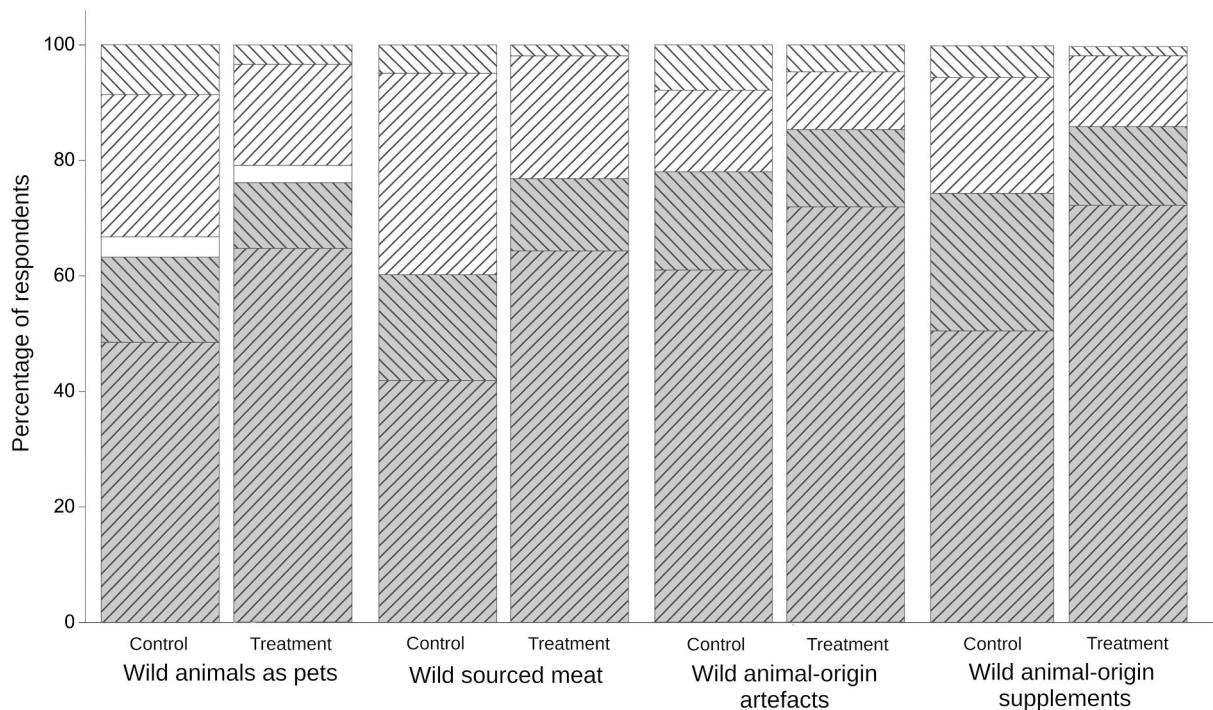


Fig. 6. The effect of respondents having viewed Section 2 (treatment respondents) prior to Section 1, versus having viewed Section 1 first (control respondents) on their stated past ownership of items of each type in Section 1. For all item types unshaded, hashed bar sections (the top two sections of each bar) represent past ownership/consumption, and shaded, hashed bar sections (the bottom two sections of each bar) represent *not* having owned or consumed the item in the past. In detail, from top to bottom, sections represent the following responses: 1) For wild animals as pets, “I have previously owned an exotic pet but don’t at the moment” “I have never owned an exotic, but have bought one for someone else”, “I have never owned an exotic pet but would like to”, “I have never owned an exotic pet and don’t want to”; 2) For wild sourced meat, “I regularly eat wild meat”, “I have previously eaten wild meat, but not recently”, “I have never eaten wild meat, but would like to”, “I have never eaten wild meat, and don’t want to”; 3) “I have owned an object made from a wild animal but don’t now”, “I currently own an object made from wild animals”, “I don’t own any objects made from wild animals, but would like to”, “I don’t own any objects made from wild animals, and don’t want to”; 4) “I regularly buy medicines made from wild animals”, “I sometimes buy medicines made from wild animals”, “I don’t buy medicines made from wild animals, but would like to”, “I don’t buy medicines made from wild animals, and don’t want to”.

proportionally higher among residents of Lima. This finding, coupled with Lima’s substantial population size (11,204,382, representing 43.0 % of the current urban population of Peru - estimated as 26,082,479, <https://worldpopulationreview.com/world-cities/lima-population>, <https://www.worldometers.info/world-population/peru-population>) indicates that a substantial proportion of the demand driving the national wildlife trade is likely to originate specifically in Lima.

Respondents from Lima were slightly over-represented in our study (representing 49.3 % of respondents to Survey A and 53.6 % of respondents to Survey B). Similarly our respondents were typically from coastal cities (e.g. 77.7 % of respondents in Survey B). Our findings are therefore likely to be primarily applicable to urban respondents from coastal locations, notwithstanding that we found no evidence in any analysis of an effect of a city’s location (i.e. whether it bordered coastal, Andean or forest habitats) on attitudes or responses to experimental messaging. These cautions aside, assuming our respondents are broadly representative of the national urban population, our results suggest that approximately 20 million city dwellers in Peru could have owned at least one wild animal-origin item in the past and, if respondents’ stated intentions accurately translate into real-world actions, that 2.6 million people may intend to purchase one in the future.

Of respondents to Survey A, the majority (an approximate mean of 70 %) understood that it was illegal to possess wild sourced pets or artefacts and remedies, with a mean of approximately 30 % of respondents either considering that it was legal to own wildlife origin pets and artefacts, or being uncertain. Respondents who were uncertain or believed ownership to be legal were significantly more likely to express high desires to purchase these items in the future (e.g. those who believed that a given item was legal to possess were between 2.17 and 3.97 times

more likely; Fig. 3). Only a minority (19.2 %) of respondents suggested that the illegality of a given item would completely stop people from buying it. Instead 62.2 % of respondents stated that illegality either made people much less likely to buy these items (27.1 %) or somewhat less likely to buy them (35.1 %). These data corroborate the findings of previous work that demonstrated widespread understanding of the fact that possessing many wildlife-origin items was illegal, but that this understanding does not necessarily prevent their purchase (WCS, 2016).

Knowledge of a given product’s legal status interacts with a variety of other factors in determining likelihood of purchase. The legal context of a purchase can influence consumers’ perceptions of likely legal punishment but also the wider level of acceptability and social approval of the consumption that wildlife product (Rizzolo, 2021). Different consumer categories, however, are likely to respond to these factors differently. As an example Hinsley et al. (2022) showed that the likelihood of consumers in China switching between synthetic (legal), farmed (legal) and wild (illegal) bear bile was affected not only by the products’ legal status but also by consumers’ knowledge and past consumption patterns, the strength of their motivation for consumption, and preferences for other product attributes, such as place of purchase. While approximately a third of consumers preferred only legal products, a further half of consumers would only consume “natural” farmed or wild bile (Hinsley, 2022). In our study, the finding of greater likelihoods of purchase among those uncertain or incorrect in their knowledge of the items’ legality, argues that demand reduction campaigns could have a significant role in informing the uncertain elements of the population, and potentially thereby lowering likelihoods of future purchase - but with the expectation that a proportion of respondents would continue consumption even when informed.

Among the 2005 respondents in Survey B all experimental treatment messages effectively lowered respondents' likelihood of choosing high likelihoods of purchase - by a mean of 6.7 % - and simultaneously increased respondents' likelihood of expressing low likelihoods of purchase - by a mean of 9.1 % - relative to respondents who were shown neutral, control information. Overall, treatment information made respondents between 1.47 and 1.86 times less likely to select higher probabilities of purchase for any given item, with messages predicated on the disease and conservation consequences having a larger effect than those predicated on legal consequences or animal welfare impacts.

The effectiveness of disease information has previously been shown by Moorhouse et al. (2017), who demonstrated – on English speaking respondents, primarily from Europe and the USA – that messages predicated on this, and on the illegality of owning some species, reduced desire to own exotic pets more than messages concerning animal welfare and species conservation, which had little impact. Previous work has demonstrated consumption of wild meat in Iquitos (a city bordering forest) continuing during the COVID-19 pandemic (Pérez-Peña et al., 2022), which could imply that disease risks do not necessarily lower demand for this product. It remains possible, however, first that those consumers did not equate consumption of wild meat with risk of contracting disease, and that messaging such as that employed in this study – which makes the link explicit – may act as a deterrent, and second that urban consumers in areas away from the forest may have different attitudes toward the risks of wild meat consumption. By contrast the effectiveness of conservation messaging on our urban Peruvian respondents was high in the current study. We speculate that respondents were motivated by the likelihood of consumption leading to extinctions of native Peruvian species – in the study of Moorhouse et al. (2017) the species conservation issues would not have occurred in a given respondent's native country.

Repetition of the messages had a minor impact on amplifying their effectiveness (making respondents who had viewed all fifteen items 1.22 times less likely to select higher probabilities or purchase than those viewing the first). The messages therefore had a cumulative effect within Section 2 of Survey B.

We were able to gauge the cumulative impact of the treatment messaging by comparing the responses to questions in Section 1 between those who had previously seen Section 2 and those who had not. In Section 1, respondents' stated future likelihood of purchasing each type of item was substantially higher among the 1000 control respondents (those who had not previously seen Section 2) than among the 1005 treatment respondents (those who had previously responded to Section 2), with a mean additional 14.1 % selecting high probabilities. Similarly a mean additional 23.9 % of treatment respondents selected low likelihoods of future purchase of items, compared with control respondents. We conclude that the repeated demand reduction messaging to respondents made them approximately three times less likely to choose higher likelihoods of purchasing such items in the future. A further impact of the demand reduction messages was to lower the proportion of respondents who stated that they had previously owned wildlife origin items: among treatment respondents the stated levels of ownership were a mean of 12.0 % lower than among control respondents, and an additional 12.1 % of treatment respondents stated that they had never owned any of the items.

These findings have two broad implications. First, and encouragingly, they suggest that respondents' social norms and beliefs surrounding the acceptability of ownership of wildlife-origin items might be malleable (e.g. Hauser et al., 2018). Respondents were randomly assigned to treatment and control groups and there was therefore no a priori reason to anticipate substantial differences in the past ownership of wildlife-origin items between these groups. The stated differences in prior ownership were therefore unlikely to represent real-world differences but rather to reflect a decreased desire among treatment respondents to provide accurate responses to the questions in Section 1. This in turn implies that the treatment messaging induced respondents

to perceive their past ownership of wildlife-origin products as inappropriate, and to seek to downplay and minimise these past behaviours.

Respondents may have altered their Section 1 responses due to social desirability bias, a common bias within survey research (Nederhof, 1985) which stems from respondents wishing to present themselves positively to the researchers, in turn leading to them overestimating positive behaviours and/or underestimating behaviours they believe will be perceived as negative. Such biases are particularly prevalent when responding to sensitive topics (in this case e.g. the illegality or perceived undesirability of their past actions) (Krumpal, 2013). Such biases can arise from respondents' desire to alleviate "cognitive dissonance" (Krumpal, 2013), a discomfort which arises when individuals become aware of the gap between their values and actions, and which motivates people to seek and implement a strategy to alleviate the feeling (e.g. Elliot and Devine, 1994; Festinger, 1957). Such strategies may involve the changing or forgetting of previous attitudes (Sezer et al., 2015; Shu et al., 2011) or downplaying of consequences and justifying actions (e.g. Curtin and Wilkes, 2007; Juvan and Dolnicar, 2014). These explanations imply that treatment messaging in our study made respondents re-evaluate their past behaviour, casting it in a negative light. This raises the possibility that such messaging has potential to modify the attitudes of urban Peruvians through demand reduction campaigns, albeit that we cannot determine the extent to which respondents may not have changed their attitudes, but merely altered their responses.

Our above findings have secondary implications for the construction of surveys that investigate activities that are either illegal or considered by respondents to be controversial. Our study design permitted detection of inauthenticity by respondents when answering questions they felt to be sensitive, and revealed that they were likely to have misrepresented their prior activities. As such our findings reinforce the conclusions of previous work showing that questionnaire surveys on sensitive wildlife issues may be prone to bias unless methodological steps are taken to avoid this (e.g. Hinsley et al., 2019) – such as the methodology we used for Section 2, which was designed to minimise the possibility of respondents understanding that different treatment and control messages were available for the same items, but instead provide a direct assessment of the change in relative attractiveness of a given product when accompanied by different types of message (e.g. Moorhouse et al., 2020).

The above notwithstanding, the likelihood of respondents misrepresenting their past behaviour has several implications for the interpretation of data from our study. In Survey A we asked respondents direct questions regarding past consumption of wild animal origin products, and it is likely that at least some of these respondents will have downplayed their involvement in such activities. In particular, 78.2 % and 61.1 % of respondents stated that they were aware that owning wild animal pets and artefacts made from wild animals, respectively, was illegal and a proportion of these respondents may accordingly have been motivated to misrepresent the past ownership of these items. The levels of prior ownership and future intentions to purchase wild animal-origin products revealed by Survey A are therefore likely to be underestimated by an unknowable amount.

Conversely, it is also plausible that respondents in Survey B may have overstated the degree to which they might refrain from future purchases of products when confronted with opportunities to purchase wild animal-origin products in the real world. We have no evidence to argue for or against this possibility. Nevertheless our principal conclusions – of widespread consumption of wildlife origin products among urban Peruvians, and that such consumption is likely to be reduced by demand reduction campaigns – are likely to be conservative in the sense that if treatment messaging fails to influence responses online, in the abstract, such messages are unlikely to work in reality. Notwithstanding that specific messages may still prove impactful for specific species and locations, we suggest that large-scale, generalised conservation marketing campaigns such as those run by large NGOs could increase their impact

by conducting similar experimental testing in advance. In this case we provided an experimental basis capable of detecting whether different types of demand reduction messaging were likely to be ineffective, and demonstrated that they are sufficiently likely to be beneficial to be worth testing in real-world scenarios (see e.g. Moorhouse et al., 2017; Moorhouse et al., 2020).

5. Conclusions

Our initial study of 501 urban respondents from Peru highlighted that over three quarters of the adult population is likely to have previously owned or consumed at least one illegal wild-animal origin product, and that a smaller, but nonetheless significant proportion of the population (9–14 %) is highly likely to continue consuming them in the future. Our experimental survey demonstrated substantial effects of demand reduction messaging on respondents' likelihood of purchasing illegal wildlife-origin items. When viewing messages concerning the negative disease and conservation consequences of purchasing an item, respondents were approximately half as likely to select high likelihoods of purchase as when viewing control information. Moreover, respondents who had been presented with all the treatment information were approximately three times less likely to select high likelihoods of purchasing wildlife-origin items in the future, and were up to twice as likely to state that they had never owned any such items in the past.

These findings suggest that social norms surrounding the acceptability of ownership of wildlife-origin items in urban Peru are highly likely to be amenable to alteration through demand reduction campaigns. Although these messages have not been tested in real-world settings our data strongly support the possibility of instilling new social norms through repeated demand-reduction messaging, especially if those messages highlight the zoonotic disease potential of such purchases and the need to conserve native Peruvian species.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.biocon.2024.110458>.

Ethics statement

Participant recruitment and consent, and initial data processing were conducted by Touchstone Partners Ltd., in adherence to the Market Research Society code of conduct (<https://www.mrs.org.uk/pdf/MRS-Code-of-Conduct-2019.pdf>). Subsequent data analysis standards were overseen by World Animal Protection, in full accordance with the British Sociological Association Statement of Ethical Practice (BSA 2017).

CRedit authorship contribution statement

T.P. Moorhouse: Conceptualization, Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **A. Elwin:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **N.C. D'Cruze:** Conceptualization, Funding acquisition, Project administration, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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