Investigating Support for Management of the Pet Trade Invasion Risk

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ABSTRACT

The non-native pet trade contributes directly to species invasions, thereby threatening wildlife. Biological invasions influence environmental change, resulting in species extinctions and biodiversity loss. To mitigate the pet trade invasion risk, interventions are required to prevent trade in non-native animals with high invasion potential, impulse or ill-informed purchases of non-native pets by individuals who may release these animals, and the deliberate release of non-native animals by pet owners. Interventions are also required to prevent the establishment of non-native animals that have been released by pet owners (e.g., euthanasia). The successful implementation of these interventions depends on the support of pet owners and the public in the form of political support for, and compliance with, interventions. In 2017–2018, using both mail and online surveys, we measured the support of 1,171 members of the public and 550 owners of non-native pets in Florida, USA, for 7 different interventions to mitigate the pet trade invasion risk, and we investigated determinants of this support. We found that individuals' support for interventions depended on their concern related to the invasion risks associated with the pet trade, trust in government to manage the pet trade, perceptions of how effective interventions would be in mitigating the pet trade invasion risk, and demographic characteristics. Support for interventions differed across pet owners and the public. Educating pet owners about the traits and cost of care for non-native animals and providing them with options to relinquish unwanted pets may reduce the pet trade invasion risk. Engaging the pet trade in the design of interventions to mitigate invasion risks is likely important to attain voluntary compliance with these interventions. The effectiveness of interventions also depends on enforcement by agencies. Implementing interventions that effectively reduce the pet trade invasion risk is important to protect native and endangered wildlife.

KEY WORDS: Florida, interventions, invasive species, ordered probit regression, pet trade.

The growing popularity of non-native pets has resulted in the pet trade becoming one of the main pathways of introduction and establishment for non-native species (i.e., pet trade invasion risk; Lockwood et al. 2019, Maceda-Veiga et al. 2019). Invasive species that are introduced through the pet trade threaten native wildlife and play a prominent role in species extinctions and biodiversity loss as demonstrated by some of the highest-profile species

invasions in North America including Burmese pythons (*Python bivittatus*) and Indo-Pacific lionfish (*Pterois* spp.; Medina et al. 2011, Dorcas et al. 2012, Sovie et al. 2016, Patoka et al. 2018). The pet trade invasion risk arises when non-native pets (animals that do not have a long history of domestication and are maintained in captivity in an area where they have not been historically found; Bush et al. 2014) are accidentally or deliberately released into the wild by pet owners, breeders, or distributors (i.e., pet importers and sellers; Lockwood et al. 2019, Maceda-Veiga et al. 2019). Accidental releases occur when pets escape captivity, likely because they are not properly caged (Hulme et al. 2017, Beever et al. 2019). The decision to deliberately release pets varies across stakeholders in the pet trade. Pet breeders and distributors may deliberately release non-native animals to establish breeding populations from which they can collect animals to sell (Episcopio-Sturgeon and Pienaar 2019), or to avoid proposed regulations that will restrict ownership or trade in these species (Hulme 2015, Romagosa 2015). Owners of non-native pets (i.e., pet owners) may also deliberately release pets because they no longer have the desire or ability to care for the pet, they cannot sell or give the pet to another individual, and they do not want to euthanize the pet (Episcopio-Sturgeon and Pienaar 2019, Lockwood et al. 2019). Pet owners are more likely to deliberately release pets if the owner did not understand the costs and effort involved in caring for the pet (e.g., they have inadequate housing for these animals; Howell and Bennett 2017, Stringham and Lockwood 2018), or if the animal becomes an inconvenience (e.g., the owner did not understand or consider the adult size, longevity, or diet of the pet; Howell and Bennett 2017, Stringham and Lockwood 2018, Warwick et al. 2018).

A range of policies and management actions (i.e., interventions to mitigate the pet trade invasion risk) are required to target all potential invasion pathways related to the pet trade. Although trade restrictions for some species have been enforced, additional interventions are required to prevent trade in non-native animals with high invasion potential (Hulme 2015, Lockwood et al. 2019), impulse or ill-informed purchases of non-native pets by individuals who may release these animals when they no longer have the ability or desire to care for these animals (Warwick et al. 2018, Maceda-Veiga et al. 2019), and deliberate releases of non-native pets (Lockwood et al. 2019, Maceda-Veiga et al. 2019). Interventions are also required to prevent the establishment of released non-native animals by capturing or euthanizing them (Beever et al. 2019, Lockwood et al. 2019). The success of these interventions depends on the support of pet owners, regulatory agencies, and the public (Hulme 2015, Warwick et al. 2018, Maceda-Veiga et al. 2019), which may be difficult to secure because invasive species management is often divisive (Hulme 2015, Beever et al. 2019) and pet owners may be unwilling to accept or acknowledge the risks pet releases pose to native wildlife and ecosystems (Patoka et al. 2018). Conflicts over management of non-native and invasive species arise if interventions affect industries that derive profit from invading species (e.g., the pet trade) or if interventions violate the personal or moral values of key stakeholder groups (e.g., opposition by animal-rights or -welfare advocates to eradication of invasive species; Beever et al. 2019). The passage of federal regulations intended to reduce the pet trade invasion risk has been successfully prevented by the pet industry in the recent past (Prestridge et al. 2011). Given public support for and the economic and political power of the pet industry, effective management of the pet trade invasion risk depends on the public, legislature, and business community recognizing the role they must each play in mitigating species invasions (Hulme 2015).

Previous studies reported that individuals who are able to identify non-native and invasive species (Somaweera et al. 2010, García-Llorente et al. 2011, Sharp et al. 2011, Verbrugge et al. 2013) and who understand that the pet trade contributes to species invasions (Episcopio-

Sturgeon and Pienaar 2019) are more likely to support interventions to mitigate species invasions. Individuals' support for invasive species management is also positively correlated with their concern about the risks of species invasions (García-Llorente et al. 2011, Schüttler et al. 2011, Sharp et al. 2011). People may differ in their concern about the ecological, economic, and human well-being (e.g., health and safety) threats posed by invasive species and hence their support for interventions to mitigate these risks (Liu et al. 2011, Gozlan et al. 2013, Estévez et al. 2015). Individuals may not support euthanasia of invasive species, owing to ethical or animal rights concerns (Schüttler et al. 2011, Sharp et al. 2011, Verbrugge et al. 2013, Estévez et al. 2015), although men are more likely to support the eradication of invasive species than women (Bremner and Park 2007, Fitzgerald et al. 2007). Older and more educated individuals also tend to be more supportive of management actions to address species invasions (Bremner and Park 2007, Fitzgerald et al. 2007, Sharp et al. 2011), and higher income individuals may be more willing to pay for interventions to mitigate invasion risks (García-Llorente et al. 2011). Finally, failure to comprehend the efficacy of management interventions and low levels of political and institutional trust may undermine support for, and compliance with, interventions to mitigate species invasions (Evans et al. 2008, Stern 2008, Mackenzie and Larson 2010, Episcopio-Sturgeon and Pienaar 2019).

Although the existing literature on people's preferences for invasive species management is informative, more social science research is needed to resolve social-ecological mismatches in managing the pet trade invasion risk (Beever et al. 2019). To build on this existing literature, we implemented a study with 2 key objectives: to measure support by the public and pet owners for additional interventions to mitigate the pet trade invasion risk and to investigate determinants of this support. We predicted that pet owners would be less supportive of interventions to manage the pet trade invasion risk than general members of the public. We further predicted that individuals' support for interventions would be positively correlated with their knowledge of invasive species and the pet trade invasion risk, perceptions of the efficacy of proposed interventions to mitigate the invasion risk, trust in government, and level of concern related to the ecological, economic and human well-being threats posed by species invasions (although we predicted that individuals would differentiate between these risks). Finally, we predicted that individuals' support for interventions would depend on their demographic characteristics and the type of intervention.

STUDY AREA

We focused on the intrastate non-native pet trade in Florida, USA, which has an elevation range from sea level to 105.2 m, natural communities ranging from broad alluvial riparian areas and upland flats and ridges in the north to tropical hammocks, swamps, rocklands, and freshwater marshes in the south, and predominant land uses of agriculture, timber production, and urban development (Myers and Ewel 1990, Florida Fish and Wildlife Conservation Commission [FWC] 2019). Florida has 3 significant trade ports through which live animals flow each year (Hardin 2007). According to the United States Fish and Wildlife Service (USFWS) Law Enforcement Management Information Systems (LEMIS) division, in 2014 an estimated 629,301 individual amphibians and reptiles were imported into Florida. Nearly 85% of the non-native reptiles and amphibians introduced into Florida are attributable to the pet trade (Krysko et al. 2016). Because the humid, subtropical climate of Florida (average annual precipitation of 137 cm, cool dry season from Oct or Nov to Apr, warm rainy season from May to Sep or Oct; Myers and Ewel 1990) resembles the climate of many invasive species, there is increased likelihood that these species will become established if released (Simberloff 1996, Hardin 2007), especially in the warm, near tropical climate of south

Florida (average temperature of 24.2°C, range = 19.9–28.5°C). As a result, Florida is currently host to the greatest number of established, non-native herpetofauna in the world (Krysko et al. 2011), which pose a potential risk to the >16,000 native wildlife species (a mix of southern temperate, neotropical, and western species) that occur in Florida, of which >147 vertebrate species and subspecies and >1,700 invertebrate species are endemic (FWC 2019). For example, there is a direct link between the invasion of the Burmese python and mammal declines within the Everglades, an internationally important biodiversity hotspot (Dorcas et al. 2012, Sovie et al. 2016). The western Pacific red lionfish (*Pterois volitans*) is another species introduced into Florida by the pet trade that poses a serious threat to ecologically and economically important coral reef species (Ruiz-Carus et al. 2006).

METHODS
Survey Design

We designed a survey (that was implemented by mail and online) to measure support for 7 interventions to reduce the pet trade invasion risk in Florida: 1) allowing trade in species that pose the smallest invasion risks in Florida (an approved list or whitelist of animals that may be owned as pets; Keller et al. 2007, Springborn et al. 2011, Hulme 2015); 2) required training for pet owners to emphasize species traits, the amount of care an animal requires, the costs associated with caring for the animal, and the life expectancy of the animal to prevent the purchase of animals that these owners are not able or willing to care for (Warwick et al. 2018, Maceda-Veiga et al. 2019); 3) a mandatory 72-hour waiting period between the purchase of a non-native pet and bringing the pet home, with a full refund provided if an individual decides not to keep the pet, to prevent impulse purchases of pets; 4) implementation of a tracking system into every non-native pet to identify owners of escaped or released pets (Perry and Farmer 2011, Maceda-Veiga et al. 2019); 5) requiring sellers of non-native pets to keep detailed information on every non-native pet sold and who purchased that animal, to dissuade pet owners from deliberately releasing pets; and 6) euthanization or 7) capture of non-native animals and their re-sale into the pet trade to remove non-native and invasive species from Florida's ecosystems. We asked survey respondents: "If a vote was held tomorrow, how supportive would you be of the [intervention]?" We used a Likert scale (Likert 1932; strongly oppose = 1, slightly oppose = 2, neutral = 3, slightly support = 4, strongly support = 5) to code responses to this question. We further measured respondents' opinions on how effective interventions would be in preventing ill-informed or impulse purchases of pets (mandatory training for pet owners, 72-hour waiting period prior to purchase of pet) or the purchase of pets that have high invasion risk (approved list of pets), reducing deliberate releases of pets by owners (micro-chipping and registration of pets, seller registration of all pets sold), and removing non-native and invasive animals from the wild (capture and sale of wild-caught non-native animals, euthanasia of non-native and invasive animals; Table 1).

Table 1. Explanatory variables included in regression analyses of pet owners' and the public's support for interventions to mitigate the pet trade invasion risk and measurement of these variables, Florida, USA, 2017–2018

Variable	Corresponding survey question	Measurement
Effectiveness of management actions in mitigating the pet invasion risk		
Mandatory training	If a law was implemented that requires a 1-hour training session before an individual may own a non-native pet, how effective do you believe this would be at preventing the release of non-native animals?	Not at all = 1, slightly = 2, somewhat = 3, very = 4, extremely = 5
Waiting period	A potential law could require people to reserve a non-native pet and wait 72 hours before they can pay for the pet and bring it home. In your opinion, how effective would this be at reducing the number of impulse purchases of non-native animals?	Not at all = 1, slightly = 2, somewhat = 3, very = 4, extremely = 5
Micro-chipping	A potential law could require that non-native pet owners get their pets microchipped and registered. If a pet was found in the wild it would result in a fine. If all pet owners complied with this program, how effective do you think registering and microchipping would be at preventing the release of non-native and invasive animals in Florida?	Not at all = 1, slightly = 2, somewhat = 3, very = 4, extremely = 5
Seller registration	A potential law could require non-native pet sellers to register all pets sold. The pet registration list would include details on who purchased the pet. Pet sellers would have to inform all individuals of this pet registration list at the time of purchase. If all pet sellers complied with this program, how effective do you think this registration list would be at preventing the release of non-native and invasive animals in Florida?	Not at all = 1, slightly = 2, somewhat = 3, very = 4, extremely = 5
Approved list	A potential regulation could be introduced that lists all the non-native animals that can be owned as pets. This regulation would be known as an 'Approved List'. Any animals not on the list would be prohibited as a pet. In your opinion, how likely is it that individuals would only purchase animals on the 'Approved List'?	Not at all = 1, slightly = 2, somewhat = 3, very = 4, extremely = 5
Capture and re-sale	A possible option for removing and/or reducing the number of non-native and invasive animals in the wild in Florida includes the capture and sale of non-native animals into the pet trade in Florida. How effective do you think this action would be at removing or reducing the number of non-native and invasive animals in the wild in Florida?	Not at all = 1, somewhat = 3, very = 4, extremely = 5

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Variable	Corresponding survey question	Measurement
Euthanasia	A possible option for removing and/or reducing the number of non-native and invasive animals in the wild in Florida is the humane killing (euthanasia) of all captured non-native animals. How effective do you think this action would be at removing or reducing the number of non-native and invasive animals in the wild in Florida?	Not at all = 1, slightly = 2, somewhat = 3, very = 4, extremely = 5

Knowledge of

Variable	Corresponding survey question	Measurement
Non-native species	Below are some animals that are found in Florida: capybara, rhesus macaque, monk parakeet, burrowing owl, Cuban tree frog, Burmese python, gopher tortoise, and green iguana. Please check the box next to each animal that you consider to be non-native to Florida.	Generated a score of the number of correct answers provided by respondents. We then converted this score to a proportion of correct responses (0 to 1).
Invasive species	A non-native animal is considered invasive when it causes damage to the environment, the economy, and/or human health and safety. Before this survey did you know this term?	No = 0, yes = 1
The invasion risk posed by the pet trade	In your opinion, how likely is it that non-native animals are introduced into Florida by the pet trade?	Binary variable: responses of not at all, slightly, and somewhat likely coded as 0; responses of very and extremely likely coded as 1.

Concern about species invasions

Variable	Corresponding survey question	Measurement
Concern about the effects of non-native and invasive species on Florida's wildlife	How concerned are you about the following possible impacts of non-native invasive animals? Non-native invasive animals: • eat native wildlife • compete with native wildlife for food	Generated a score (2–10) to measure this concern by summing responses to each of the individual questions. Response options for individual questions were coded as not at all = 1, slightly = 2, moderately = 3, highly = 4, extremely = 5.
Concern about the economic and human welfare effects of non-native and invasive species	How concerned are you about the following possible impacts of non-native invasive animals? Non-native invasive animals: • cause property damage (like digging under walls) • harm cats and dogs • cost taxpayers money to control them How concerned are you that non-native invasive animals may cause injuries or harm to people? • Bite people • Scratch people	Generated a score (6–30) to measure this concern by summing responses to each of the individual questions. Response options for individual questions were coded as not at all = 1, slightly = 2, moderately = 3, highly = 4, extremely = 5.

Variable	Corresponding survey question	Measurement
	• Transfer disease to people	
Trust in government		
Trust in government knowledge related to managing the pet trade	Please indicate the degree to which you agree with the following statement: The state government has the knowledge to manage the non-native pet trade	Strongly disagree $= -2$, disagree $= -1$, neutral $= 0$, agree $= 1$, strongly agree $= 2$, I don't know $= 0$
Trust in government effectiveness in managing the trade	Please indicate the degree to which you agree with the following statement: The state government has been effective in managing the non-native pet trade	Strongly disagree $= -2$, disagree $= -1$, neutral $= 0$, agree $= 1$, strongly agree $= 2$, I don't know $= 0$

We designed 3 questions to measure respondents' knowledge of non-native and invasive animals and the invasion risk related to the trade in non-native pets. We measured respondents' knowledge of non-native animals by presenting them with the pictures and names of 8 animals and asking them to identify which of these animals are not native to Florida: capybara (*Hydrochoerus hydrochaeris*), rhesus macaque (*Macaca mulatta*), monk parakeet (*Myiopsitta monachus*), burrowing owl (*Athene cunicularia* ; native), Cuban tree frog (*Osteopilus septentrionalis*), Burmese python, gopher tortoise (*Gopherus polyphemus* ; native), and green iguana (*Iguana iguana*). We selected these animals based on input from invasion ecologists who work in Florida, who were of the opinion that although the majority of respondents were likely to know that the Burmese python is an invasive species owing to media coverage, many Floridians mistakenly believe that species such as the monk parakeet are native to Florida because they have been established in Florida for decades (since 1969 for the monk parakeet; Owre 1973). We also measured respondents' knowledge of the definition of an invasive animal and their understanding of the invasion risk associated with the pet trade (Table 1).

We measured respondents' concern about the effects of invasive animals (Table 1). We included 8 different effects of invasive animals that could be categorized as ecological, economic, or human well-being effects to determine whether concern differed across type of effect. Finally, we measured respondents' trust in the state government's ability to manage the pet trade invasion risk (Table 1).

Before finalizing the survey, we conducted expert review of the survey instrument with 2 invasion ecologists and 3 human dimensions experts. We also used cognitive testing (Alaimo et al. 1999, Dillman et al. 2011) to pre-test the survey instrument with 20 members of the public and the non-native pet trade. The survey instrument was reviewed by staff in the Non-Native Fish and Wildlife Program at FWC, who had requested this study. Our research was approved by the University of Florida Institutional Review Board (protocol 201701436).

Survey Implementation

We employed a mixed-mode survey design to improve response rates, reduce coverage bias, and reduce nonresponse errors (Kaplowitz et al. 2004). We implemented mail-based surveys

from June to August 2017 and online surveys from September 2017 to April 2018. Our sample size was determined by available grant funds. We mailed 4,000 surveys to Florida residents (1 survey undeliverable) using the tailored design method (individuals received an announcement postcard, a survey, a reminder postcard, and a second mailing of the survey if they had not yet participated in the research; Dillman et al. 2011). According to the LEMIS database, Miami, Florida is one of the biggest import locations of live animals in the United States. Therefore, we mailed 2,000 surveys to postal addresses in the south Florida counties of Miami-Dade, Broward, Collier, Lee, Hendry, Palm Beach, and Monroe counties, and 2,000 surveys to postal addresses in the remaining 60 Florida counties. Our choice of which counties to include in the sample was informed by discussions with invasion ecologists. We further stratified the sample by age (based on the 2010 Census).

We paid a company that administers online surveys (Qualtrics) to survey additional Florida residents using the same sample stratification approach that we adopted in the mail-based survey. We also sent an online invitation to participate in this research to 502 individuals who had contacted the FWC about non-native animals, 444 FWC Amnesty Program approved pet adopters, and 3,331 Florida Class III Wildlife for Exhibition or Public Sale permit holders and Possession or Exhibition of Venomous Reptiles or Reptiles of Concern license holders. Finally, we emailed 68 pet store owners and asked them to forward the survey to their customer email list. We sent e-mail invitations to participate in the survey to approved pet adopters, exotic animal permit holders, and pet stores to ensure that pet owners were adequately represented in the final sample. We obtained e-mail lists of individuals who had contacted FWC, FWC Amnesty Program pet adopters, and Florida permit holders from FWC in accordance with s. 119 Florida Statutes and the Florida Sunshine Law.

Statistical Analysis

We used the statistical analysis software Stata/SE 15.0 to analyze our data (StataCorp 2017). We ran multivariate analysis of variance to confirm whether exotic pet owners who were recruited using different survey methods (mail, online) or from different lists (e.g., FWC Amnesty Program approved pet adopters) were part of the same statistical population. We used non-parametric (Kruskal-Wallis) analysis of variance to compare stakeholders' (general members of the public and pet owners) support for the 7 interventions to mitigate the pet trade invasion risk, and their perceptions of how effective these interventions would be in mitigating the invasion risk because these data were ordinal and not normally distributed. We used chi-square tests and independent *t*-tests to ascertain whether responses to survey questions differed according to stakeholder group, depending on whether responses were measured as nominal or interval data. We considered a result statistically significant if the *P*-value was ≤0.05.

To test whether respondents' concern about the pet trade invasion risk differed according to type of effect (ecological, economic, human well-being), we used principal factor analysis to determine the dimensionality of survey items that were intended to measure respondents' concern about these effects of invasive species (Afifi et al. 2012). Survey items that loaded onto factors with an eigenvalue of ≥1 measured a single construct, which we included in the regression models as a single explanatory variable. We generated these constructs (scores) by summing together responses to the questions that loaded onto the factor. We used Cronbach's alpha (Cronbach 1951) to measure the inter-item reliability of items used to generate these constructs (scores). We assumed that a score measured a single construct if Cronbach's alpha for that construct was ≥0.7 (Gliem and Gliem 2003).

We used ordered probit regression models to analyze respondents' support for each potential action to mitigate the pet trade invasion risk, and determinants of this support. Regression analysis allowed us to test for the effects of multiple explanatory variables on respondents' support for the interventions, taking their other characteristics into account. The ordered probit regression model is the appropriate model to use when the dependent variable (i.e., support for each of the interventions, Y) is ordinal (Afifi et al. 2012). The model compared the probability that a respondent belonged to outcome category k (in our analysis, the respondent's level of support for an intervention) or a lower category with the probability that the respondent belonged to a category $>k$, such that the possible odds to be modeled were $\frac{Pr(Y \leq k)}{Pr(Y > k)}$, where k took the value of 1 (strongly oppose), 2 (slightly oppose), 3 (neutral), 4 (slightly favor), and 5 (strongly favor). We held coefficients on the explanatory variables constant across all odds, but the intercepts (α) varied for each of the odds, such that:

$$\ln\left(\frac{Pr(Y \leq k)}{Pr(Y > k)}\right) = \alpha_k + \boldsymbol{\beta} \times \mathbf{X} \text{ for } k = 1, 2, 3, 4, 5,$$

where $\mathbf{X}$ was a matrix of explanatory variables (perceived effectiveness of the intervention; stakeholder group [pet owner vs. general public]; knowledge of non-native and invasive species and the invasion risk associated with the pet trade; concern about the ecological, economic, and human well-being effects of invasive species; trust in government; sociodemographic variables) and $\boldsymbol{\beta}$ was a vector of parameters to be estimated. We included explanatory variables in the regression analyses based on our predictions of determinants of support for interventions to mitigate the pet trade invasion risk.

We set up a suite of models for each intervention that contained all possible combinations of explanatory variables (perceived effectiveness of the intervention, stakeholder group, knowledge, concern about the effects of invasive species, trust in government, sociodemographic variables). Because we measured the perceived effectiveness of interventions using an ordinal scale from not at all effective to extremely effective (i.e., category widths did not represent equal increments of effectiveness and thus could not be entered into the regression as a single variable coded from 1 to 5), we entered respondents' perceptions of the efficacy of interventions in the regression as 4 binary variables (with the response of not at all effective omitted to avoid multicollinearity (i.e., the dummy variable trap). To test for differences in support for management actions across the 2 stakeholder groups, we included interaction variables in the ordered probit models (pet owner = 1 for non-native pet owners and 0 for general members of the public). As such, we specified the ordered probit model as:

$$\ln\left(\frac{Pr(Y \leq k)}{Pr(Y > k)}\right) = \alpha_k + \beta_1 \times \text{slightly effective}$$
$$+ \beta_2 \times \text{somewhat effective}$$
$$+ \beta_3 \times \text{very effective}$$
$$+ \beta_4 \times \text{extremely effective}$$
$$+ \beta_5 \times \text{pet owner}$$
$$+ \sum_i (\beta_i^0 + \beta_i^1 \times \text{pet owner}) \times \mathbf{X}_i,$$

where **X** included respondents' knowledge, concern about the effects of invasive species, trust in government, and sociodemographic variables. For example, we measured the correlation between pet owners' knowledge of non-native animals and their support for interventions as

$$\left(\beta_i^0 + \beta_i^1 \times \text{pet owner}\right) = \left(\beta_i^0 + \beta_i^1 \times 1\right) = \left(\beta_i^0 + \beta_i^1\right) \times$$

knowledge. By contrast, we measured the correlation between the public's knowledge of non-native animals and their support for interventions as

$$\left(\beta_i^0 + \beta_i^1 \times \text{pet owner}\right) = \left(\beta_i^0 + \beta_i^1 \times 0\right) = \beta_i^0 \times$$

knowledge. In testing for the best fit models, we generated 2 versions of the ordered probit models, models that included interaction variables (based on stakeholder group) and models that excluded these interaction variables. We identified the best-fit model for each intervention based on Akaike's Information Criterion (AIC; Burnham and Anderson 2004), whereby the best-fit model had the lowest AIC.

RESULTS

We received 427 completed mail-based surveys (10.7% response rate). Although Qualtrics did not collect information that would allow us to calculate the response rate for the online survey they administered to Florida residents, 1,246 individuals opened the survey link, of which 851 individuals were eligible to take the survey, and 759 individuals completed the survey (89.2% completion rate). We received 115 completed surveys from individuals who had contacted the FWC about non-native animals (22.9% response rate), 81 completed surveys from FWC Amnesty Program approved pet adopters (18.2% response rate), and 319 completed surveys from Florida Class III Wildlife for Exhibition or Public Sale permit holders and Possession or Exhibition of Venomous Reptiles or Reptiles of Concern license holders (9.6% response rate). We collected 20 surveys by e-mailing pet store owners and from individuals who contacted us asking to participate in the survey. Although we recruited exotic pet owners using different methods, these pet owners belonged to the same statistical population ($F_{9,1,449} = 1.34$, $P = 0.211$).

A majority of respondents (53.9%) were female (Table 2), slightly higher than Florida's female population of 51.1%. The median age of respondents (45–54 yr) was consistent with the Florida adult median age of 50–54 years. Respondents' median income was between $50,000 and $99,999, which is greater than the Florida household median income of $48,900. Survey respondents typically had a higher education level (median level of a bachelor's degree) than Florida residents (median of some college or an associate's degree). Respondents consisted of 1,171 members of the Florida public (68.0%) and 550 pet owners (which included survey respondents who stated that they own an exotic pet, individuals with Florida Class III Wildlife for Exhibition or Public Sale permit holders, Possession or Exhibition of Venomous Reptiles or Reptiles of Concern license holders, and pet adopters, 32.0%).

Table 2. Sociodemographic characteristics of pet owners and general members of the public who responded to a survey about their support for interventions to mitigate the pet trade invasion risk, Florida, USA, 2017–2018

	General members of the Florida public (n = 1,171)		Exotic pet owners (n = 550)	
	Number	%	Number	%
Gender				
Male	468	40.0	303	55.1
Female	688	58.8	240	43.6
Prefer not to say	10	0.9	7	1.3
No answer	5	0.4	0	0.0
Age				
<25 yr	59	5.0	33	6.0
25–34 yr	121	10.3	77	14.0
35–44 yr	141	12.0	118	21.5
45–54 yr	191	16.3	139	25.3
55–64 yr	267	22.8	113	20.5
65–74 yr	273	23.3	60	10.9
≥75 yr	111	9.5	10	1.8
No answer	8	0.7	0	0.0
Education level				
<12th grade	14	1.2	8	1.5
High school graduate	121	10.3	55	10.0
Some college or an associate's degree	359	30.7	203	36.9
Bachelor's degree	393	33.6	157	28.5
Graduate degree	278	23.7	127	23.1
No answer	6	0.5	0	0.0
Annual income				
<$25,000	115	9.8	41	7.5
$25,000–$49,999	216	18.4	93	16.9
$50,000–$99,999	438	37.4	218	39.6

	General members of the Florida public (n = 1,171)		Exotic pet owners (n = 550)	
	Number	%	Number	%
$100,000–$199,999	266	22.7	160	29.1
≥$200,000	81	6.9	36	6.5
No answer	55	4.7	2	0.4

Overall, respondents were most supportive of a law requiring non-native pet owners to get their pets microchipped and registered (57.7% of respondents strongly favored this intervention), and least supportive of the euthanasia of invasive species (only 26.8% of respondents strongly favored this intervention; Fig. 1). Support for additional interventions to mitigate the pet trade invasion risk differed between pet owners and general members of the Florida public. Members of the public (4.33 ± 0.96 [SD]) were more supportive of the implementation of a 1-hour training session before an individual may own a non-native pet than pet owners (3.85 ± 1.24; $\chi^2_1 = 53.381$, $P < 0.001$). Members of the public (4.49 ± 0.87) were also more supportive of a law requiring non-native pet owners to get their pets micro-chipped and registered (3.60 ± 1.47; $\chi^2_1 = 135.158$, $P < 0.001$), a law requiring people to reserve a non-native pet and wait 72 hours before they can purchase the pet (4.36 ± 0.92 for the public; 3.48 ± 1.48 for pet owners; $\chi^2_1 = 123.929$, $P < 0.001$), seller registration of all non-native pets sold (4.50 ± 0.83 for the public; 3.57 ± 1.46 for pet owners; $\chi^2_1 = 111.194$, $P < 0.001$), an approved list of species that people may own as pets (4.42 ± 0.84 for the public; 3.27 ± 1.56 for pet owners; $\chi^2_1 = 146.843$, $P < 0.001$), and the euthanasia of invasive species (3.28 ± 1.49 for the public; 2.69 ± 1.48 for pet owners; $\chi^2_1 = 55.303$, $P < 0.001$; Fig. 1). By contrast, pet owners (3.73 ± 1.26) were more supportive of the capture and sale of non-native animals into the pet trade than members of the public (3.44 ± 1.40; $\chi^2_1 = 13.956$, $P < 0.001$).
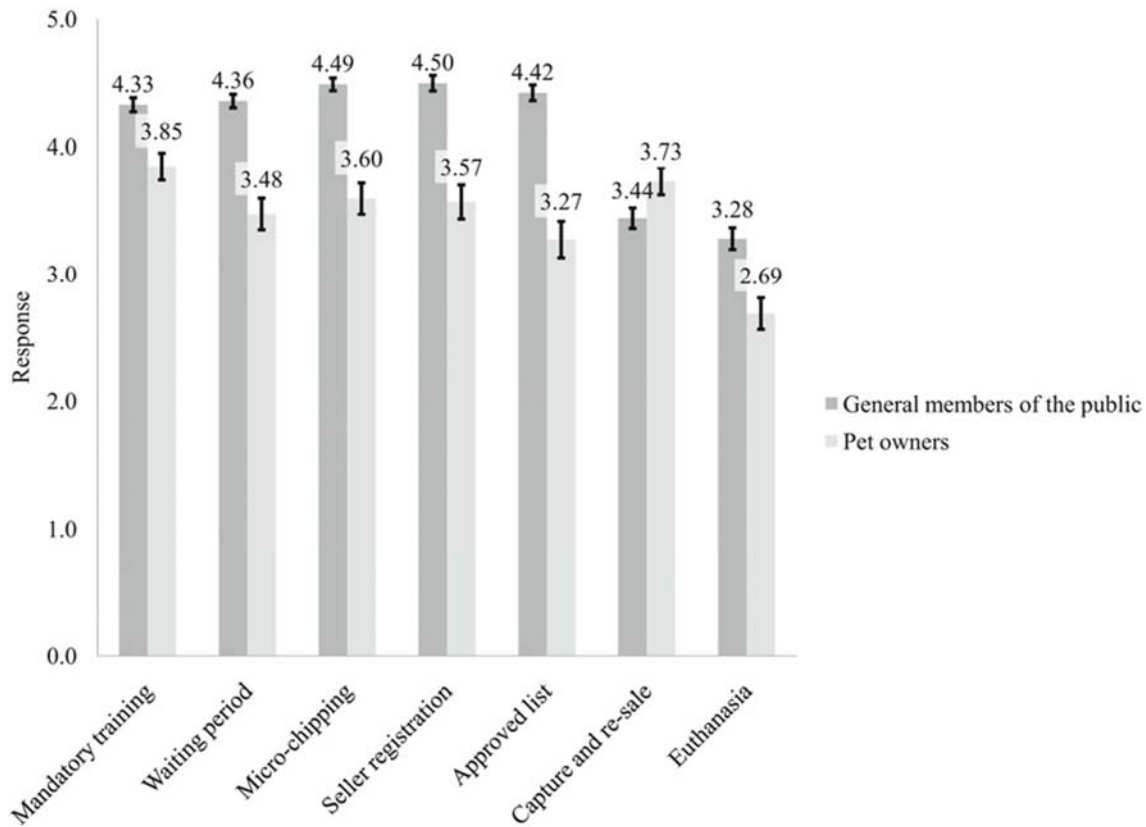
Figure 1. Mean levels of support for management actions to mitigate the pet trade invasion risk in Florida, measured from surveys of the general public and non-native species pet owners, Florida, USA, 2017–2018. Responses coded as strongly oppose = 1, slightly oppose = 2, neutral = 3, slightly favor = 4, and strongly favor = 5. Error bars represent 95% confidence intervals for mean values.

Pet owners and members of the public also differed in their perceptions of how effective the interventions would be in mitigating the pet trade invasion risk. Pet owners rated the effectiveness of a 1-hour training session before an individual may own a non-native pet (2.73 ± 0.94 for the public; 2.84 ± 1.06 for pet owners; $\chi^2_1 = 5.359$, $P = 0.021$) and the capture and sale of non-native animals into the pet trade (2.94 ± 1.08 for the public; 3.05 ± 1.17 for pet owners; $\chi^2_1 = 3.905$, $P = 0.048$) higher than respondents from the general public (Fig. 2). By contrast, members of the general public rated the effectiveness of a law requiring people to reserve a non-native pet and wait 72 hours before they can purchase the pet (3.03 ± 1.01 for the public; 2.75 ± 1.18 for pet owners; $\chi^2_1 = 22.044$, $P < 0.001$), seller registration of all non-native pets sold (3.29 ± 1.01 for the public; 3.00 ± 1.16 for pet owners; $\chi^2_1 = 17.367$, $P < 0.001$), an approved list of species that people may own as pets (2.90 ± 0.90 for the public; 2.58 ± 1.09 for pet owners; $\chi^2_1 = 20.970$, $P < 0.001$), and the euthanasia of invasive species (3.48 ± 1.26 for the public; 3.09 ± 1.33 for pet owners; $\chi^2_1 = 30.933$, $P < 0.001$) higher than pet owners.
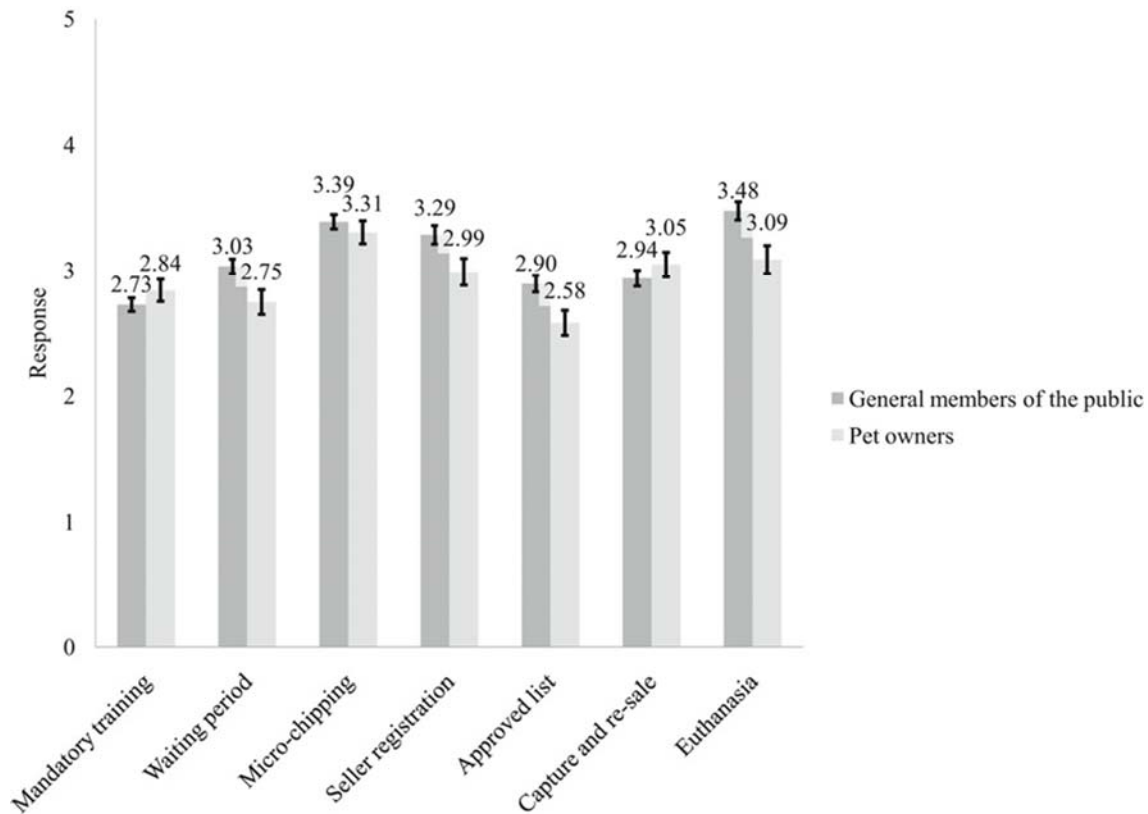
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Figure 2. Mean perceived effectiveness of management actions in mitigating the pet trade invasion risk in Florida, measured from surveys of the general public and non-native species pet owners, Florida, USA, 2017–2018. Responses coded as not at all effective = 1, slightly effective = 2, somewhat effective = 3, very effective = 4, and extremely effective = 5. Error bars represent 95% confidence intervals for mean values.

Pet owners were able to correctly identify a greater share of animals in terms of whether they were native versus non-native (~7 of 8 animals; 88%) than the Florida public (~5 of 8 animals; 68.6%; $t_{1,719} = 17.367$, $P < 0.001$; Table A1, available online in Supporting Information). Similarly, a greater percentage of pet owners (95.3%) knew the definition of an invasive species, compared to general members of the public (78.3%; $\chi^2_1 = 78.713$, $P < 0.001$; Table A1). Although pet owners were more knowledgeable about non-native and invasive species, the public (4.21 ± 0.94) were more likely to consider the pet trade responsible for the introduction of non-native animals into Florida than pet owners (3.91 ± 1.08; $\chi^2_1 = 24.325$, $P < 0.001$; not at all likely = 1, extremely likely = 5; Table A2, available online in Supporting Information).

Pet owners were more concerned (not at all concerned = 1; extremely concerned = 5) than the general public about the ecological effects of invasive animals, namely that these animals may eat native wildlife (3.77 ± 1.12 for the public; 3.96 ± 1.06 for pet owners; $\chi^2_1 = 10.427$, $P = 0.001$) or compete with native wildlife for food (3.85 ± 1.10 for the public; 4.00 ± 1.05 for pet owners; $\chi^2_1 = 7.078$, $P = 0.008$; Table A3, available online in Supporting Information). By contrast, members of the general public were more concerned about the economic and human well-being effects of invasive animals, namely that these animals may harm cats and dogs (3.96 ± 1.13 for the public; 3.14 ± 1.31 for pet owners; $\chi^2_1 = 141.396$, $P < 0.001$), bite people

(3.73 ± 1.19 for the public; 2.78 ± 1.37 for pet owners; $\chi^2_1 = 169.342$, $P < 0.001$), scratch people (3.59 ± 1.22 for the public; 2.62 ± 1.34 for pet owners; $\chi^2_1 = 181.466$, $P < 0.001$), transfer disease to people (3.98 ± 1.13 for the public; 3.14 ± 1.38 for pet owners; $\chi^2_1 = 133.324$, $P < 0.001$), cause property damage (3.85 ± 1.11 for the public; 3.21 ± 1.20 for pet owners; $\chi^2_1 = 102.250$, $P < 0.001$), or cost taxpayers money to control invasive animal populations (4.03 ± 1.06 for the public; 3.56 ± 1.16 for pet owners; $\chi^2_1 = 60.944$, $P < 0.001$).

Based on the results of the principal factor analysis, we retained 2 measures of concern about the effects of invasive animals: concern about the effects of invasive animals on wildlife and concern about the effects of invasive animals on humans (Table A4, available online in Supporting Information). We summed values for respondents' concern about invasive animals eating native wildlife and competing with native wildlife for food to generate a score of respondents' concern about the effects of invasive animals on wildlife (a measure of ecological concern). Respondents' concern about the effects of invasive animals on humans was composed of 6 items that were intended to measure concern about the economic and human well-being effects of species invasions: property damage caused by invasive animals, harm that invasive animals may cause cats and dogs, the cost to taxpayers to control invasive animals, invasive animals biting or scratching people, and invasive animals transmitting disease to people. The principal factor analysis demonstrated that although respondents differentiated between ecological and anthropocentric effects of species invasions, they collated economic and human well-being effects in terms of the pet trade invasion risk. Respondents' average level of concern about invasive animals' effects on wildlife (scaled by the number of items used to generate this measure of concern) was 3.86 ± 1.06, (range = 1–5; 3.81 ± 1.07 for the public; 3.98 ± 1.01 for pet owners). Respondents' average level of concern about invasive animals' effects on humans (scaled by the number of items used to generate this measure of concern) was 3.60 ± 1.04 (3.85 ± 0.95 for the public; 3.07 ± 1.05 for pet owners).

When asked to indicate their trust in the state government's ability to manage the pet trade invasion risk, members of the public more strongly agreed (strongly disagree = 1; strongly agree = 5) that the state government has the knowledge to manage the pet trade (3.69 ± 0.99 for the public; 3.38 ± 1.24 for pet owners; $\chi^2_1 = 16.425$, $P < 0.001$; Table A5, available online in Supporting Information). Pet owners more strongly agreed that the state government has been effective in managing the pet trade (2.58 ± 1.00 for the public; 2.77 ± 1.13 for pet wners; $\chi^2_1 = 7.685$, $P = 0.006$).

Ordered Probit Regression Analysis

Based on the ordered probit regression analysis, there was no correlation between respondents' knowledge of the definition of an invasive species and their support for interventions (Table 3). However, general members of the public's support for interventions to prevent impulse or ill-informed purchases of pets (required training for pet owners, a mandatory waiting period) and the deliberate release of pets (microchipping of pets, seller registration of pets) was positively correlated with their knowledge of non-native animals. By contrast, pet owners' knowledge of non-native animals was negatively correlated with their support for interventions to prevent impulse or ill-informed purchases of pets, the deliberate release of pets, and trade in non-native animals with high invasion potential (an approved list

of species that may be traded as pets). General members of the public who recognized the invasion risk associated with the pet trade were more likely to support a 72-hour waiting period between a pet owner reserving and acquiring a pet. By contrast, pet owners who recognized the pet trade invasion risk were more likely to support a law requiring non-native pet sellers to register all pets sold and an approved list of species that could be traded as pets. There was no correlation between respondents' support for interventions to prevent the establishment of non-native species (capture of non-native animals and their sale as pets, euthanasia of all captured non-native animals) and their knowledge of non-native and invasive animals and the invasion risk associated with the pet trade.

Table 3. Ordered probit regression analysis of support for management actions to mitigate the pet trade invasion risk in Florida from surveys of the general public and non-native species pet owners, Florida, USA, 2017–2018

	Mandatory training		Waiting period		Micro-chipping		Seller registration		Approved list		Capture and re-sale		Euthanasia	
	β	P	β	P	β	P	β	P	β	P	β [a]	P	β	P
Perceived effectiveness of action														
Slightly	0.352	0.001	1.010	<0.001	0.723	<0.001	0.720	<0.001	0.802	<0.001	0.585	<0.001	0.948	<0.001
Somewhat	0.886	<0.001	1.623	<0.001	1.112	<0.001	1.284	<0.001	1.357	<0.001	1.145	<0.001	1.431	<0.001
Very	1.208	<0.001	2.256	<0.001	1.614	<0.001	1.709	<0.001	1.875	<0.001	1.878	<0.001	1.800	<0.001
Extremely	1.591	<0.001	2.669	<0.001	1.929	<0.001	2.071	<0.001	1.996	<0.001	2.351	<0.001	2.384	<0.001
Knowledge of														
Non-native species	0.422	0.027	0.457	0.019	0.469	0.020	0.832	0.001	0.288	0.240				
× pet owner[b]	−0.726	0.029	−0.770	0.027	−1.001	0.004	−1.506	<0.001	−1.356	0.001				
Invasive species	0.132	0.209	0.111	0.308	−0.030	0.790	0.066	0.604	0.017	0.890				
× pet owner	−0.243	0.372	−0.006	0.982	−0.152	0.589	−0.017	0.956	−0.159	0.610				
Invasion risk posed by the pet trade	0.159	0.147	0.433	<0.001	0.173	0.127	0.041	0.757	0.142	0.272				
× pet owner	0.020	0.902	−0.160	0.321	0.211	0.190	0.358	0.048	0.407	0.024				
Concern about species invasions														
Concern about effects to wildlife	0.061	0.014	0.042	0.098	0.098	<0.001	0.072	0.031	0.074	0.019			0.050	0.019
× pet owner	−0.020	0.611	−0.040	0.326	−0.061	0.133	−0.051	0.282	−0.047	0.305			−0.027	0.437
Concern about effects to humans	0.022	0.009	0.008	0.318	0.007	0.402	0.016	0.167	0.026	0.018			0.011	0.148
× pet owner	0.015	0.254	0.027	0.040	0.022	0.085	0.025	0.120	0.019	0.213			0.015	0.216
Institutional trust														
Trust in government knowledge about	0.083	0.048	0.072	0.098	0.078	0.085	0.094	0.112	0.065	0.240	0.090	0.016	−0.028	0.461

	Mandatory training		Waiting period		Micro-chipping		Seller registration		Approved list		Capture and re-sale		Euthanasia	
	β	P	β	P	β	P	β	P	β	P	β [a]	P	β	P
managing the trade														
× pet owner	0.075	0.221	0.094	0.138	0.082	0.204	0.052	0.494	0.062	0.407	−0.144	0.011	0.136	0.021
Trust in government effectiveness in managing the trade	−0.089	0.039	−0.107	0.016	−0.110	0.016	−0.204	<0.001	−0.140	0.010	0.022	0.556	−0.024	0.540
× pet owner	−0.020	0.753	−0.087	0.189	−0.051	0.441	0.017	0.821	0.029	0.703	0.059	0.323	−0.097	0.109
Demographics														
Gender[c]	0.386	<0.001	0.323	<0.001	0.283	0.002	0.393	0.001	0.189	0.086	−0.097	0.197	−0.364	<0.001
× pet owner	0.039	0.769	0.248	0.067	0.134	0.326	0.105	0.517	0.232	0.140	0.046	0.712	−0.226	0.080
Age (yr)[d]	0.007	0.007	0.016	<0.001	0.013	<0.001	0.018	<0.001	0.015	<0.001	0.008	<0.001	0.011	<0.001
× pet owner	−0.009	0.052	−0.013	0.004	−0.010	0.035	−0.014	0.014	−0.006	0.235	−0.010	0.016	−0.019	<0.001
Education (yr)[e]	−0.031	0.107	−0.025	0.211	−0.023	0.269	−0.051	0.049	−0.014	0.577	−0.044	0.010	0.008	0.631
× pet owner	0.037	0.128	0.016	0.518	0.032	0.204	0.046	0.120	0.027	0.346	0.062	<0.001	0.045	0.027
Income[f]	0.000	0.787	0.000	0.662	0.001	0.290	0.002	0.053	0.000	0.735	0.000	0.653	0.001	0.364
× pet owner	0.001	0.569	0.001	0.361	−0.001	0.662	−0.001	0.754	0.000	0.841	−0.002	0.123	−0.001	0.372
Intercepts														
α_1	0.024		0.986		0.849		0.768		1.010		−0.441		1.658	
α_2	0.524		1.440		1.359		1.385		1.418		0.039		2.206	
α_3	1.337		2.330		1.926		2.095		2.177		0.864		2.890	
α_4	2.179		3.294		2.803		2.992		3.111		1.555		3.516	
Log likelihood	−1588.179		−1,453.665		−1,451.727		−1,006.392		−1,074.432		−1,964.485		−1,965.220	
Akaike's Information Criterion (AIC)	3,236.359		2,967.329		2,963.454		2,072.784		2,208.865		3,968.970		3,978.439	
Corrected AIC	3,237.639		2,968.607		2,964.731		2,074.569		2,210.650		3,969.546		3,979.262	
Pseudo R^2	0.1305		0.2426		0.1925		0.2447		0.2410		0.1172		0.1646	

[a] Empty cells indicate that variables were not included in the best-fit models.

[b] Interaction variables (× pet owner) capture differences in support for management actions across the 2 stakeholder groups (pet owner = 1 for non-native pet owners and 0 for general members of the public). For example, the correlation between pet owners' knowledge of non-native animals and their support for interventions is $\left(\beta_i^0 + \beta_i^1 \times \text{pet owner} \right) = \left(\beta_i^0 + \beta_i^1 \times 1 \right) = \left(\beta_i^0 + \beta_i^1 \right) \times$ knowledge. The correlation between the

public's knowledge of non-native animals and their support for interventions as

$$\left(\beta_i^0 + \beta_i^1 \times \text{pet owner}\right) = \left(\beta_i^0 + \beta_i^1 \times 0\right) = \beta_i^0 \times$$
knowledge.

Respondents' support for mandatory training of pet owners, microchipping of non-native pets, seller registration of all non-native pets, an approved list of non-native pets and euthanasia of all captured non-native animals in Florida was positively correlated with their concern about the effects of invasive animals on native wildlife. Respondents' concern about the effects of invasive animals on humans (economic, human well-being) was also positively correlated with their support for mandatory training for pet owners and an approved list of non-native pets. Pet owners with greater concern about the effects of invasive animals on humans were more likely to support a mandatory waiting period before acquiring a pet. There was no correlation between respondents' support for the capture and sale of non-native animals and their concern about the effects of invasive animals on wildlife or humans.

Across all interventions, respondents' level of support for the intervention was positively correlated with their perceptions of how effective the intervention would be in mitigating the pet trade invasion risk (larger positive coefficients for higher levels of perceived efficacy; Table 3). Respondents with greater trust in the state government's knowledge about managing the pet trade were more likely to support mandatory training for pet owners prior to acquiring a non-native pet. Pet owners with greater trust in government knowledge were also more likely to support euthanasia of all captured non-native animals in Florida. General members of the public who had greater trust in government knowledge were more likely to support the capture of non-native animals in Florida and their sale as pets, whereas pet owners with greater trust in government knowledge were less likely to support this intervention. Pet owners and general members of the public who expressed greater trust in the government's effectiveness were less likely to support interventions to prevent trade in non-native animals with high invasion potential, impulse or ill-informed purchases of non-native pets, and the deliberate release of non-native pets.

Female respondents were more likely to support interventions to prevent impulse or ill-informed purchases and the deliberate release of non-native pets. By contrast, they were less likely to support euthanasia of all captured non-native animals in Florida. Support for interventions to prevent trade in non-native animals with high invasion potential, impulse or ill-informed purchases of non-native pets, and the deliberate release of non-native pets was positively correlated with respondents' age. Although there was a positive correlation between general members of the public's age and their support for interventions to prevent the establishment of non-native species in Florida, older pet owners were less likely to support the capture and sale of non-native animals or euthanasia of all captured non-native animals in Florida. Respondents with a higher level of education were less likely to support a

law requiring pet sellers to register all non-native pets sold. Pet owners with a higher level of education were more likely to support euthanasia of all captured non-native animals in Florida and the capture and sale of non-native animals as pets. General members of the public with a higher level of education were less likely to support the capture and sale of non-native animals as pets. There was no correlation between respondents' income and their support for any of the interventions.

DISCUSSION

Support by the public and pet owners for additional interventions to mitigate the pet trade invasion risk varied according to the type of intervention. Consistent with previous findings, respondents expressed least support for euthanasia of invasive species, possibly owing to ethical or animal rights concerns (Schüttler et al. 2011, Sharp et al. 2011, Verbrugge et al. 2013, Estévez et al. 2015). As we had predicted, pet owners were generally less supportive of these interventions (except the capture of non-native species in the wild and their sale into the pet trade) than members of the public. Although we found that support for interventions to mitigate the pet trade invasion risk differed across stakeholders, support for interventions also depended on individuals' knowledge and concern related to the invasion risks associated with the pet trade, trust in government, and demographic characteristics.

Consistent with our predictions, we found that respondents' knowledge of non-native animals was correlated with their support for interventions to mitigate the pet trade invasion risk, although the direction of this correlation depended on stakeholder group. Although general members of the public with greater knowledge of non-native animals were more likely to support interventions that would prevent impulse or ill-informed purchases and the deliberate release of pets, pet owners with greater knowledge of non-native animals were less supportive of these interventions and an approved list of animals that may be traded as pets. One possible explanation for this finding is that although pet owners were more knowledgeable about non-native animals, they were also more likely to be emotionally attached to these animals, and hence unwilling to restrict trade in animals that they view as companions or beneficial to people (e.g., in terms of improved health; Alves and Rocha 2018). Research on people's preferences for feral cat management supports this inference. Loyd and Hernandez (2015) reported that although cat owners were more knowledgeable about cats, people's attitudes towards cats were more important than knowledge in determining their support for interventions to manage feral cats.

There was some evidence that support for interventions to mitigate the pet trade invasion risk was positively correlated with respondents' recognition that the pet trade is a pathway for species invasions, although knowledge of why an animal would be defined as invasive was not correlated with support for any of the interventions. Rather, support for most interventions was positively correlated with respondents' concern about the ecological effects of invasive species. There was also some evidence that support for interventions to mitigate the pet trade invasion risk was positively correlated with respondents' concerns about the risk of invasive animals to humans (composed of economic and human well-being effects). Although pet owners expressed higher levels of concern about the ecological effects of invasive animals, members of the general public expressed greater concern about the economic and human well-being effects of invasive animals. Our findings were consistent with prior research reporting that people distinguish between the ecological and anthropocentric threats posed by invasive species (Liu et al. 2011, Gozlan et al. 2013, Estévez et al. 2015) and that support for the management of invasive species is positively correlated

with concern about the effects of invasive species (Schüttler et al. 2011, Sharp et al. 2011). Taken in concert, our findings provided additional evidence that attitudes (how people evaluate a situation based on their affective response to that situation; Manfredo et al. 1995) are stronger predictors of support for interventions to manage invasive species than knowledge (beliefs based on factual information; Manfredo et al. 1995, Sharp et al. 2011). Our finding that gender and age were more highly correlated with support for interventions than respondents' education levels further suggests that knowledge is not the limiting factor on support for interventions (Bremner and Park 2007, Fitzgerald et al. 2007, Sharp et al. 2011).

Efforts to increase knowledge of invasive species may not increase support for interventions to mitigate the pet trade invasion risk (Sharp et al. 2011, Heberlein 2012). Rather, communication efforts may be more effective in preventing species invasions if focus is placed on informing pet owners (especially novice pet owners) about the traits of the species that they intend to purchase and the cost of caring for these species to prevent ill-informed and impulse purchases of pets. Similarly, better informing pet owners about options to adopt out their pets, and facilitating pet adoptions, may prevent deliberate releases of pets when owners are opposed to euthanizing these animals. Because pet owners demonstrated greater concern about the ecological effects of invasive species and greater support for the capture and sale of non-native animals than general members of the public, they may be amenable to participating in programs to relinquish their pets to rescue groups or other individuals who will care for these pets, rather than releasing these pets into Florida's ecosystems.

Consistent with our prior predictions and the existing literature, respondents' support for interventions to mitigate the pet trade invasion risk was positively correlated with the perceived effectiveness of interventions to mitigate the pet trade invasion risk. We also found that although respondents were generally more likely to support interventions if they believed the state government has the knowledge to manage the pet trade, they were less likely to support the interventions if they believed that the state government has been effective in managing the pet trade. We infer that if stakeholders believe that government agencies have been effective in managing the pet trade invasion risk, they are less likely to support additional management efforts even if they recognize that these agencies have the competency to manage invasion risks. Less than 25% of pet owners (and <15% of general members of the public) agreed that state government efforts to manage the pet trade have been effective, which helps to explain respondents' support for additional interventions.

Government agencies may be able to increase their effectiveness in managing the pet trade (and associated invasion risks) by engaging the pet trade in the development of regulations and management actions to increase trust and compliance with these actions (Episcopio-Sturgeon and Pienaar 2019). Even if the pet trade and other key stakeholders are involved in the design of interventions, some members of the pet trade may not be supportive of interventions to mitigate invasion risks associated with the trade. Judicious implementation of rules and policies that constrain or prevent actions by members in the pet trade that result in species invasions would complement voluntary approaches to mitigating the pet trade invasion risk. For example, pet distributors and breeders could be required to provide customers with detailed, consistent information on the traits and level of care that pets require prior to the sale of the animal. In designing such rules and policies, agencies should keep in mind that rules and regulations are difficult to change once implemented and may have unintended consequences (Rivalan et al. 2007). Decision-makers should also recognize that rules and regulations are unlikely to be effective if they are not adequately enforced by

trained staff with the resources needed to monitor compliance with these rules and regulations (Keane et al. 2008, Challender et al. 2015).

Although we implemented best practices in conducting this research, response rates were low for all methods of survey distribution (range = 9.6–22.9%), which is consistent with the general decline in response rates for social science surveys (Stedman et al. 2019). Our sampling strategy was limited by budget constraints, and we had insufficient funds to test for non-response bias. This research was specific to Florida, and actions by state government agencies to mitigate the invasion risks associated with intrastate trade in pets. We also note that we asked respondents their stated support for interventions, which may deviate from their actual support (Heberlein 2012). There may have been some level of social desirability bias in respondents' stated support for these interventions, although we made every effort to minimize this bias by rigorously pre-testing the survey instrument. Our list of potential interventions was not exhaustive, and we focused on the actions of pet owners rather than other stakeholders in the pet trade (breeders, distributors, importers). Despite these limitations, our study provides unique insight into the public's and pet owners' perceptions of the pet trade invasion risk and how it might be addressed.

MANAGEMENT IMPLICATIONS

Education and outreach efforts about invasive species are unlikely to alter the behavior of pet owners, in particular their decision to release pets. Rather, effort may be better spent in implementing policies that require pet sellers to inform pet owners about the traits of the animals they intend to purchase, and the level of care that these animals require, to reduce impulse or ill-informed purchases of pets that owners are then more likely to release. Increased opportunities for pet owners to relinquish their pets to rescue groups or individuals who are able and willing to care for these pets may also prevent deliberate releases of pets. Efforts should be made by agencies and organizations to collaborate with the pet trade industry to design policies and management actions to increase voluntary compliance. Although engaging the pet trade industry may promote voluntary compliance with policies and management actions by the majority of the industry, sufficient resources must be allocated by agencies to enforcing interventions to ensure compliance by individuals who oppose additional measures to mitigate the pet trade invasion risk. Finally, agencies may have to commit to the eradication of invasive species even if there is public and stakeholder opposition to these eradication efforts. In explaining the need for eradication efforts, agencies should highlight the negative effects of invasive species. If invasive species have ecological and anthropocentric effects, then this should be clearly communicated because different individuals are more likely to be persuaded to support eradication based on which effects (ecological, economic, or human well-being) are of greatest concern to them.

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