Survey of non-native small mammals traded in South Africa

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ABSTRACT

The sale of live non-native animals has become a social norm and is of global concern. The pet trade industry has become one of the main pathways where non-native small mammals are introduced worldwide. We conducted a questionnaire survey in South African pet shops from September 2018 to September 2019 to gain insights into non-native small mammalian species trade in South Africa. We also investigated whether the pet shop owners were aware of the South African National Environmental Management: Biodiversity Act (NEM: BA; No. 10 of 2004), which regulates and provides management and conservation of the country's biodiversity. A total of 111 pet shop owners/managers responded to the survey, with 26.6% of the owners reporting the sale of birds, 25.1% of fish and 22.5% of mammals. A total of 16 non-native small mammalian species were reported sold, with European rabbits (*Oryctolagus cuniculus*), Norwegian rats (*Rattus norvegicus*) and house mice (*Mus musculus*) being the most commonly sold pets. We found that breeders, animal rescues and pet shops were the major suppliers of small mammal pets, and in terms of the regulation, most respondents (67.8%) were aware of NEM: BA. However, despite the knowledge of the regulations, some of the traded species pose a serious invasion threat. As a result, we recommend increased regulation, monitoring and public awareness to prevent the potential negative impacts associated with non-native mammal species in South Africa.

Keywords: escape, invasion pathways, pet trade, prohibited species, regulations, release, risk, South Africa

1 INTRODUCTION

Non-native animals have been and continue to be introduced in South Africa through various pathways that include stowaways, biological control, scientific research, food, zoo and pet trade (Faulkner et al., 2020; Measey et al., 2020; Moshobane et al., 2020). The pet trade industry is growing in South Africa and includes several animal species from arthropods, amphibians, reptiles, fish, birds and mammals (Maligana et al., 2020; Moshobane et al., 2020; Nelufule et al., 2020; Shivambu et al., 2020a, 2020b, 2020c; van Wilgen et al., 2008). Some non-native species have established feral populations (i.e. species once domesticated but now living in the wild) through pet trade releases and escapes worldwide (Lockwood et al., 2019; da Rosa et al., 2017; Shivambu et al., 2020a, 2021b). Understanding the role of the pet trade in introducing non-native species is essential in preventing their associated potential environmental and socio-economic impacts (Shivambu et al., 2021b).

Most companion/pet species are acquired from pet expos, breeders, online trade and/ or pet shops (Halsby et al., 2014; Kelso, 2018; Nelufule et al., 2020; Shivambu et al., 2021b). Recent studies on pet trade have focussed on online trade and pet shops as the main source of introduction for live non-native pets (Lockwood et al., 2019; Mahmood et al., 2011; Nelufule et al., 2020; Shivambu et al., 2021b; Su et al., 2015). These two sources are relatively easy to study and are more accessible sources of information than private breeders or pet expos (Maligana et al., 2020; Nelufule et al., 2020). The majority of pet shops globally, including South Africa, are located in urban areas, especially large cities and are often found in shopping malls (Mahmood et al., 2011; Shivambu et al., 2020a, 2020c; Soorae et al., 2008). These shops sell different types of non-native pets that include amphibians, reptiles, birds, aquatic organisms and small mammals (Mahmood et al., 2011; Maligana et al., 2020; Nelufule et al., 2020; Shivambu et al., 2020b; Soorae et al., 2008; Warwick et al., 2018). Small mammals such as Norwegian rats (*Rattus norvegicus*), mice (*Mus musculus*, *Mastomys coucha*), Guinea pigs (*Cavia porcellus*), hamsters (*Phodopus roborovskii*, *Mesocricetus auratus*) and European rabbits (*Oryctolagus cuniculus*) are sold in various physical pet and online shops in South Africa and globally (Kelso, 2018; Lankau et al., 2017; Maligana et al., 2020; McLaughlin & Strunk, 2016; Shivambu et al., 2020b; Westbroek, 2014).

The trading of these non-native pets has since been criticised by public health, animal welfare and biodiversity conservation authorities (Spee et al., 2019; Warwick et al., 2018). Animal welfare concerns have been raised as often these pets suffer from stress, mishandling and improper restrain during capture, transportation, breeding and housing (Ashley et al., 2014; Grant et al., 2017). Public health research indicates that non-native pets are responsible for transmitting zoonotic diseases to humans. For example, rats and mice are reservoirs for pathogens that cause diseases such as rat-bite fever, cowpox, dermatophytosis and Carrion's disease, which can be fatal to humans (Chomel et al., 2006; Smith et al., 2012; Warwick et al., 2012). In addition, Bovine tuberculosis transmitted by domesticated ferrets (*Mustela putorius furo*) has been reported to negatively impact beef, dairy and venison production and sale in New Zealand (Byrom, 2002; de Lisle et al., 2008).

Species conservation research highlights that several non-native species may become invasive or endangered as a result of their removal from the wild in their native ranges (Bush et al., 2014; Warwick et al., 2018). Consequently, different countries have developed legislation to regulate some non-native animal trade given the associated ecological risks (Spee et al., 2019; Stoakes, 2014). Established pet mammals such as sugar gliders (*Petaurus breviceps*), common marmosets (*Callithrix jacchus*) and eastern grey squirrels (*Sciurus*

carolinensis) have been reported to potentially have relatively high ecological risks (da Rosa et al., 2018; Shivambu et al., 2020b). For example, sugar gliders prey on Critically Endangered swift parrots (*Lathamus discolour*) in Tasmania, Australia (Campbell et al., 2018), while common marmosets threaten populations of Wied's (*Callithrix kuhlii*) and buffy-tufted (*Callithrix aurita*) marmosets in Brazil, through hybridisation (Cezar et al., 2017; Moraes et al., 2019; Shivambu et al., 2020b). Some of these invasive species compete with livestock for resources; for example, European rabbits compete with livestock for pasture in Australia (Fleming et al., 2002).

There are currently 24 non-native small mammalian species traded as pets in South Africa, but only four of these are regarded as invasive and include European rabbits, eastern grey squirrels, Norwegian rats and house mice (Shivambu et al., 2020b, 2021a, 2021b). These species have a long history of establishment in South Africa (Measey et al., 2020), with Norwegian rats and house mice having been introduced as stowaways through the shipping trade, while European rabbits and eastern grey squirrels were introduced as farm and ornamental animals (Measey et al., 2020). House mice and Norwegian rats are more widely distributed in South Africa than European rabbits and eastern grey squirrels (Figure S1).

In South Africa, non-native species are regulated under the South African National Environmental Management: Biodiversity Act (No. 10 of 2004; NEM: BA), which groups species into four categories, namely, category 1a, category 1b, category 2 and category 3 (DEA, 2016). Category 1a are invasive species that require compulsory control, removal and destruction. According to the law, these species need to be eradicated, and no permits should be issued. Category 1b are invasive species that need to be controlled, removed and destroyed, and their trade is strictly prohibited. Category 2 are species with the potential of becoming invasive and requires a permit for trade. Lastly, category 3 are invasive species prohibited for trade or breeding and may remain in permitted areas or provinces. Relatively, few non-native small mammalian pets are prohibited from being imported into South Africa, under these regulations. For example, currently, European hedgehogs (*Erinaceus europaeus*), short-tailed weasels/stoats (*Mustela ermine*) and brushtail possums (*Trichosurus vulpecula*) cannot be imported (DEA, 2016).

Popular small mammals in the South African pet trade industry, such as Norwegian rats, house mice and European rabbits, are listed as category 1b for South African offshore islands (DEA, 2016; Shivambu et al., 2020b, 2021b). According to the South African regulations, these three species may not be owned, imported, moved, sold and given as gifts, but this applies only to the country's offshore islands. There are currently no regulations that prevent the selling, importing or breeding of these three established species in mainland South Africa. Rats and mice are also sold in pet shops in South Africa and other countries as food for other pets, such as snakes (Cooper & Williams, 2014; Harker et al., 2011; Kanagarajah et al., 2018; Lee et al., 2008; Maligana et al., 2020). Pet shops do not just sell these non-native pets but have to apply for permits to trade in some of these species (Drews, 2001; Stoakes, 2014; Su et al., 2015). Pet shops are also highly regulated and regularly inspected; consequently, they offer fewer non-native pet species than online trading (Pasmans et al., 2017; Shivambu et al., 2020b, 2021b).

In South Africa, ~42 pet shops are registered with the South African Pet Traders Association (SAPTA), but only 19 of these sell non-native small mammals (SAPTA, 2019). Our present study, therefore, investigated (a) the extent of trade in non-native small mammal species sold in South Africa; (b) the sources from where pet shops acquire their non-native small

mammals, and (c) whether the pet shops were aware of the regulations which govern the sale of non-native pets. We predicted that (a) rodents would be the most commonly traded species because they are relatively easy to maintain, are cheaper and are often sold as food for reptiles such as snakes (Maligana et al., 2020; Shivambu et al., 2021b) and (b) pet shop owners acquire their pets from different sources.

2 METHODS

2.1 Questionnaire survey

We compiled a list of pet shops selling non-native animals in South Africa using the South African Pet Traders Association (SAPTA; http://www.sapettraders.co.za/) and pet shop directory (http://www.pet-shops.co.za/) websites. An additional list was compiled by searching for pet shops on Google earth (https://earth.google.com/web/) and maps (https://www.google.co.za/maps) using phrases such as 'pet shops in South Africa' or 'list of pet shop names in South Africa'. A list of pet shops included contact details, email and business addresses. Permission to conduct the questionnaire survey was granted by the Humanities and Social Research Ethics Committee of the University of KwaZulu-Natal (Protocol number: HSS/0908/018D). The online questionnaire survey was developed using Google forms (https://www.google.com/forms/about/) and circulated through email addresses and advertising websites for online pet shops. The questionnaire consisted of 17 questions, of which seven were multiple-choice, eight were checkboxes, and two were fill-in (https://goo.gl/forms/in1C2zlyawJctMUg2; Table S1). The first page of the questionnaire included a short paragraph describing the study. The questionnaire survey remained active for a year, from September 2018 to September 2019. Various pet shops across South Africa were also visited to conduct face-to-face questionnaire surveys. We visited 130 pet shops across South Africa (Figure 1) during a parallel study (Shivambu et al., 2021b), of which 89 had responded to the online version of the questionnaire, 22 responded to the face-to-face survey, and 10 did not allow us into their premises, while nine pet shops refused to participate in the survey.

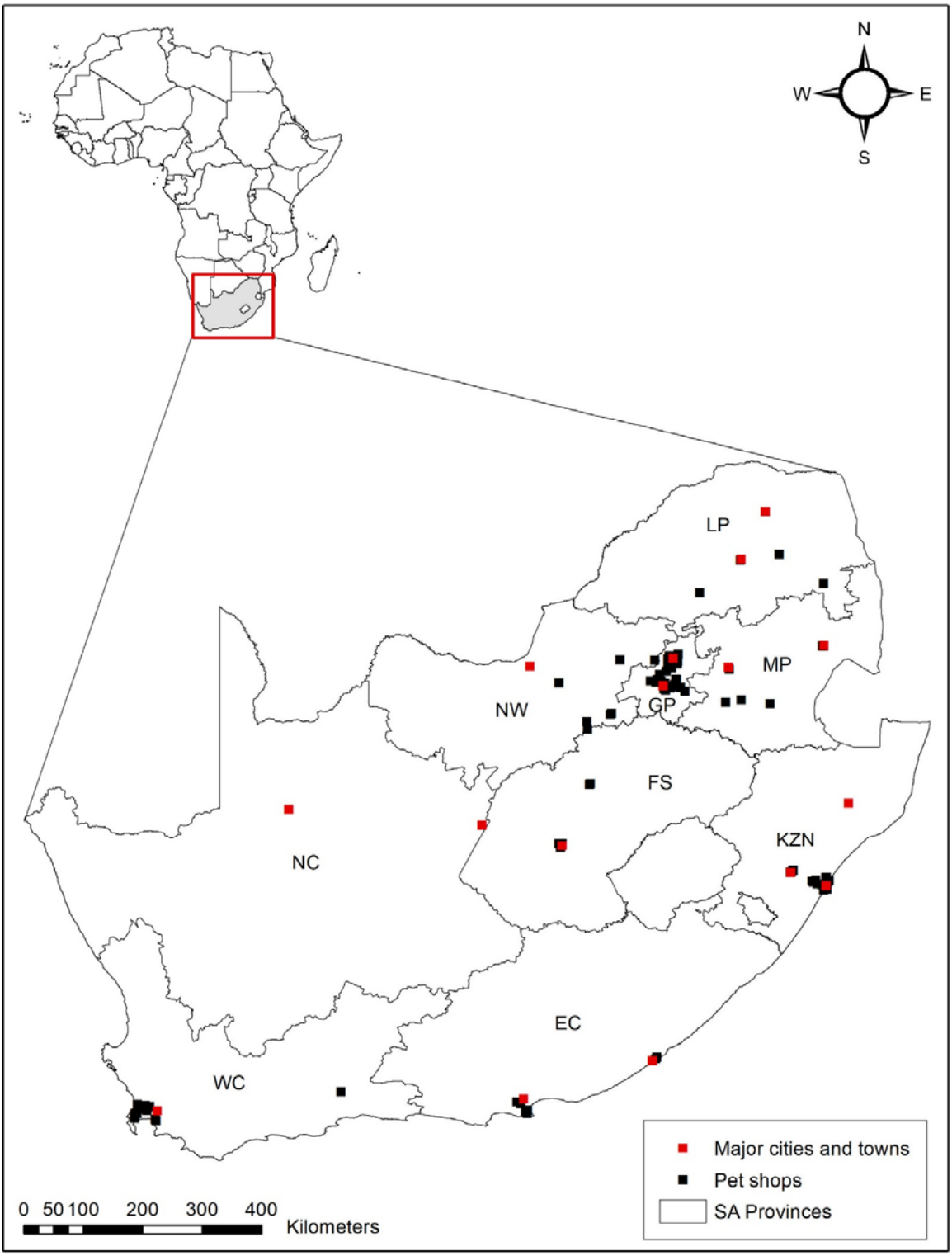

FIGURE 1. Map of South Africa showing the physical pet shop locations surveyed between September 2018 and September 2019 in the respective provinces. EC, Eastern Cape; FS, Free State; GP, Gauteng; KZN, KwaZulu-Natal; LP, Limpopo; MP, Mpumalanga; NW, North West; NC, Northern Cape; WC, Western Cape Provinces

2.2 Statistical analyses

To determine whether data were normally distributed, identical and independent, we used the Kolmogorov–Smirnov normality test (Lilliefors, 1967). We found that the data were not normally distributed ($n = 111$; $D = 0.341$; $p < 0.05$); therefore, a Kruskal–Wallis test by ranks (Kruskal & Wallis, 1952) was used to test for the differences between the number of respondents. We further used the Mann–Whitney pairwise test (Mann & Whitney, 1947) with Bonferroni *p*-values adjusted at $p = 0.01$ to determine the statistically significant difference between the number of respondents. The Mann–Whitney pairwise test was also used to determine the difference between the number of small mammal species across provinces in South Africa. Species abundance was determined by summing the number of different small mammal species reported for sale by each respondent in different pet shops across South Africa. Species richness was determined by summing the number of different small mammal species reported for sale across each province. The responses were grouped by province for statistical analyses. All statistical analyses were based on algorithms in R Studio software packages, version 3.6.3 (R Core Team, 2018).

3 RESULTS

3.1 The number of questionnaire survey respondents

A total of 111 pet shop owners responded to the questionnaire survey. However, we could only analyse the results from 107 responses because of some incomplete responses. We found that most of the respondents were from Gauteng Province (35.5%; $n = 38$), followed by KwaZulu-Natal (18.7%; $n = 20$) and Western Cape (15.9%; $n = 17$) Provinces (Table S2). Most of the respondents in Gauteng Province considered that their province had between 50 and 80 pet shops, while respondents from KwaZulu-Natal and Western Cape Provinces considered that their provinces had ~20 and ~40 pet shops respectively (Table S2). Respondents from the remaining six provinces (Limpopo, Mpumalanga, Eastern Cape, North West, Free State and Northern Cape) considered that they had between one and 10 pet shops in their province (Table S2).

3.2 Species traded in South African pet shops

In the present study, seven major animal taxa were recorded to be traded in South African pet shops (Figure 2). Birds (26.6%; $n = 103$), fish (25.1%; $n = 97$) and mammals (22.5%; $n = 87$) were the animal taxa sold most often by pet shops (Kruskal–Wallis test by ranks: $\chi^2 = 26.77$; df = 6; $n = 386$; $p = 8.43e\text{-}05$; Table S2). About 17.3% ($n = 67$) of the pet shop respondents indicated that they sold reptiles, while 3.8% ($n = 15$) sold amphibians and 2.9% ($n = 10$) sold arthropods (Figure 2; Table S2). The other animal taxa, such as molluscs and invertebrates, were traded by less than 2% ($n = 7$) of the pet shops (Figure 2; Table S2).

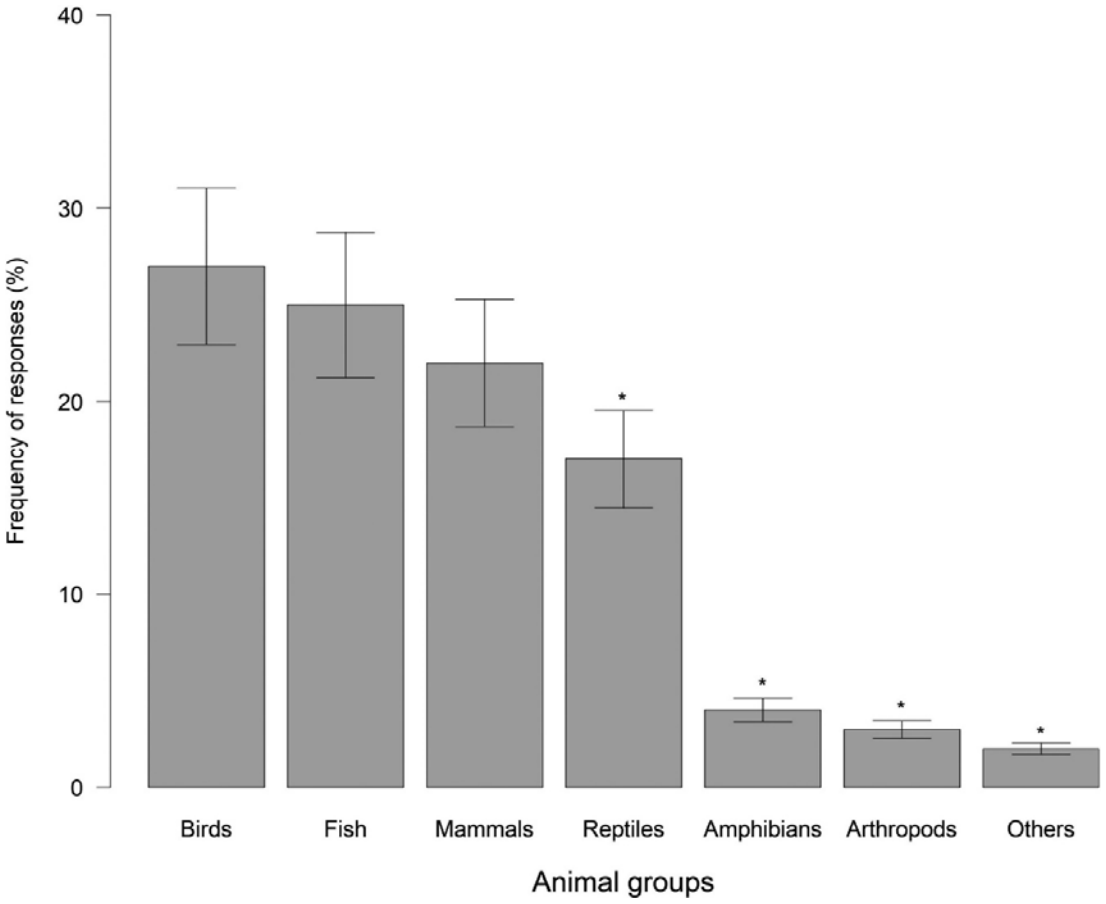

FIGURE 2. Range of non-native animal taxa reported as sold by pet shop owners in South Africa in the present study (number of responses [n = 386]). *p < 0.01

Small mammals formed the main focus of the next phase of the questionnaire survey in this study. A total of 16 small mammal species were reported to be traded by 89 pet shops (Figure 3; Table S2). Most pet shops indicated that they trade in European rabbits (16.2%; n = 76), Norwegian rats (15.4%; n = 72), house mice (13.9%; n = 65), Guinea pigs (13.5%; n = 63), golden hamsters (*M. auratus*; 8.1%; n = 38) and winter white dwarf hamsters (*Phodopus sungorus*; 2.8%; n = 13; Figure 3; Table S2). There were significantly higher percentages of respondents who traded in these species than other small mammal species sold (Kruskal–Wallis test by ranks: χ^2 = 42.60; df = 15; n = 468; p = 1.52e-05; Table S2). Short-tailed chinchillas (*Chinchilla chinchilla*), long-tailed chinchillas (*Chinchilla lanigera*), common degus (*Octodon degus*), Mongolian gerbils (*Meriones unguiculatus*), sugar gliders (*P. breviceps*), four-toed hedgehogs (*Atelerix albiventris*) and lesser hedgehog tenrecs (*Echinops telfairi*) were not commonly sold (Figure 3; Table S2). The least popular non-native small mammals traded were eastern grey squirrels, domesticated ferrets and common marmosets (Figure 3; Table S2).

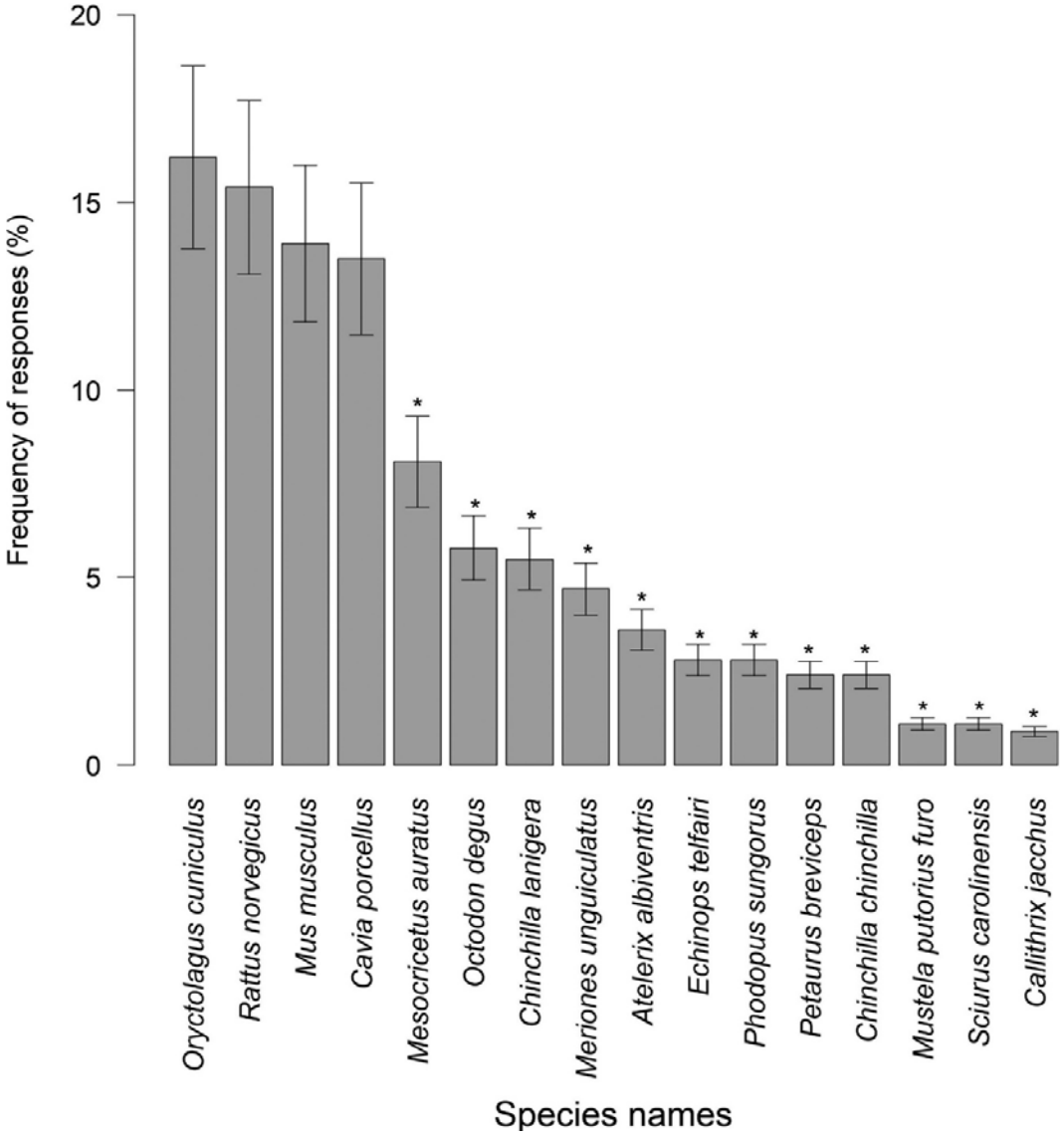

FIGURE 3. Non-native small mammals reported as sold by pet shop owners in South Africa in the present study (number of responses [n = 468]). *p < 0.01

Our results showed that the number of small mammal species varied across provinces (Kruskal–Wallis test by ranks: χ^2 = 55.78; df = 8; n = 468; p = 4.87e-10; Table S2). The number of species in Gauteng Province was significantly higher (46%; n = 216) than in other provinces (Mann–Whitney pairwise test with Bonferroni corrected p-values: p < 0.001; Table 1). This was followed by KwaZulu-Natal Province, which represented 20% (n = 94) of the respondents. The number of species in North West (n = 42) and Western Cape (n = 40) Provinces were significantly similar (Table 1). Pet shops in Gauteng were more diverse in species richness, followed by KwaZulu-Natal, North West and Western Cape Provinces (Table 1). In the other five provinces (Limpopo, Free State, Eastern Cape, Mpumalanga and Northern Cape), fewer than 10 different small mammal species were sold (Table 1).

TABLE 1. Mann–Whitney pairwise test comparing the number of small mammal species reported sold in South African Provinces (number of respondents [n = 486])

Provinces	EC	FS	GP	KZN	LP	MP	NW	NC	WC	Species abundance	Species richness
EC		1	7.14e−05**	0.04*	1	1	0.28	1	0.94	11	7
FS	1		0.00**	0.27	1	1	1	1	1	24	7
GP	7.14e−05**	0.00**		0.69	0.00**	3.39e−05**	0.00**	6.70e−05**	0.00**	216	16
KZN	0,03*	0.27	0,69		0.32	0.01*	1	0.04*	1	94	13
LP	1	1	0.00**	0.32		1	1	1	1	24	7
MP	1	1	3.39e−05**	0.01*	1		0.03*	1	0.11	6	4
NW	0.28	1	0.00**	1	1	0.03*		0.29	1	42	13
NC	1	1	6.70e−05**	0.04*	1	1	0.29		1	11	8
WC	0,94	1	0.00**	1	1	0.11	1	1		40	12

Note: **$p < 0.01$; *$p < 0.05$.

Abbreviations: EC, Eastern Cape; FS, Free State; GP, Gauteng Province; KZN, KwaZulu-Natal; LP, Limpopo Province; MP, Mpumalanga Province; NC, Northern Cape and WC, Western Cape; NW, North West.

3.3 Sources of trade

Our results showed that non-native small mammal species in the pet trade in South Africa were generally obtained from a range of sources, and there was a significant difference between these sources (Kruskal–Wallis test by ranks: $\chi^2 = 17.58$; df = 6; $n = 197$; $p = 0.00$; Figure 4; Table S2). Most pet shop owners indicated that they obtained their small mammal pets from specific breeders (34.0%; $n = 67$). Between 10% and 16% of respondents indicated that they acquired their pets for trade from animal rescues (15.7%; $n = 31$), other pet shops (13.7%; $n = 27$), overseas trade (12.7%; $n = 25$) and online trade (12.2%; $n = 24$), while others self-bred their pets to sell (10.2%; $n = 20$; Figure 4; Table S2). Only 1.5% ($n = 3$) of the respondents indicated that they acquired their pets for trade from the wild (Figure 4; Table S2).

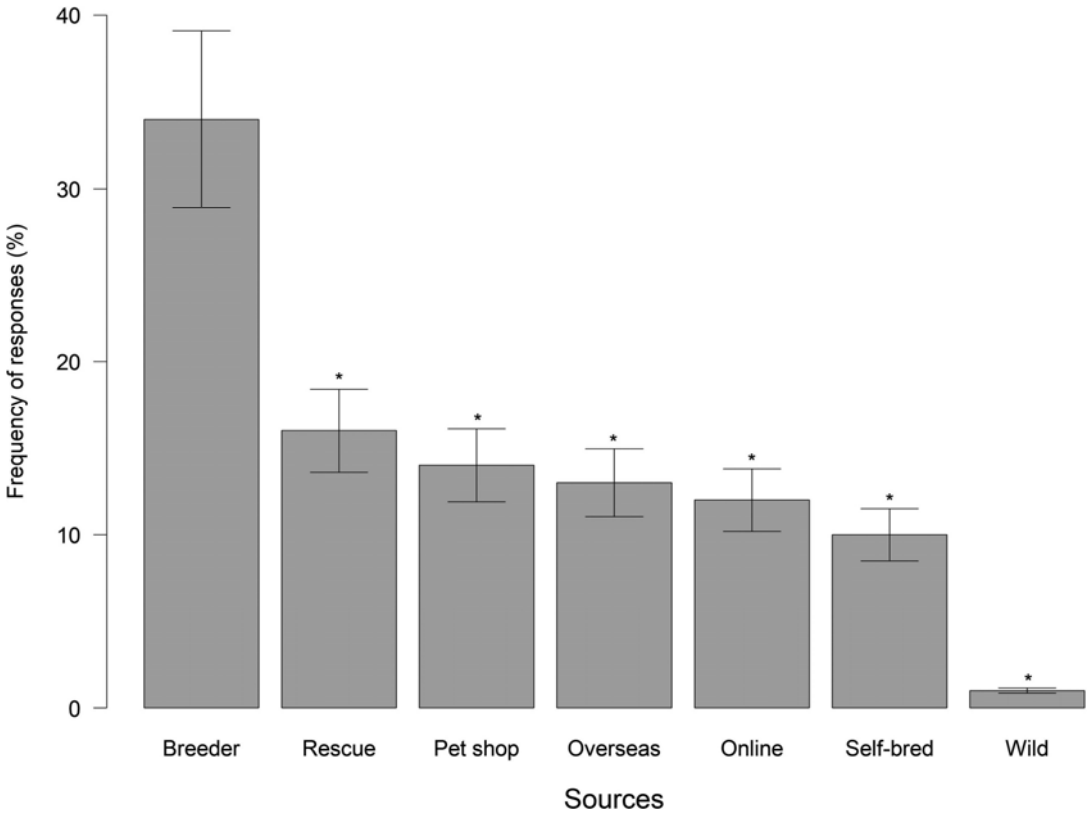

FIGURE 4. List of sources where pet shop owners in South Africa acquired their non-native small mammal species. (*$p < 0.01$)

3.4 Trends in sales and South African National Environmental Management: Biodiversity Act (NEM: BA; No. 10 of 2004)

A total of 37.0% ($n = 33$) respondents indicated an increase in the sale of small mammal species between 2000 and 2017. This was attributed to reasons such as high demand, affordable prices and the relative ease of maintaining small mammal species (Table S2). Those who indicated that their sales were not increasing indicated that NEM: BA regulations were the main reason, followed by competition with other pet shops, and other reasons included that people are afraid of zoonotic diseases (Table S2). About 49.4% ($n = 43$) of pet

shop owners indicated that small mammals constituted a small percentage of their sales, and the majority indicated that they would continue to sell them (Table S2).

Our results showed that there was a significant difference between those who were aware (67.8%; $n = 59$) of NEM: BA regulations and those who were not (32.2%; $n = 28$; Kruskal–Wallis test by ranks: $\chi^2 = 14.31$; df = 1; $n = 87$; $p = 0.02$; Table S2). A total of 71.3% ($n = 62$) of respondents were against small mammal trade to be regulated, while 28.7% ($n = 25$) agreed with the regulation. Respondents who indicated that the sale of small mammals should be regulated suggested that firm regulations should be developed, fines should be imposed on those who broke the law, and illegal traders should be criminally charged (Table S2). Some respondents indicated that imports of small mammal species should be strictly controlled. However, respondents who argued that the sale of small mammals should not be regulated claimed that the pet trade industry saves endangered species, forms part of the economy, is part of the education process and also promote animal conservation (Table S2). A total of 57.5% ($n = 50$) of pet shop owners indicated that they lose individuals of small mammal species through escapes, while 42.5% ($n = 37$) showed that they do not lose them (Table S2). However, those who showed that they lose small mammal species as escapes also indicated that most mammals are re-captured as they escape into a closed environment.

4 DISCUSSION

The pet trade industry is growing in South Africa, and pet shops are one of the top avenues where non-native pets are traded (Maligana et al., 2020; Nelufule et al., 2020; Shivambu et al., 2020a, 2020b, 2020c, 2021b; van Wilgen et al., 2008). Consequently, species introduced through this avenue should be documented, as non-native species pets may potentially become invasive through accidental escapes and intentional releases (da Rosa et al., 2017; Shivambu et al., 2021b). Documenting these species will assist in knowing which species may potentially pose invasion threats should they establish feral populations (Shivambu et al., 2021a). Our study showed that Gauteng, Western Cape and KwaZulu-Natal provinces had the most pet shops selling non-native pets. These three provinces are among the fastest-growing economies in South Africa, and the relatively high number of pet shops may be explained by the economic status of these provinces (Shivambu et al., 2021b). In addition, the number of species was high for these provinces. Although KwaZulu-Natal Province had more pet shops, its species richness was similar to North West Province, which had few pet shops. This suggests that species richness may not be correlated with the number of pet shops (Shivambu et al., 2021b).

In our study, the number of pet shops that sell non-native pets may have been an underestimate of the total number of pet shops in South Africa. For example, most of the respondents in Gauteng Province indicated that they have between 50 and 80 pet shops. This number is higher than the number of pet shops surveyed in a recent previous study (Shivambu et al., 2021b), indicating that some pet shops may not be registered with the South African Pet Traders Association or similar and that they only operate privately online. A study by Martin and Coetzee (2011) on aquatic macrophytes reported that various private vendors who sell different non-native species are generally not registered with any organisation. Our study found that 83% ($n = 92$) of the pet shops were not registered with SAPTA. Consequently, unregistered vendors may pose a challenge for biodiversity law enforcement, making it difficult to regulate the pet trade industry, particularly for species requiring a permit for trade.

Our study found five major vertebrate taxa (i.e. amphibians, birds, fish, mammals, reptiles) and three invertebrate groups (arthropods, molluscs and insects) of non-native animals in the trade, indicating that the pet trade industry in South Africa is diverse. As a result, this warrants further investigation to determine which species from the reported taxa are being traded. Although small mammal species were the third-most traded taxa in our study, they were traded in all the provinces in South Africa. However, rodents were the most frequently traded pets than other non-native small mammal species. The popularity of rodents may be because most are relatively easy to maintain and are often traded as food for reptiles, for example rats, hamsters and mice (Cooper & Williams, 2014; Kanagarajah et al., 2018; Maligana et al., 2020). Pet shop owners tend to sell more common pet species than rare species (Shiau et al., 2006; Shivambu et al., 2021b). For example, rodents were sold by all the respondents in our study, showing that they are available in most provinces and pet shops. Consequently, the most popular species are most likely to escape or be released from captivity than the least popular species (Macdonald et al., 2017).

Parallel studies by Shivambu et al. (2020b, 2021b) in South Africa found that the most common species in both the pet shop and online trade were European rabbits, house mice, Norwegian rats, Guinea pigs, winter white dwarf hamsters and golden hamsters. Some of these species have high potential socio-economic and environmental impacts (Shivambu et al., 2020b). In particular, European rabbits, house mice and Norwegian rats can potentially cause invasion impacts in South Africa, given that they are long-established on offshore islands and the mainland of South Africa (Measey et al., 2020). European rabbits reduce vegetation on a South African offshore island (Robben Island) (Measey et al., 2020; Sherley, 2016). Norwegian rats pose health risks to humans because they harbour zoonotic agents and diseases such as *Streptobacillus moniliformis*, Leptospirosis, Toxoplasmosis, *Trypanosoma lewisi* and *Gongylonema* sp in South Africa (Archer et al., 2017, 2018; Julius et al., 2021; Taylor et al., 2008). Although some of the non-native small mammals were sold by relatively few pet shops, they have a history of causing severe ecological impacts (Shivambu et al., 2020b). For example, black-tufted ear marmosets (*Callithrix penicillata*) are known to predate on native birds in Brazil, and also hybridise with native marmosets (Alexandrino et al., 2012; Moraes et al., 2019). In addition, eastern grey squirrels, which are already thriving in urban and commercial areas in South Africa, are likely to negatively impact forest production, crops of agricultural importance and telecommunication infrastructure such as cables (Measey et al., 2020). In the United Kingdom, the damage associated with this species in woodlands is ~£10 million per annum (Merrick et al., 2016). We suggest that the sale of these species should be monitored and managed to prevent invasions and potential impacts, as reported by Shivambu et al. (2020b).

Pet shop owners have neither control over who they sell their pets to nor do they know if their clients will release the species or not. This indicates that education about the potential impacts of non-native pets, in general, is necessary. Many pet shop owners indicated that species escape from enclosures but are later found inside their pet shops. However, this may pose an invasion risk if some small mammal species escape unnoticed as they typically can tolerate a wide range of climatic conditions, have high reproductive rate, catholic diets, are commensal, and predators are mostly ineffective in controlling them (Clout & Russell, 2008; Langton et al., 2001; Latham et al., 2017; Meyer, 2008). In addition, some of the pet owners may release their species for various reasons. These include fear of zoonotic diseases, species becoming aggressive, lack of knowledge regarding the species kept, unwanted pets and loss of interest in the pets (Padilla & Williams, 2004; Reaser & Meyers, 2007; Secretariat of the CBD, 2010; Stringham & Lockwood, 2018).

Breeders were the most common suppliers for non-native small mammalian species to South African pet shops. This showed that different breeders in the country supply different small mammalian species to the growing pet trade business. The trade in small mammals is likely to increase given that most of the respondents indicated that they would continue to sell these species, although it makes a relatively small percentage of their sales. In addition, potential invasive small mammals may likely be imported into the country as some pet shop owners indicated that they were not aware of the regulations. Lack of knowledge of regulations resulted in the introduction of some potentially invasive plant species in South Africa (see Martin & Coetzee, 2011). However, knowledge of regulations does not necessarily indicate that some pet shop owners may not import prohibited species. For example, prohibited and invasive amphibians, crayfish and birds were sold in the European Union and Canada, despite regulations (Auliya et al., 2016; Faulkes, 2018; Genovesi et al., 2015; Patoka et al., 2014). This suggests that existing regulations need to be implemented and enforced to prevent the introduction of potentially harmful species. This potential problem may be exacerbated further by the percentage of respondents who opposed regulating the non-native small mammal pet trade. However, those who indicated that the pet trade species should be regulated suggested the introduction of firm regulations, enforcing the law and imposing fines on illegal traders.

Some pet shop owners indicated that the pet trade industry saves endangered species, creates jobs and forms part of the economy. The pet trade industry also has some disadvantages as some of the endangered species causing problems in introduced ranges are established invasive species in many countries. For example, European rabbits are critically endangered in their native range yet invasive in their introduced ranges (Lees & Bell, 2008; Marchetti & Engstrom, 2016). This species is associated with both environmental and socio-economic impacts (Hagen & Kumschick, 2018; Shivambu et al., 2020b).

5 CONCLUSIONS

Our study showed a relatively large number of pet shops selling non-native animals in South Africa, and provinces with fast-growing economies had the most pet shops. Therefore, we recommend that pet shops in those provinces be regularly monitored and encouraged to register with the country's pet trader association. South Africa may also need to move towards strong control for the traded animals. This may help determine the actual number of pet shops in each province, and therefore, they can be easily assessed in terms of animal welfare and legal compliance. The most popular non-native small mammals were European rabbits and rodents. Therefore, we recommend monitoring these species in pet shops as some have potentially high environmental and socio-economic impacts (Shivambu et al., 2020b). Specific breeders are the major suppliers for non-native small mammalian species in pet shops, and further studies should investigate how many breeders are in South Africa and whether they are aware of the regulations related to non-native small mammals. Government regulatory authorities need to engage with the pet trade industry, including the general public, regarding the sale of non-native pets to prevent introducing potentially invasive companion animals/pets.

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CONFLICT OF INTEREST

The authors declare no conflict of interest nor competing interests.

AUTHOR CONTRIBUTIONS

NS and CTD conceptualised the study and sample design. CTD sought funding. NS implemented the study. NS and TCS analysed the data. NS drafted the manuscript, while TCS and CTD reviewed the manuscript.

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