Received: 23 July 2020 | Revised: 21 June 2021 | Accepted: 9 July 2021

DOI: 10.1111/csp2.504

Conservation Science and Practice
A journal of the Society for Conservation Biology
Open Access
WILEY

PERSPECTIVE

Reptile pet trade in Brazil: A regulatory approach to sustainable biodiversity conservation

Érica Fonseca[1] | Caroline Zank[2] | Sonia Zanini Cechin[1] | Camila Both[3]

[1]Departamento de Biologia, Programa de Pós-Graduação em Biodiversidade Animal, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brazil

[2]Departamento de Ecologia, Universidade Federal do Rio Grande do Sul, Núcleo de Ecologia de Rodovias e Ferrovias, Porto Alegre, Rio Grande do Sul, Brazil

[3]Departamento Interdisciplinar, Universidade Federal do Rio Grande do Sul, Campus Litoral Norte, Tramandaí, Brazil

Correspondence
Érica Fonseca, Departamento de Biologia, Programa de Pós-Graduação em Biodiversidade Animal, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brazil.
Email: erica.fonsecae@gmail.com

Funding information
Coordenação de Aperfeiçoamento de Pessoal de Nível Superior; Conselho Nacional de Desenvolvimento Científico e Tecnológico, Grant/Award Numbers: 150621/2018-3, 309095/2016-6

Abstract

The pet trade is the main cause of the growing number of exotic reptiles worldwide, posing a risk for invasion emergence and species extinction. In this study, we identify and analyze the obstacles involved in controlling the native and exotic reptile trade in Brazil to identify the main gaps and limitations in this regard. We propose measures that will aid in the planning of public policies that are more effective to protect native fauna. The pet trade regulation in Brazil is currently guided by poorly implemented policies. The main problems are associated with failures in legislation and enforcement, corruption, and lack of resources. As a result, the illegal trade control, current efforts for the sustainable use of biodiversity, and the prevention of the introduction of exotic species are insufficient. We recommend a multidisciplinary approach, based on actions to reduce legislation deficiencies and inconsistencies, intensification of inspection actions, and investment in educational actions aimed at raising societal awareness.

KEYWORDS

illegal pet trade, invasive species, overexploitation, policy direction, sustainability

1 | INTRODUCTION

In the last century, the global economy has opened new pathways for the pet trade to become globally widespread and profitable (Baker et al., 2013). Currently, reptiles are the second group of vertebrates with the highest number of commercialized species (Bush, Baker, & Macdonald, 2014). In the past decade, around 18 and 20 million reptiles were imported into the United States and Europe, respectively (Auliya et al., 2016; HSUS, 2001). The increase in the popularity of reptiles is related, in particular, to the growing affluence of the middle class in emerging economies, expanding the number of consumers, and increased accessibility to the Internet and social networks (Bush et al., 2014; Kikilius, Hare, & Hartley, 2012). By connecting people around the world, the internet has massively expanded the volume of national and international trade, increasing the circulation of live reptiles worldwide and the pet trafficking (Lavorgna, 2014; Siriwat & Nijman, 2018). This growing market for pet reptiles has led to the emergence of a complex, often illegal, commercial network that affects both

biodiversity and human society (Auliya et al., 2016; Chomel, Belotto, & Meslin, 2007).

The illegal pet trade represents the second largest threat to the survival of certain reptiles, due to the continuous and uncontrolled removal of specimens from nature, comprising overexploitation (Auliya et al., 2016; Natusch & Lyons, 2012). This is particularly apparent in South America, the world's second largest captive-bred reptile exporter, where biodiversity is high, financial resources are limited and border control is flawed due to lack of awareness and lack of economic incentives to protect their borders (Nuñez & Pauchard, 2010; Robinson, Griffiths, St. John, & Roberts, 2015; Wilson-Wilde, 2010). The international reptile pet trade raises another major concern: the introduction of exotic species. Currently, escape and release are the main routes for the introduction of invading reptiles, which can cause ecological, economic and human health impacts (Fritts, 2002; La Laina, Nekaris, Nijman, & Morcatty, 2021; Stringham & Lockwood, 2018). Considering that current invasions are a consequence of past introductions, the increased demand for pet reptiles sets a warning for the risk of further invasions in the future, especially in emerging countries, where a greater number of invasions are expected, involving a greater taxonomic diversity than the current invasions (Essl et al., 2011; Lockwood et al., 2019; Scheffers, Oliveira, Lamb, & Edwards, 2019).

Brazil is one of the countries with the greatest reptile richness in the world (795 species), behind only Australia (1,057) and Mexico (942) (Costa & Bernils, 2018; Uetz, Freed, & Hošek, 2021). Many species of reptiles are exploited in the country for medicinal, religious, clothing, food and pet purposes (Alves et al., 2012). Although the legal breeding and sale of native reptiles as pets is extremely restricted (only 13% of the 438 commercial wild animal breeding sites breed reptiles), the popularity of reptiles as pets has increased in recent decades, following the global trend (Alves et al., 2019; IBAMA, 2019). The growth in demand in Brazil can also be linked to the great variety and abundance of species that can be acquired and to the restrictions on the commercialization of other animal groups (Alves et al., 2019; Patoka et al., 2018). As a consequence of increased demand, the number of invasive reptile records has increased and the pet trade has become primarily responsible for the introduction of exotic reptiles in the country, although the import of any exotic reptiles for use as pets is prohibited (e.g., Fonseca, Both, & Cechin, 2019; Hoogmoed & Avila-Pires, 2015; Prates, Hernandez, Samelo, & Carnaval, 2016). Recent studies reveal that at least 46 native and 47 exotic reptiles are used as pets in Brazil (Alves et al., 2019; Fonseca et al., 2019). In general, pet reptile trade in Brazil is composed predominantly of species traded illegally on the internet, within groups on social networks and messaging applications, and is concentrated in rich and developed areas of the country (Alves et al., 2019; Fonseca et al., 2019; Magalhães & São-Pedro, 2012).

Recent changes in Brazilian legislation have aggravated the situation by allowing some states to implement their own policies, allowing for more species to be raised on a commercial scale, including exotic species. However, Brazil is still unable to adequately control the pet trade of other groups, even those under an extensive and specific legal framework, such as birds and ornamental aquaculture species (Alves, Lima, & Araújo, 2013; Patoka et al., 2018). As an aggravating factor, the current government acts by weakening environmental regulations and institutions in favor of the productive and economic sectors (Fearnside, 2016; Tollefson, 2018). This scenario undermines efforts to fulfill the commitments made in the Convention on Biological Diversity (CBD, 2011) to conserve native species and prevent the introduction of exotic species. In this context, it is paramount to review the control of the reptile trade in Brazil to develop effective strategies to protect the native fauna. We present an overview of the challenges and obstacles encountered in controlling the reptile pet trade in Brazil and propose measures to assist in fauna management and public policy planning.

2 | POLITICAL, TECHNICAL, AND SOCIAL CHALLENGES TO CONTROL THE REPTILE PET TRADE IN BRAZIL

Brazilian environmental legislation, in its current form, is not efficient in animal trade control and wildlife protection. The main limiting factor for expanding the trade of legalized wild animals in Brazil has been the absence of the publication of the "Pet List," a list of wild species (except for aquarium animals) that may be marketed as pets in the country. This list should have been published by IBAMA (the Brazilian federal authority responsible for the implementation of national environmental policies) in 2008, which has not yet occurred (CONAMA Resolution No. 394/2007; a list of all the legal instruments mentioned in this article can be found in Appendix S1). The absence of the list created a loophole that allows states to authorize the trade of native or exotic species. This is due to the ambiguity of Complementary Law No. 140/2011, which transfers part of fauna management to Brazilian states, including the licensing of new commercial wildlife breeding sites. Complementary Law No. 140/2011, however, does not define which federative

entity (the Union or the State) is responsible for preparing the Pet List. Thus, some Brazilian states have independently published their regulations and species lists with different and even opposite positions. In the case of reptiles, while the state of Rio de Janeiro prohibits the establishment of commercial breeding grounds for exotic animals, the state of Alagoas authorizes them. As the import of exotic reptiles is prohibited in Brazil, if no import license is obtained, the law allows for commercial exotic species enterprises to acquire them from zoos, which can sell excess exotic fauna, or illegal exotic specimens originating from seizure (IBAMA Ordinance No. 118-N/1997). The import ban, therefore, does not prevent the sale and breeding of exotic reptiles in Brazil. Thus, the risk of introducing exotic species in a given state may exist due to legalization in neighboring states. The lack of clarity and disparate regulations between states make environmental control and the success of regional efforts to prevent the introduction of non-native species difficult.

When transferring part of the fauna responsibility to states and municipalities in 2011, the Brazilian government disregarded the logistical capacity (material, financial, and personal resources) of state agencies to plan and implement actions to monitor the legal and illegal pet trade. Since then, enforcement actions have been compromised in many Brazilian states. Few states have their own structure for receiving and screening seized animals. The situation in many centers is precarious, with a lack of resources for hiring professionals, buying feed, medicines, and fuel (Derevecki, 2017; Kuhnen & Kanaan, 2014). The overcrowding of reception and sorting centers, in some cases associated with the low training of environmental agents (including firefighters and military police), eventually resulting in the unlawful release of seized specimens (IBAMA, 2019). According to IBAMA-established guidelines concerning the destination of apprehended wild animals, release can be carried out in cases which (a) the specimen is native to the release area, (b) is healthy, and (c) has not been domesticated. However, in practice, it is common to release exotic species, as well as native specimens into other populations—far from their original distribution—and immediately after their seizure, in effect, without any veterinary evaluation (IBAMA, 2019). In addition to the risk of invasions and introducing unknown pathogens to the local fauna, this practice affects the genetic identity of local populations, which may lead to genetic pollution with the formation of hybrids and loss or alteration of variation and genetic adaptations, consequently making it difficult to understand the evolutionary history of these populations (Laikre et al., 2010; Travis, Watson, & Tauer, 2011). Reception and sorting center overcrowding also makes new apprehensions difficult. In such circumstances, the infringer (including repeating offenders) may temporarily assume the custody of the seized animal (Normative Instruction IBAMA No. 19/2014). This measure not only encourages recidivism but also authorizes the possession of pets of an illegal origin.

Corruption also facilitates transnational wildlife trafficking and allows for illegal transactions and services through document forgery, bribery, and money laundering (Destro, Pimentel, Sabaini, Borges, & Barreto, 2012; Van Uhm & Moreto, 2017). A practice used by hobbyists concerning reptiles is the implantation of microchips of legalized animals in illegal animals, usually exotic (L Borges, pers. comm.). As the exchange is usually made in cospecific individuals, the crime goes unnoticed during the inspection or is difficult to prove. Another practice, well documented in birds, is the laundering of wild-caught animals in legal breeding sites. This consists of falsifying and/or duplicating bird rings; and birth records to legalize wild-caught specimens (Renctas, 2001). In Brazil, over 80% of birds in captivity consist of wild-caught animals with fake rings (Alves et al., 2013). It is estimated that over 400 species and 50,000 wild birds are illegally traded as pets in Brazil (Regueira & Bernard, 2012; Alves et al., 2013). Similar practices can be expected to occur with reptiles.

Corrupt practices and illegal pet trade are supported by weak and deficient criminal sanctions. Currently, Brazilian criminal environmental legislation punishes the illegal domestic breeder in the same way as the trafficker. Environmental crimes are considered lesser offensive potential crimes and, usually, only fines are imposed. The values of these fines, in turn, are insignificant in comparison with the profit obtained from the illegal trade: R$5,000.00 (about $939.00; converted to $09/09/2020 using an exchange rate 1$= 5.32 R$; Brazilian real (BRL)) per native wildlife specimen included in the official list of endangered species (ICMBio, 2018) and regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and R$500.00 (about $94.00) per unlisted species (Decree No. 6514/2008); and less than 5% of environmental fines are paid (Borges, 2018). Environmental sanctions also exhibit certain weaknesses that result in consumer impunity and encourage recidivism, such as allowing fine waivers in cases of the domestic custody of non-threatened wild species (Law No. 9,605/1998; Decree No. 6,514/2008). In addition, no restrictions on the entry of international traffickers previously convicted of trafficking wildlife in the country are in place. Thus, foreign

traffickers continue to return to Brazil with exotic species, mainly from the United States and Europe, and traffic native fauna outside the country (e.g., Zanchetta, 2013; G1 SP, 2017). Finally, Brazil has not yet established specific regulations to control the illegal pet trade on the internet, one of the main allies in the worldwide expansion of animal trafficking in recent years (Lavorgna, 2015). It is possible to find a high number of offers of both Brazilian and exotic reptiles to be raised as pets on social media, most from trafficking or illegal breeding sites (Magalhães & São-Pedro, 2012; Bourscheit, 2018).

In addition to the aforementioned situations, successive environmental agency budget cuts are also an issue. In a federal context, in the last seven years, the Ministry of the Environment (MMA) has suffered over a $264 million budget reduction (WWF Brasil, 2018). This has directly affected the federal environmental control and enforcement sector, which includes the fight against crimes against wildlife (WWF Brasil, 2017). As a result, enforcement actions and the number of fines have decreased across the country (Dantas, 2019; IBAMA, 2019). The tendency is for budgetary restrictions to prevail in the coming decades, due to the new fiscal regime adopted in 2016, which limits adjustments and federal public spending (Constitutional Amendment No. 95/2016) and, more recently, due to the effects of COVID-19.

3 | POLICY, MANAGEMENT, AND EDUCATION RECOMMENDATIONS

The regulation of the trade of reptiles as pets must strike a balance between economic development and biodiversity conservation. Unfortunately, accurate data on illegal reptiles' trade in Brazil are lacking and, therefore, do not allow for more specific recommendations. We suggest that initial efforts should be directed toward reducing poaching as a precautionary measure, along with developing strategies to strengthen regulation and control structures and then implement well-structured legal trade (Figure 1). As some measures must be designed according to needs and the specific environmental, political and socioeconomic context of each location, we advocate the adoption of a multidisciplinary and multitasking approach, involving the participation of policy makers from federal, state and municipal levels, wildlife managers, researchers, NGOs, and communities.

A starting point is to eliminate discrepancies between state regulations through federal regulations, with the publication of a national pet list. Positive lists are more effective for regulation than prohibitive lists (Hulme, 2015). It is essential that the proposal for inclusion of species be based on technical criteria and considering invasion risk assessment protocols for candidate species. Our suggestion is that the national list contains only native

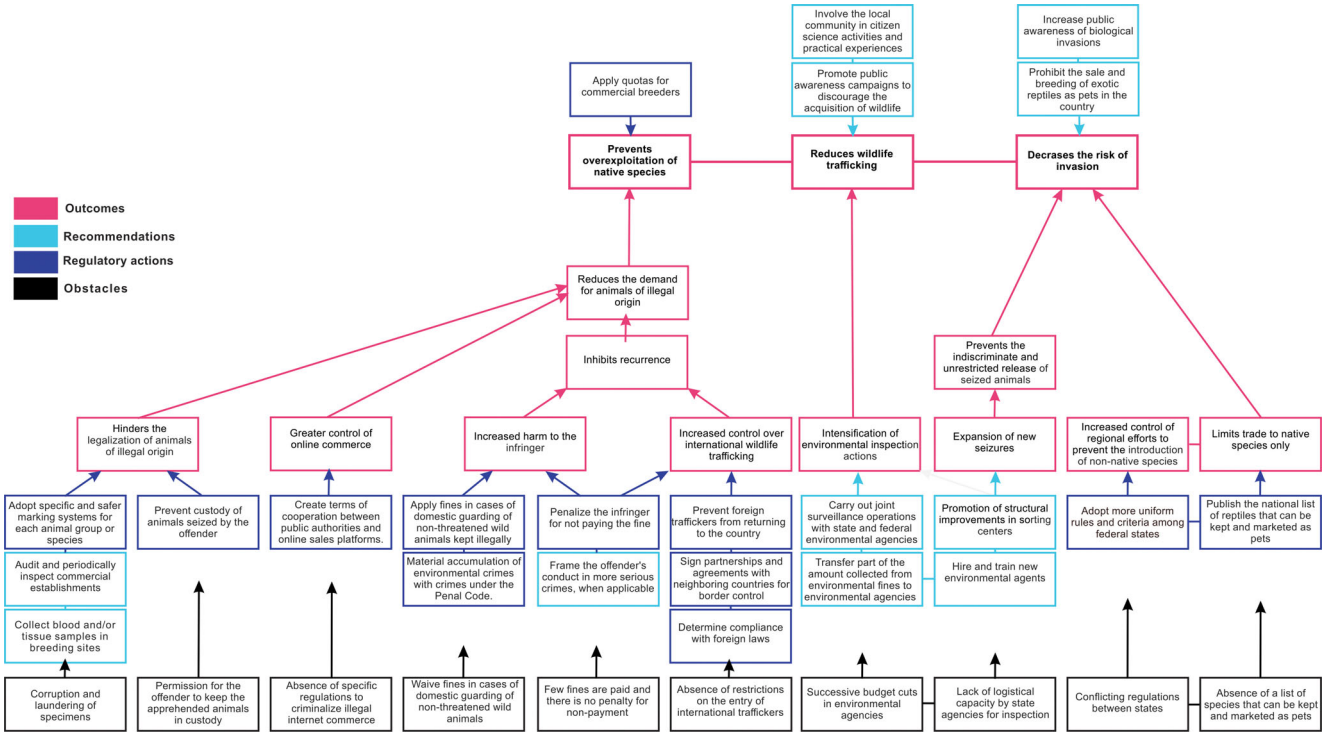

FIGURE 1 A simplified framework of regulatory actions and recommendations for the reptile pet trade in Brazil. Arrows connect obstacles to actions and/or recommendations and their respective effects. Lines that connect boxes indicate an intracategorical relationship

reptiles (except for endemic, rare, and threatened species) that exhibit a low risk of invasion (i.e., species whose life history traces and environmental tolerance indicate low establishment risks). There is evidence worldwide that the breeding of exotic reptiles as pets leads to new invasions, regardless of the level of control (Kraus, 2009; Martins, Assalim, & Molina, 2014). Although the use of native reptiles in the pet trade can also cause invasions in environments where the species does not naturally occur, the commercial breeding of low-invasive, widely distributed species and the adoption of more uniform regulations and criteria among Brazilian states can minimize the risk of future invasions. In terms of conservation, elucidating which factors influence consumer demand and choices (e.g., beauty, color, size, sex, and price) is essential for the selection of native reptiles for sale, also considering the conservation status of the species (Drury, 2009). The species available in the legal trade are expected to meet this demand; otherwise, the illegal trade will continue to attract consumers (see Drury, 2009). Certain measures must be applied to protect natural populations (see Figure 1). First, informing hobbyists of details about the biology, behavior, and nutritional requirements of the desired species that may discourage impulse acquisitions. Second, an annual quota that can be applied to commercial breeders, limiting the maximum number of individuals that can be sold according to the number of breeding stock available and the reproductive biology of each species. Periodic audits and the collection of blood and/or tissue samples to confirm the relationship between animals in breeding sites can also inhibit animal laundering. Additionally, specific marking systems for each animal group or species should be required. In this sense, photographic identification can be used in combination with other individual marking systems to prevent fraud. Photographic identification is a nonintrusive identification method based on distinct individual ornamentation or morphology patterns and can be used for most reptile species, regardless of size or age (see Sacchi et al., 2010; Sacchi, Scali, Mangiacotti, Sannolo, & Zuffi, 2016).

Increasing budgets, staff, agent qualification and, above all, local enforcement efforts are effective protective measures for species threatened by illegal pet trade (Jachmann, 2003, 2008). For example, in Zambia, South Africa, the increased budget and enforcement efforts have had a significant impact on the success of elephant conservation (Jachmann, 2003). In this context, an alternative to obtain financial resources would be to transfer at least 50% of the amount collected from environmental fines to inspection agencies and the rest to projects involving environmental education and nature conservation. Currently, 80% of this amount (about $567 million) is destined to the Federal Government and the remainder, to the financing of socioenvironmental projects (WWF Brasil, 2018). Other available resources will allow for the hiring and training of new federal and state agents, in order to intensify environmental enforcement actions in the country.

Most of the exotic reptiles found in Brazil have South American origins, which makes the inspection of more than 16,000 km of borders with 10 other South American countries a particular challenge (Fonseca et al., 2019). As narcotics and weapons routes often coincide with wild animal smuggling routes, joint actions between IBAMA and the Federal Police (a Brazilian police institution displaying a maritime, airport and border police function that aids in preventing drug trafficking) can reinforce enforcement at the federal level (Cook, Roberts, & Lowther, 2002). However, the combat against international animal trafficking cannot be the exclusive responsibility of the countries of origin or destination. Although CITES provides an international framework to regulate fauna and flora species trade, it is unable to combat illegal trade, and only ensures compliance with trade regulations established by member states (see Nowak, 2016). An agreement signed between Brazil and Peru aims, among other things, to implement a communication and training system to promote efficiency in the management, inspection and control of renewable natural resources (Decree 5855/2006). Similarly, Chile and Argentina have a treaty that aims to control the introduction and spread of invasive species across borders (Agustín, Lobos, & Jaksic, 2005). Other partnerships and agreements between the Brazilian government and neighboring countries should help in actions to combat trafficking and the introduction of exotic species. Additionally, it is essential that Brazil and other countries determine compliance with fauna and flora laws in force abroad in their legislation and make the importer responsible for illegal practices. In this sense, the United States has a reference law, the U.S. Lacey Act, which prohibits the possession and trade of imported species if these activities are illegal in the country of origin.

Recurrence and noncompliance with environmental laws in the country are associated with a certainty of impunity. In this sense, the material cumulation of environmental crimes typified in Law 9,605/1998 and the framing of the offender in Penal Code crimes, such as conspiracy, illegal possession of firearms and reception, should be considered, when appropriate, to ensure more severe sentences. However, it is imperative to evaluate alternatives to penalize the offender if the fine is not paid. One option would be to include the offender in the register of people with financial debts, making it difficult to obtain financial credit, for example. The control of the illegal wildlife trade on the internet must be enforced

(Figure 1). In order to do so, a solution would be the creation of terms of cooperation between public entities and online sales platforms, preventing the sale of native and exotic specimens (Cardozo, 2019). We also suggest a revision in favor of revoking regulations that allow the offender to guard animals seized in the face of the impossibility of immediate disposal. An alternative already provided by law, allows volunteers duly registered by the competent environmental agency and without environmental crime precedents to be allowed provisional custody of the apprehended specimen.

Different education and environmental awareness levels influence the way the individual perceives and interacts with the environment and society. In general, lower levels of education are associated with less confidence in political and government institutions, less knowledge on legislation and limited notions of sustainable development and environmental awareness (Chetwynd, Chetwynd, & Spector, 2003; Lima, 2007). However, in Brazil, the use of reptiles as a pet seems to be associated with high levels of education and income (Alves et al., 2019). One way to reduce long-term pressures is to invest in educational actions aimed at raising the population's awareness of wildlife trafficking and the risk of introducing exotic species (Figure 1). A low-cost, wide-ranging awareness-raising measure includes adding information on the illegal origin, history of invasion, and potential zoonosis contamination (e.g., Brown, 2004; Colomb Cotinat et al., 2014) to species identification plates displayed in breeding sites open to the public. Educational campaigns should be developed and implemented in conjunction with environmental agencies, NGOs, universities, zoos and museums, among others. Campaigns should warn about the dangers associated with releasing pets in natural environments, and discourage the acquisition of wild animals, mainly of illegal origin. Campaigns focused on disease risk and the legal consequences of acquiring pets of illegal origin appear to be more effective in reducing demand than those focused on ethical arguments, such as animal welfare and species extinction (Moorhouse, Balaskas, D'Cruze, & Macdonald, 2017). Involving children and the local community in citizen science activities and practical experiences can also increase knowledge on native wildlife and environmental awareness and, consequently, lead to greater incentives for wildlife protection (Awasthy, Popovic, & Linklater, 2012; Beery & Jørgensen, 2016). Finally, although studies on invasive species in the country have increased in recent decades, knowledge of the subject is still limited to a few researchers and the academic environment (Frehse, Braga, Nocera, & Vitule, 2016). Most reptile breeders in Brazil have higher education in biology and veterinary medicine, therefore, it is essential to intensify the discussion of the topic in environmental and animal health disciplines, in addition to developing public campaigns to disseminate information about biological invasions (Alves et al., 2019; Cardador, Tella, Anadón, Abellán, & Carrete, 2019).

4 | CONCLUSIONS

The wildlife trade must be understood as an issue involving conservation, bioinvasion, sustainability, economy, health and education, among other topics. Decisions based on a single theme can have negative consequences for humans, as is the case with pandemics triggered by contact with wild fauna, and also for wildlife, intensifying overexploitation, the illegal trade and invasion. Currently, the regulation of the pet reptile trade in Brazil is guided by poorly implemented policies, aggravated by budget cuts and weakening environmental laws. The legalization of the reptile pet trade represents the activation of a time bomb for the emergence of species invasions and extinctions in this obscure scenario. We herein propose a variety of measures based on the elimination of weaknesses and inconsistencies in the legislation, greater investment in inspection and education and greater engagement by communities, governments, public institutions, and society in sustainable wildlife management (Figure 1). Finally, we recommend greater engagement by the Brazilian scientific community to guide the formulation of public and environmental policies (e.g., population viability analyses, economic principles applied to the wildlife trade, the monitoring of illegal trade) and to develop innovative solutions that integrate local, national and international knowledge.

ACKNOWLEDGMENTS

E. F. is grateful to L. Borges, C. Brasileiro, T. Gomes, M. Bender, and M. Borges-Martins for suggestions on a former version of the manuscript, and M. Antônio de Freitas for reviewing and commenting on the final manuscript. We thank four anonymous reviewers for their helpful comments that improved earlier versions of this manuscript. Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) supported S. Z. C. and C. B. (processes No. 309095/2016-6 and 150621/2018-3, respectively). E. F. received scholarship provided by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Érica Fonseca: Conception. **Érica Fonseca** and **Caroline Zank**: Original draft writing. **Camila Both** and

Sonia Zanini Cechin: Oversight. All authors: Review and editing.

DATA AVAILABILITY STATEMENT

This article did not use primary data.

ETHICS STATEMENT

Institutional ethics review was not required.

ORCID

Érica Fonseca https://orcid.org/0000-0002-5432-8453
Camila Both https://orcid.org/0000-0002-4590-7242

REFERENCES

Agustín, I. J., Lobos, G. A., & Jaksic, F. M. (2005). Invasive vertebrate species in Chile and their control and monitoring by governmental agencies. *Revista Chilena de Historia Natural*, *78*(1), 143–154.

Alves, R. R. N., Araújo, B. M. C., Policapo, I. S., Pereira, H. M., Borges, A. K. M., Vieira, W. L. S., & Vasconcellos, A. (2019). Keeping reptiles as pets in Brazil: Ethnozoological and conservation aspects. *Journal for Nature Conservation*, *49*, 9–21. https://doi.org/10.1016/j.jnc.2019.02.002

Alves, R. R. N., Lima, J. R. F., & Araújo, H. F. (2013). The live bird trade in Brazil and its conservation implications: An overview. *Bird Conservation International*, *23*, 53–65.

Alves, R. R. N., Vieira, K. S., Santana, G. G., Vieira, W. L. S., Almeida, W. O., Souto, W. M. S., … Pezzuti, J. C. B. (2012). A review on human attitudes towards reptiles in Brazil. *Environmental Monitoring and Assessment*, *184*, 6877–6901.

Auliya, M., Altherr, S., Ariano-Sanchez, D., Baard, E. H., Brown, C., Brown, R. M., … Ziegler, T. (2016). Trade in live reptiles, its impact on wild populations, and the role of the European market. *Biological Conservation*, *204*, 103–119. https://doi.org/10.1016/j.biocon.2016.05.017

Awasthy, M., Popovic, A. Z., & Linklater, W. L. (2012). Experience in local urban wildlife research enhances a conservation education programme with school children. *Pacific Conservation Biology*, *18*, 41–46.

Baker, S. E., Cain, R., van Kesteren, F., Zommers, Z. A., D'Cruze, N., & Macdonald, D. W. (2013). Rough trade: Animal welfare in the global wildlife trade. *Bioscience*, *63*, 928–938.

Beery, T., & Jørgensen, K. A. (2016). Children in nature: Sensory engagement and the experience of biodiversity. *Environmental Education Research*, *24*, 13–25. https://doi.org/10.1080/13504622.2016.1250149

Borges, A. (2018). Ibama recebe fração mínima das multas aplicadas anualmente. Retrieved from https://politica.estadao.com.br/noticias/geral,ibama-recebe-fracao-minima-das-multas-aplicadas-anualmente,70002633610

Bourscheit, A. (2018). 300 grupos de Whatsapp estão ligados ao tráfico de animais em todo o país. Retrieved from https://theintercept.com/2018/10/10/grupos-whatsapp-trafico-de-animais/

Brown, C. (2004). Emerging zoonoses and pathogens of public significance—An overview. *Revue Scientifique et Technique, Office International Epizooties*, *23*, 435–442.

Bush, E. R., Baker, S. E., & Macdonald, D. W. (2014). Global trade in exotic pets 2006–2012. *Conservation Biology*, *28*, 663–676.

Cardador, L., Tella, J. L., Anadón, J. D., Abellán, P., & Carrete, M. (2019). The European trade ban on wild birds reduced invasion risks. *Conservation Letter*, *12*, e12631. https://doi.org/10.1111/conl.12631

Cardozo, C. (2019). MP-BA e OLX firmam acordo para combater venda de animais silvestres na internet. Retrieved from https://www.bahianoticias.com.br/justica/noticia/61297-mp-ba-e-olx-firmam-acordo-para-combater-venda-de-animais-silvestres-na-internet.html

Chetwynd, E., Chetwynd, F., & Spector, B. (2003). *Corruption and poverty: A review of recent literature* (pp. 1–22). Washington, DC: Management Systems International.

Chomel, B. B., Belotto, A., & Meslin, F. X. (2007). Wildlife, exotic pets, and emerging zoonoses. *Emerging Infectious Diseases*, *13*, 6–11.

Colomb Cotinat, M., Le Hello, S., Rosieres, X., Lailler, R., Weill, F. X., & Jourdan Da Silva, N. (2014). Salmonelloses chez des jeunes enfants et exposition aux reptiles domestiques: Investigation en France métropolitaine en 2012. *Bulletin Epidémiologique Hebdomadaire*, *2014*(1–2), 2–8.

Convention on Biological Diversity. (2011). COP-10 decision X/2. Strategic plan for biodiversity 2011–2020, CBD Secretariat. Retrieved from https://www.cbd.int/decision/cop/?id=12268

Cook, D., Roberts, M., & Lowther, J. (2002). The International Wildlife Trade and Organised Crime: a review of the evidence and the role of the UK. *Regional Research Institute, University of Wolverhampton*. Report, Godalming, WWF-UK.

Costa, H. C., & Bernils, R. S. (2018). Répteis do Brasil e suas Unidades Federativas: Lista de espécies. *Herpetologia Brasileira*, *8*, 11–57.

Dantas, D. (2019). Ibama corta 22% das ações de fiscalização previstas. Retrieved from https://oglobo.globo.com/sociedade/ibama-corta-22-das-acoes-de-fiscalizacao-previstas-23937584

Derevecki, R. (2017). Sem centro de triagem, PR não tem local público para abrigar animais silvestres. Retrieved from https://www.gazetadopovo.com.br/curitiba/sem-centro-de-triagem-pr-nao-tem-local-publico-para-abrigar-animais-silvestres-7g7jgk3z41cp9a9dtkb6sz12y/

Destro, G. F. G., Pimentel, P. L., Sabaini, R. M., Borges, R. C., & Barreto, R. (2012). Efforts to combat wild animals trafficking in Brazil. In G. A. Lameed (Ed.), *Biodiversity enrichment in a diverse world*. Brazil: InTech Brazil. https://doi.org/10.5772/48351.

Drury, R. (2009). Reducing urban demand for wild animals in Vietnam: Examining the potential of wildlife farming as a conservation tool. *Conservation Letters*, *2*, 263–270.

Essl, F., Dullinger, S., Rabitsch, W., Hulme, P. E., Hülber, K., Jarošík, V., … Pyšek, P. (2011). Socioeconomic legacy yields an invasion debt. *Proceedings of the National Academy of Sciences of the United States of America*, *108*, 203–207. https://doi.org/10.1073/pnas.1011728108

Fearnside, P. M. (2016). Brazilian politics threaten environmental policies. *Science*, *353*(6301), 746–748. https://doi.org/10.1126/science.aag0254

Fonseca, É., Both, C., & Cechin, S. Z. (2019). Introduction pathways and socio-economic variables drive the distribution of alien

amphibians and reptiles in a megadiverse country. *Diversity and Distribution*, *25*(7), 1–12. https://doi.org/10.1111/ddi.12920

Frehse, F. A., Braga, R. R., Nocera, G. A., & Vitule, J. R. S. (2016). Non-native species and invasion biology in a megadiverse country: Scientometric analysis and ecological interactions in Brazil. *Biological Invasions*, *18*, 3713–3725. https://doi.org/10.1007/s10530-016-1260-9

Fritts, T. H. (2002). Economic costs of electrical system instability and power outages caused by snakes on the Island of Guam. *International Biodeterioration & Biodegradation*, *49*, 93–100.

G1 SP. (2017). PF encontra cobras e lagartos em bagagem de passageiro no Aeroporto de Cumbica. Retrieved from https://g1.globo.com/sao-paulo/noticia/pf-encontra-cobras-e-lagartos-em-bagagem-de-passageiro-no-aeroporto-de-cumbica.ghtml

Hoogmoed, M. S., & Avila-Pires, T. C. S. (2015). *Lepidodactylus lugubris* (Duméril & Bibron 1836) (Reptilia: Gekkonidae), an introduced lizard new for Brazil, with remarks on and correction of its distribution in the New World. *Zootaxa*, *4000*(1), 90–110.

HSUS. (2001). *The trade in live reptiles: Imports to the United States*. Washington, DC: The Humane Society of the United States.

Hulme, P. E. (2015). Invasion pathways at a crossroad: Policy and research challenges for managing alien species introductions. *Journal of Applied Ecology*, *52*, 1418–1424.

IBAMA, Instituto Brasileiro de Meio Ambiente. (2019). Dados abertos. Retrieved from http://dadosabertos.ibama.gov.br

ICMBio, Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). (2018). *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção* (p. 4162). Brasília: ICMBio.

Jachmann, H. (2003). Elephant poaching and resource allocation for law enforcement. In S. Oldfield (Ed.), *The trade in wildlife: Regulation for conservation*. London: Earthscan.

Jachmann, H. (2008). Illegal wildlife use and protected area management in Ghana. *Biological Conservation*, *141*, 1906–1918. https://doi.org/10.1016/j.biocon.2008.05.009

Kikilius, K. H., Hare, K. M., & Hartley, S. (2012). Online trading tools as a method of estimating propagule pressure via the pet-release pathway. *Biological Invasions*, *14*(12), 2657–2664. https://doi.org/10.1007/s10530-012-0262-5

Kraus, F. (2009). *Alien reptiles and amphibians: A scientific compendium and analysis*. Springer Science & Business Media: Dordrecht, the Netherlands.

Kuhnen, V., & Kanaan, V. (2014). Wildlife trade in Brazil: A closer look at wild pets welfare issues. *Brazilian Journal of Biology*, *74*(1), 124–112. https://doi.org/10.1590/1519-6984.18912

La Laina, D. Z., Nekaris, K. A. I., Nijman, V., & Morcatty, T. Q. (2021). Illegal online pet trade in venomous snakes and the occurrence of snakebites in Brazil. *Toxicon*, *193*, 48–54.

Laikre, L., Schwartz, M. K., Waples, R. S., Ryman, N., & The GeM Working Group. (2010). Compromising genetic diversity in the wild: Unmonitored large-scale release of plants and animals. *Trends in Ecology and Evolution*, *25*(9), 520–529. https://doi.org/10.1016/j.tree.2010.06.013

Lavorgna, A. (2014). Wildlife trafficking in the internet age. *Crime Science*, *3*(5), 1–12.

Lavorgna, A. (2015). The social organization of pet trafficking in cyberspace. *European Journal on Criminal Policy and Research*, *21*(3), 353–370. https://doi.org/10.1007/s10610-015-9273-y

Lima, G. G. B. (2007). Conservação da fauna e da flora silvestres no Brasil: A questão do tráfico ilegal de plantas e animais silvestres e o desenvolvimento sustentável. *Revista Jurídica*, *9*(86), 134–150.

Lockwood, J. L., Welbourne, D. J., Romagosa, C. M., Cassey, P., Mandrak, N. E., Strecker, A., … Keller, R. (2019). When pets become pests: The role of the exotic pet trade in producing invasive vertebrate animals. *Frontiers in Ecology and the Environment*, *17*, 323–330. https://doi.org/10.1002/fee.2059N

Magalhães, A. L. B., & São-Pedro, V. A. (2012). Illegal trade on non-native amphibians and reptiles in southeast Brazil: The status of e- commerce. *Phyllomedusa*, *11*, 155–160. https://doi.org/10.11606/issn.2316-9079.v11i2p155-160

Martins, R. A., Assalim, A. M., & Molina, F. B. (2014). The presence of the Red-eared slider, *Trachemys scripta elegans* (Wied, 1838) (Testudines, Emydidae), an invasive species, in the Paraibuna river basin, Southeastern Brazil. *Herpetology Notes*, *7*, 437–441.

Moorhouse, T. P., Balaskas, M., D'Cruze, N. C., & Macdonald, D. W. (2017). Information could reduce consumer demand for exotic pets. *Conservation Letters*, *10*, 337–345.

Natusch, D. J., & Lyons, J. A. (2012). Exploited for pets: The harvest and trade of amphibians and reptiles from Indonesian New Guinea. *Biodiversity and Conservation*, *21*, 2899–2911.

Nowak, K. (2016). CITES alone cannot combat illegal wildlife trade. South African Institute of International Affairs. *Saiia Policy Insights*, *34*, 1–11.

Nuñez, M. A., & Pauchard, A. (2010). Biological invasions in developing and developed countries: Does one model fit all? *Biological Invasions*, *12*(4), 707–714. https://doi.org/10.1007/s10530-009-9517-1

Patoka, J., Magalhães, A. L. B., Kouba, A., Faulkes, Z., Jerikho, R., & Vitule, J. R. S. (2018). Invasive aquatic pets: Failed policies increase risks of harmful invasions. *Biodiversity and Conservation*, *27*, 3037–3046. https://doi.org/10.1007/s10531-018-1581-3

Prates, I., Hernandez, L., Samelo, R. R., & Carnaval, A. C. (2016). Molecular Identification and Geographic Origin of an Exotic Anole Lizard Introduced to Brazil, with Remarks on Its Natural History. *South American Journal of Herpetology*, *11*(3), 220–227. https://doi.org/10.2994/SAJH-D-16-00042.1

Regueira, R. F. S., & Bernard, E. (2012). Wildlife sinks: Quantifying the impact of illegal bird trade in street markets in Brazil. *Biological Conservation*, *149*(1), 16–22. https://doi.org/10.1016/j.biocon.2012.02.009

RENCTAS, Rede Nacional de Combate ao Tráfico de Animais Silvestres. (2001). *Primeiro Relatório Nacional sobre o Tráfico de Fauna Silvestre*. Brasília: Renctas.

Robinson, J. E., Griffiths, R. A., St. John, F. A. V., & Roberts, D. L. (2015). Dynamics of the global trade in live reptiles: Shifting trends in production and consequences for sustainability. *Biological and Conservation*, *184*, 42–50. https://doi.org/10.1016/j.biocon.2014.12.019

Sacchi, R., Scali, S., Mangiacotti, M., Sannolo, M., & Zuffi, M. A. L. (2016). Digital identification and analysis. In C. K. Dodd (Ed.), *Reptile ecology and conservation. A handbook of techniques*. Oxford: Oxford University Press.

Sacchi, R., Scali, S., Pellitteri-Rosa, D., Pupin, F., Gentilli, A., Tettamanti, S., … Fasola, M. (2010). Photographic identification in reptiles: A matter of scales. *Amphibia-Reptilia*, *31*, 489–502. https://doi.org/10.1163/017353710X521546

Scheffers, B. R., Oliveira, B. F., Lamb, I., & Edwards, D. P. (2019). Global wildlife trade across the tree of life. *Science*, *366*(6461), 71–76. https://doi.org/10.1126/science.aav5327

Siriwat, P., & Nijman, V. (2018). Illegal pet trade on social media as an emerging impediment to the conservation of Asian others species. *Journal of Asia-Pacific Biodiversity*, *11*(4), 469–475. https://doi.org/10.1016/j.japb.2018.09.004

Stringham, O. C., & Lockwood, J. L. (2018). Pet problems: Biological and economic factors that influence the release of alien reptiles and amphibians by pet owners. *Journal of Applied Ecology*, *55*(6), 1–9. https://doi.org/10.1111/1365-2664.13237

Tollefson, J. (2018). Tropical trump' victory in Brazil stuns scientists. *Nature*. https://doi.org/10.1038/d41586-018-07220-4

Travis, D. A., Watson, R. P., & Tauer, A. (2011). The spread of pathogens through trade in wildlife. *Revue scientifique et technique*, *30*, 219–239. https://doi.org/10.20506/rst.30.1.2035

Uetz, P, Freed, P., & Hošek, J. (2021). The reptile database. Retrieved from http://www.reptile-database.org

Van Uhm, D. P., & Moreto, W. D. (2017). Corruption within the illegal wildlife trade: A symbiotic and antithetical enterprise. *The British Journal of Criminology*, *58*(4), 864–885. https://doi.org/10.1093/bjc/azx032

Wilson-Wilde, L. (2010). Wildlife crime: A global problem. *Forensic Science, Medicine, and Pathology*, *6*(3), 221–222.

WWF-Brasil, World Wildlife Fund. For Nature Brasil. (2017). *Cortes no orçamento da união para 2018 atingem Unidades de Conservação e combate ao desmatamento* (p. 7). Brasília: WWF-Brasil – Políticas Públicas.

WWF-Brasil, World Wildlife Fund. For Nature Brasil. (2018). *Financiamento público em meio ambiente: Um balanço da década e perspectivas* (p. 12). Brasília: WWF-Brasil – Políticas Públicas.

Zanchetta, I. (2013). Coreanos são presos em Mato Grosso por biopirataria no Parque Indígena do Xingu. Retrieved from https://www.socioambiental.org/pt-br/noticias-socioambientais/coreanos-sao-presos-em-mato-grosso-por-biopirataria-no-parque-indigena-do-xingu

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Fonseca, É., Zank, C., Cechin, S. Z., & Both, C. (2021). Reptile pet trade in Brazil: A regulatory approach to sustainable biodiversity conservation. *Conservation Science and Practice*, e504. https://doi.org/10.1111/csp2.504