International Journal of Primatology (2024) 45:834–859
https://doi.org/10.1007/s10764-024-00419-5

An Ethical Matrix for the Reintroduction of Trafficked Primates: A Platyrrhine Case Study

Guillermina Hernández-Cruz[1] · Renata G. Ferreira[2] · Michael Mendl[1] · Nicola J. Rooney[1] · Siobhan Mullan[3]

Received: 11 December 2023 / Accepted: 26 January 2024 / Published online: 19 February 2024

Abstract

The illegal primate trade is one of the major drivers of the decline of nonhuman primate populations and a threat to their wellbeing. Thousands of trafficked primates enter rescue centers every year, and their destiny (release back into the wild, long-term captivity, or euthanasia) involves controversial decisions and complex ethical considerations. To navigate these issues, we developed an ethical matrix, an ethical framework previously used to address conservation-related issues. We gathered information from studies on the reintroduction of trafficked platyrrhines in Latin America from 1990 to 2022 to develop the matrix. We found 22 studies performed in eight Latin American countries, which included howler monkeys, spider monkeys, woolly monkeys, capuchin monkeys, squirrel monkeys, marmosets, and tamarins. We found that the reintroduction of trafficked platyrrhines may yield positive results for the welfare of individuals and for the conservation of their taxa and some of the potential negative effects, such as spillover of infectious agents to free-ranging populations or to human populations, or competition for resources between reintroduced monkeys and resident conspecifics have not yet been documented in the scientific literature, although this does not mean that they do not occur. We conclude that the ethical matrix is a useful method to consider the interests of all potential stakeholders and that the reintroduction of trafficked primates may be a viable management option if the individual welfare of the animals is considered, programs comply with the IUCN and government guidelines, and the objective and justification of the reintroduction are clear.

Keywords Ethical framework · Stakeholder · Neotropical primate · Rehabilitation · Refaunation

Handling Editor: Joanna (Jo) M. Setchell

Extended author information available on the last page of the article

Introduction

The illegal wildlife trade is one of the top five illegal international trades and one of the major threats to nonhuman primate (hereafter, primate) species (Ruíz-García & Shostell, 2016; Esmail *et al*., 2020; Estrada *et al*., 2020). Approximately 60% of primate species are currently under threat of extinction; approximately 75% have declining populations (Estrada *et al*., 2017). Between 2005 and 2014, approximately 450,000 live primates were legally traded (Estrada *et al*., 2017). Primates are traded for biomedical research, meat consumption, to zoos or private collections, and as pets (Nijman *et al*., 2011; Estrada *et al*., 2017). A much greater number of primates may be illegally trafficked within and between countries (Svensson *et al*., 2023), with an increasing number of wildlife reaching rescue centers worldwide (Goldenberg *et al*., 2022). For example, in Brazil, approximately 4,600 monkeys were received in government wildlife rescue centers between 1999 and 2006 (Levacov *et al*., 2011), with a constant increase in rescues over recent years (Ferreira *et al*., 2022). After animals are received by a rescue center, there are three options for management: (1) euthanasia, (2) long-term captivity, or (3) rehabilitation and release back into the wild. Euthanasia is rare, and many wildlife rescue centers cannot keep animals for long periods of time because of the constant influx of other wildlife. In some cases, animals end up in zoos or other captive settings; however, many animals are eventually released back into the wild (Palmer, 2020; Mitman *et al*., 2021).

Although releasing rescued primates back into the wild is sometimes considered a conservation strategy (Estrada *et al*., 2017, 2020), it can have positive and negative consequences for the individual animal, as well as the environment, resident wildlife species, and even for humans (Mitman *et al*., 2021). In this context, the term "reintroduction" often is used to refer to both "reintroduction" and "reinforcement," as defined in the International Union for the Conservation of Nature (IUCN) Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013; p. 3): "*reintroduction is the intentional movement and release of an organism inside its indigenous range from which it has disappeared*" and "*reinforcement is the intentional movement and release of an organism into an existing population of conspecifics.*" According to the IUCN, both are types of conservation translocations, in which living organisms are moved and released, intentionally, with the main goal of providing a conservation benefit, either for the animal or plant species that is being translocated, or for their ecosystem (IUCN/SSC, 2013). We use the term "reintroduction" as a generic term to refer to moving primates from captivity to the wild, for conservation or other reasons, in line with previous studies (Beck, 2018; Palmer, 2020), which also focused on the rehabilitation and reintroduction of trafficked primates (i.e., born in the wild and raised in captivity by humans) (Palmer, 2020).

The IUCN has proposed a set of guidelines for reintroduction. These include the Guidelines for the Management of Confiscated Live Organisms (Maddison, 2019) and the IUCN/SSC Re-Introduction Specialist Group: Guidelines for Nonhuman Primate Re-Introductions (Baker, 2002). These guidelines include

procedures that should be undertaken before attempting any nonhuman primate reintroduction, such as disease screening, and behavioral and genetic assessment (Baker, 2002; Maddison, 2019). Unfortunately, a review of studies from 1989 to 2012 showed that only a handful of primate rehabilitation and reintroduction projects around the world follow these guidelines (Guy *et al*., 2014).

Reintroduction of trafficked individuals raises complex ethical concerns. Palmer (2018, 2020) examined the reasons behind the ongoing rehabilitation and reintroduction programs of trafficked orangutans (*Pongo* spp.), despite the known low post-release survival of primate reintroduction projects and their arguably low value to conservation (Palmer, 2018, 2020). A recent comprehensive review identified welfare as the primary purpose for more than half (60%) of primate reintroductions and translocations (i.e., movement of free-ranging primates to other sites; Beck, 2018). Conversely, conservation was the primary purpose in only 12% of the 234 projects reviewed (Beck, 2018). There seems to be a major disconnect between this and the IUCN guidelines on reintroduction, which state that reintroductions should be performed for conservation benefits (Beck, 2018).

Although practitioners involved in primate rehabilitation and reintroduction may be aware of the low post-release survival rates in these programs, they will likely continue because reintroduction may be viewed as the only solution for trafficked primates and preferable to life in captivity or euthanasia and because of a perceived moral responsibility toward displaced individuals, as is the case in trafficked orangutans (Palmer, 2018, 2020). Euthanasia, for example, is illegal in Indonesia, one of the two countries where orangutans are found (the other being Malaysia), and if it was performed, it could lead to a severe social backlash in these and other countries (Usher, 2016 in Palmer, 2018, 2020). Moreover, rehabilitators and other practitioners involved in primate rehabilitation and reintroduction projects may disagree as to whether euthanasia of certain individuals, particularly healthy ones, is ethically justifiable (Palmer, 2020). Similarly, life in captivity may be seen as incarceration by those working in primate rehabilitation projects (Palmer, 2020). Overall, primate rehabilitators and other practitioners agree that, as humans, we are morally responsible for trafficked individuals whilst they are being rehabilitated but disagree as to whether we are still morally responsible for individuals once they have been released back into the wild and to what extent and when to intervene after release (Palmer, 2020).

When confronted with ethical issues and faced with scarcity of resources, as is the reality of many primate-range countries, practitioners working in primate rehabilitation and reintroduction projects often make decisions based on values, such as freedom, wellbeing, and wildness, but differ on how to prioritize them (Palmer, 2020). These values shape rehabilitation and reintroduction approaches and methods from when individuals are accepted into the rescue/rehabilitation center to when they are released back into the wild and beyond (Palmer, 2020). Finding solutions for the ethical dilemmas that arise at each step of the rehabilitation and reintroduction process is a complex task for primate conservationists and other practitioners (Palmer, 2020). Hence, a systematic analysis of the ethical issues on the rehabilitation and reintroduction of trafficked primates could be a valuable contribution to this area.

The Ethical Matrix is an analytical tool originally proposed by Mepham in 1994 (Mepham *et al*., 2006). Methodologically speaking, the Ethical Matrix seeks to develop the principles encompassed by common morality, which refers to the ethical code of a society. Thus, the aim of the Ethical Matrix is to use principles that represent two major ethical theory traditions: consequentialism and deontology. Overall, consequentialism focuses mainly on the outcomes or consequences of choices (Card & Smith, 2020). In other words, a choice is morally right based solely on its consequences (Sinnott-Armstrong, 2021). In this sense, a certain choice could be deemed as morally right under a consequentialist perspective as long as the outcome is beneficial, even if the way of achieving the said outcome is morally wrong. Conversely, deontology focuses on the way choices (or decisions) are made, that is if they are made following a moral rule or norm. Certain choices can be deemed as morally wrong even if the outcomes or consequences of these choices are beneficial; thus, only choices that conform to moral rules will be morally right (Larry & Moore, 2021). The three standard principles of the Ethical Matrix are *respect for wellbeing*, *autonomy,* and *fairness* (Mepham *et al*., 2006). These principles are also reflected in the principles of biomedical ethics developed by Beauchamp and Childress (2013). Both sets of authors discuss the grounds for choosing these principles. Broadly, the Ethical Matrix encompasses consequentialism and deontology in two of its three standard principles. The principle of *respect for wellbeing* represents utilitarianism, a consequentialist theory that seeks to "maximize the good" (i.e., obtaining the most beneficial outcome for the greatest number of individuals) (Mepham *et al*., 2006). The principle of *autonomy* represents deontological theories by following the moral rule of treating individuals as "ends" that are important in themselves and not purely as "means" to achieve the desired outcomes (Mepham *et al*., 2006). Finally, respect for justice (i.e., for all entities involved) reflects Rawls' Theory of Justice (Rawls, 1999) and is represented in the principle of *fairness* (Mepham *et al*., 2006).

In the Ethical Matrix, the principles *respect for wellbeing*, *autonomy*, and *fairness* are arranged in columns and the "groups of interest" (i.e., the groups that may be affected by the issue in question) are placed in rows. The weight placed on each of the cells depends on the value judgement of those conducting the analysis. The expected outcomes include raising awareness of ethical issues, providing a basis for ethical decision-making, and explaining the reasoning that led to specific ethical decisions (Mepham *et al*., 2006). The Ethical Matrix has been used to address various ethical issues, such as the use of biotechnology (Forsberg, 2004), genetically modified fish (Kaiser *et al*., 2007) and fisheries (Kaiser & Forsberg, 2001), quality and ethics in educational research (Tangen, 2014), and ethical analysis in veterinary science (Millar, 2012). More recently, a revised version of the Ethical Matrix has been published to address conservation-related issues (Biasetti & de Mori, 2021). The Ethical Matrix has several strengths (e.g., inclusion of a wide range of stakeholders, aiding transparency in decision-making and identifying areas of conflicting interests) and limitations (e.g., that it is not a decision tool in itself, that not everyone places the same weight on the ethical concerns and that it relies on evidence, which may be unavailable or of poor quality) when applied to animal-human interactions (Mullan & Fawcett, 2017).

Platyrrhines are commonly kept as pets in Latin American countries (Nunes *et al*., 2021). Platyrrhines inhabit Central and South America and include 204 taxa that occupy a wide range of tropical environments (Mittermeier *et al*., 2013; Püschel *et al*., 2017). Platyrrhine species accounted for approximately 4% of live primates traded between 2005 and 2014 (Estrada *et al*., 2017) and are frequently traded in Central and South America, including countries, such as Mexico, Peru, and Brazil (Duarte-Quiroga & Estrada, 2003; de Souza Fialho *et al*., 2016; Mitman *et al*., 2021; Nunes *et al*., 2021). As with other primate species, platyrrhines rescued or confiscated from the pet trade often are rehabilitated and released back into the wild, posing multiple challenges for their conservation and welfare as well as for public health (Mitman *et al*., 2021; Ferreira *et al*., 2022).

We investigated the ethical issues that may arise from the reintroduction of trafficked primates by using platyrrhines as a case study and the revised version of the Ethical Matrix (Mepham, 1996) for the ethical analysis of conservation-related issues (Biasetti & de Mori, 2021). To do this, we reviewed recent published and unpublished studies on the rehabilitation and reintroduction of trafficked platyrrhines performed between 1990 and 2022, identified the relevant stakeholders or "groups of interest", and identified their value demands, following the example of an Ethical Matrix tailored for conservation-related issues (Biasetti & de Mori, 2021). The Ethical Matrix refers to the reintroduction of trafficked platyrrhines only, not to the rehabilitation or captive component that may precede this.

Methods

The authors considered a range of ethical frameworks suitable for addressing this issue and concluded that the Ethical Matrix may be most appropriate. This reflects the ethical stance of the team in that they were not guided by a deontological requirement and considered respect for wellbeing, autonomy, and fairness to be relevant principles to try to adhere to.

Gathering information

In the context of building an Ethical Matrix for conservation, the stakeholders are potential ecological entities (e.g., ecosystems, taxa), individual animals or humans, and human communities that may be affected by the issue in question (Biasetti & de Mori, 2021). The use of the term "stakeholder" in this instance is deliberately broad to capture the effect on anything worthy of moral consideration and is not limited to elements that could have a conscious opinion on the ethical question. The *value demands* are the requirements that must be met to protect the ethical principles—respect for wellbeing, autonomy, and fairness—of the stakeholders (Biasetti & de Mori, 2021).

We gathered information relevant to this study by conducting a search of the available scientific literature on reintroductions of rescued and confiscated platyrrhines in Latin America performed between 1990 and 2022. To incorporate only the

most recent evidence thereby reflecting current or recent practices and literature, we had to derive an arbitrary cutoff; we considered the year 1990 to be suitable in providing both sufficient recency and weight of evidence.

We considered information related to the welfare of these animals in captivity (i.e., during rehabilitation and before being rescued or confiscated), the financial costs, and the views of human stakeholders involved. We conducted the literature search using Web of Science, Science Direct, Google Scholar and Google. We used the search terms primate* AND rehabilitation*, primate* AND reintroduction*, primate* AND translocation*, and primate* AND trafficked* in English, Spanish, and Portuguese. From this search, we included only studies of trafficked platyrrhines. We also reviewed the IUCN Guidelines for Nonhuman Primate Re-introductions (Baker, 2002), IUCN Reintroduction News: Special Primate Issue (Soorae & Baker, 2002), the IUCN Global Reintroduction Perspectives Series (Soorae, 2008; 2010, 2011, 2013, 2016), and the IUCN Global Conservation and Translocation Perspectives (Soorae, 2021). Finally, we reviewed the information available in the book, *Unwitting Travelers: A History of Primate Reintroduction* (Beck, 2018).

Identification of stakeholders

Following the recommendations published by Biasetti & de Mori (2021) for building ethical matrices related to conservation issues, we selected seven stakeholders based on their involvement in the ethical issue and suitability for assessment (Mepham *et al*., 2006) and belonging to the three categories proposed by Biasetti & de Mori (2021): (1) ecosystem, (2) animals, or (3) humans involved.

The first stakeholder category, the *ecosystem*, refers to all the living organisms in the release site or the area where the monkeys are released as part of the reintroduction project. This includes other animals, plants, and fungi, and the way they interact with each other (Cambridge Dictionary, 2021). The second stakeholder category, the *primate species of concern*, refers to the platyrrhine species that is part of the rehabilitation and reintroduction project (e.g., mantled howler monkey, *Alouatta palliata*). The third stakeholder category is the *individual rescued/reintroduced primates* that are part of the reintroduction project and will be released. The fourth stakeholder category is the *individual free-ranging primates living at the release site*, if any. The relevance of this stakeholder category depends on the specific characteristics of the rehabilitation and reintroduction project. Some projects could be performed in areas without free-ranging primates where this stakeholder category may not be necessary. However, if there are no free-ranging monkeys living at the release site, but the geographic area is known to be part of the natural area of occurrence of the species, then it is worth including this stakeholder category as unforeseen changes may occur in the future. Platyrrhines are represented in three different stakeholder categories: *primate species of concern*, *individual rescued/reintroduced primates* and *individual free-ranging primates living at the release site*. This is intentional to reflect the fact that in certain situations, particularly those related to conservation, the interests of individual animals may conflict with the interests of their species as a whole; thus, it is recommended to place them in multiple stakeholder categories (Biasetti & de Mori, 2021). Concern for the individuals reflects

an animal welfare or animal rights position, whereas conservation efforts are primarily concerned with populations and their ecosystems and tension between these two positions often is at the heart of conservation ethical challenges.

The fifth stakeholder category, the *local human communities living in or near the release site,* refers to human communities living at the release site or near to it. These could be small, such as rural communities with few residents, or larger communities, such towns and villages. Like the fourth stakeholder category, human communities may or may not be present at the release site, but their inclusion as a stakeholder category may be important if the likelihood of such communities establishing in the release area in the future is high. The sixth stakeholder category, the *staff involved in the rehabilitation and reintroduction project,* refers to all the people who work directly or indirectly with the rescued/confiscated primates that will be released. This could include veterinarians, biologists, academic researchers, wildlife rehabilitators, caregivers, undergraduate students, and all the staff of the rescue center and the people involved in the rescue or confiscation of the animals, such as environmental agency workers, police officers, and fundraisers. Finally, the seventh stakeholder category is the *local society*. This refers to human communities that may be directly interested in the rehabilitation and reintroduction project, such as people interested in animal welfare, wildlife conservation, or environmental education or local industries in the area that may be affected by decisions made regarding the rehabilitation and reintroduction project.

Results

In our literature search, we found 22 studies performed between 1990 and 2022 in eight Latin American primate-range countries (i.e., Colombia, Belize, Brazil, Argentina, Peru, Costa Rica, Panama, and French Guiana) and involving several native primate species (Table I). These included howler monkeys (*Alouatta* spp.), spider monkeys (*Ateles* spp.), woolly monkeys (*Lagothrix* sp.), capuchin monkeys (*Cebus* sp. and *Sapajus* sp.), squirrel monkeys (*Saimiri* sp.), marmosets (*Callithrix* sp.), and tamarins (*Saguinus* sp.). The studies included between one and 78 individuals, and most were conducted with wild-born monkeys that were rescued or confiscated from the illegal pet trade (91%, 20/22). Two studies included monkeys born in captivity along with the wild-born animals.

The Ethical Matrix highlighted in particular the evidence from the studies of the potential for both positive welfare benefits for individuals and conservation of the species but that these may require some particular actions to achieve. In addition, it was able to identify areas of interest for the humans involved or affected by reintroduction which should be considered (Table II).

Discussion

Our Ethical Matrix for the reintroduction of trafficked platyrrhines revealed several potential ethical issues and conflicts, mainly related to the wellbeing of the reintroduced monkeys, conservation of the primate species of concern and other primate

Table I Summary of reintroduction projects performed with trafficked platyrrhines between 1990 and 2022

Case study	Species	Sample size	Age categories	Rehabilitation duration	Post-release monitoring duration (months unless otherwise stated)	Health screening (findings)	Genetic testing	Post-release survival (%)
Pottie *et al*., 2021	Black-faced spider monkeys (*Ateles chamek*)	32	Not reported	Not reported	3–6	Yes (pathogens not reported)	Not reported	0–83
Cezimbra *et al*., 2021	Brown howler monkeys (*Alouatta guariba*)	6	Juveniles and adults	Only reported for some individuals – 5 months	12+	Yes (pathogens not reported)	No	100
Ramírez García, 2020	Woolly monkeys (*Lagothrix* sp.)	14	Juveniles and adults	2–5 months	7+	Yes (pathogens not reported)	Not reported	20–44
Tricone, 2018	Black howler monkeys (*Alouatta pigra*)	20	Juveniles and adults	Not reported	3	Yes (pathogens not reported)	Not reported	70
International Animal Rescue, 2018 in Beck, 2018	Mantled howler monkeys (*Alouatta palliata*)	5	Not reported	Not reported	None	Yes (pathogens not reported)	Not reported	Not reported
Neves *et al*., 2017 in Beck, 2018	Brown howler monkeys (*Alouatta guariba*)	2	Adults	Not reported	Not reported	Not reported	Not reported	Not reported
Beaver, 2017 in Beck, 2018	Brown woolly monkeys (*Lagothrix lagothrica*)	5	Adults	Not reported	Not reported	Not reported	Not reported	Not reported

Table I (continued)

Case study	Species	Sample size	Age categories	Rehabilitation duration	Post-release monitoring duration (months unless otherwise stated)	Health screening (findings)	Genetic testing	Post-release survival (%)
Sita, 2016	Robust capuchin monkeys (*Sapajus* spp.)	78	Juveniles and adults	8.5 months	6	Yes (tuberculosis i.e., TB, hepatitis B, toxoplasmosis, intestinal parasites, arbovirus)	No (only visual identification of species)	35
Escobar, 2016 in Beck, 2018	Brown howler monkeys (*Alouatta guariba*)	4	Adults	9 months	Not reported	Not reported	Not reported	Not reported
Arango Guerra *et al.*, 2013	Cotton-top tamarins (*Saguinus oedipus*)	5	Juveniles and adults	18 weeks	1	Not reported	Not reported	Not reported
Bennett *et al.*, 2013	Brown woolly monkeys (*Lagothrix lagothrica*)	11	Juveniles and adults	Not reported	6	Not reported	Not reported	Not reported
de Palomino, 2013	Peruvian spider monkeys (*Ateles chamek*)	9	Juveniles and adults	6 years	12	Yes (pathogens not reported)	Not reported	100
Brockett, 2008 in Beck, 2018	Spider monkeys (*Ateles* spp.)	3	Not reported	Not reported	25 days	Yes (pathogens not reported)	Not reported	66

Table I (continued)

Case study	Species	Sample size	Age categories	Rehabilitation duration	Post-release monitoring duration (months unless otherwise stated)	Health screening (findings)	Genetic testing	Post-release survival (%)
Brockett, 2008 in Beck, 2018	Black howler monkeys (*Alouatta pigra*)	28	Not reported	Not reported	12+	Yes (pathogens not reported)	Not reported	82
Milton & Hopkins, 2006 in Beck, 2018	Geoffroy's spider monkey (*Ateles geoffroyi*)	5	Not reported	Not reported	One month or less	Not reported	Not reported	0
Bruno *et al*., 2005	Black-and-gold howler monkeys (*Alouatta caraya*)	34	Juveniles and adults	Not applicable (long-term semicaptivity)	Not applicable	Not reported	Not reported	Not applicable
Centro de Primatología Araguatos, 2004	White-fronted capuchin monkeys (*Cebus albifrons*)	17	Juveniles and adults	12 weeks	3.5	Yes (TB, hepatitis B, toxoplasmosis, intestinal parasites)	Yes	Not reported
Vogel *et al*., 2002	Common squirrel monkeys (*Saimiri sciureus*)	14	Adults	7 months	15 weeks	Not reported	Not reported	Not reported
Suárez *et al*., 2001	Brown capuchin monkeys (*Sapajus apella*)	9	Adults	5 months	6.5	Yes (TB, toxoplasmosis, intestinal parasites)	Not reported	Not reported

Table I (continued)

Case study	Species	Sample size	Age categories	Rehabilitation duration	Post-release monitoring duration (months unless otherwise stated)	Health screening (findings)	Genetic testing	Post-release survival (%)
Brockett & Clark, 2000	Black howler monkeys (*Alouatta pigra*)	2	Juveniles	15 months	Not reported	Yes (TB, intestinal parasites)	Not reported	Not reported
Vié *et al*., 1997 in Beck, 2018	Black red-faced spider monkey (*Ateles paniscus*)	1	Juvenile	Not reported	Not reported	Not reported	Not reported	Not reported
Passamani & Passamani, 1994 in Beck, 2018	Geoffroy's marmoset (*Callithrix geoffroyi*)	23	Not reported	Not reported	16 weeks	Yes (pathogens not reported)	Not reported	43–74

Table II Ethical matrix for the reintroduction of trafficked platyrrhines

	a) Wellbeing	b) Autonomy	c) Fairness
A. Ecosystem	*Conservation of the ecosystem*: Biodiversity and the ecosystem where the monkeys will be released must be conserved (i.e., not impacted negatively by the release of the rescued individuals). Hence, appropriate measures should be taken to minimize risks for the conservation of all species living in the ecosystem.	*Freedom from human intervention*: The reintroduction of rehabilitated monkeys should not compromise the species living in the release site, e.g., they should not compete for resources (i.e., overexploit resources) or introduce pathogens to naïve environments.	*Respect for the worth of every species*: There should be respect for the existence and value of all species living in the ecosystem where the rehabilitated monkeys will be reintroduced, i.e., no hierarchy of species irrespective of the human lens of interest such as aesthetics, genetic proximity or usefulness to humans.
B. Platyrrhine species of concern	*Conservation of the species:* Health and genetic risks posed by released individuals could be associated with decreased long-term survival and/or damage to the viability of the species. This could also be the case if there was an increase in competition for food or other resources. There also could be a benefit for the species if population numbers were decreasing and rescued individuals were to be reintroduced to boost population numbers. In any case, genetic testing would give insight about the impact on the conservation of the species as a whole.	*Free from human intervention:* Conservation efforts as well as rehabilitation and reintroduction projects should not compromise primate populations in terms of long-term survival and viability. This could occur if pathogens were introduced to naïve populations or if there was overexploitation of resources at the release site, particularly in species with small populations or which are critically endangered.	*Respect for the worth of the species:* There should be respect for the existence and value of the species. Many platyrrhine species are considered umbrella species and have important ecosystem functions.

Table II (continued)

	a) Wellbeing	b) Autonomy	c) Fairness
C. Reintroduced individual monkeys	*Health and physical and psychological welfare:* These are heavily dependent on the release method and the level of post-release monitoring and provisioning. Reintroduction may lead to long-term survival and a good quality of life, or it may lead to a poor quality of life and even death. A thorough assessment of the risks and benefits of the reintroduction project for the wellbeing of the trafficked individuals should be conducted before their release and data gathered about outcomes to inform future evaluations. This should be weighed up against the wellbeing of the animals if they were to remain in captivity.	*Living natural lives and exercising species-specific behaviors:* The reintroduced monkeys should be able to express their complete, natural behavioral repertoire. Some animals, however, may not be able to do this. This could be the case of individuals who have been severely affected by previous trauma. Permanent captivity should be considered for these individuals.	*Respect for the worth of every individual:* Living in similar or better conditions than those of conspecifics in exemplary captive conditions. All individuals should be valued equally regardless of their background (e.g., free-ranging, captive-raised) and treated fairly with respect to options for release.
D. Free-ranging individual monkeys living at the release site	*Health and physical and psychological welfare:* Health and welfare risks for free-ranging monkeys living at the release site could include infectious diseases and competition for food, territory, or other resources. Potential positive outcomes could include increasing genetic diversity, diminishing inbreeding vortices, (positive) social interactions, including reproduction, and protection from predators via increase in group size.	*Living natural lives and exercising species-specific behaviors:* This may depend on the size and resources available at the release site. Once the rescued individuals are released, if the population is too large for the ecosystem to sustain, the free-ranging individuals could be prevented from leading natural lives or exercising species-specific behaviors. Sites in the historical range of species but currently defaunated or with small group sizes should be favored.	*Respect for the worth of every individual: Valuing the existing individuals equally to the reintroduced monkeys.* Not living in worse conditions after the rescued monkeys are released (i.e., conditions should be the same or better for the free-ranging monkeys after the rescued individuals are released).

Table II (continued)

	a) Wellbeing	b) Autonomy	c) Fairness
E. Local human communities living in or close to the release site	*Health and physical, psychological, economic and social welfare:* The release of rescued monkeys into the area should not pose a health or safety risk for local human communities, such as an increased risk of infection with zoonotic pathogens, injuries from aggression of released monkeys, or crop-feeding behaviors. Moreover, it could also offer wellbeing opportunities, such as ecotourism and pride in the environment.	*Freedom of choice:* The local human communities should be informed and consulted about the reintroduction project. Ideally, they should be actively involved in the design of the project and approve it before releasing the monkeys into the area.	*Fair treatment:* Right to be involved, informed, considered and consulted regarding the reintroduction project. Right to have an economic benefit from the reintroduction project, if possible (e.g., ecotourism).
F. People involved in the rehabilitation and reintroduction project	*Health and physical and psychological welfare*: Assessment of health and safety risks (e.g., injuries and zoonotic pathogens) and prevention of psychological discomfort and/or stress. Offer of wellbeing opportunities, such as financial, educational, pride in involvement in a project that promotes environmental education and/or conservation.	*Self-determination:* Having access to proper practical training (e.g., handling monkeys) and being stimulated/ allowed to express their own concerns and interests.	*Fair treatment*: Working under clear instructions and in a safe environment and benefit from the research, if any is being carried out and according to their participation (e.g., authorship in scientific publications or conferences). Staff involved, such as veterinarians, biologists, psychologists and caregivers should have the freedom to act according to the codes of conduct of their profession or institution.
G. Local society	*Psychological welfare*: Prevention of psychological discomfort and/or stress and promotion of wellbeing opportunities such as involvement in ecotourism, environmental education, etc.	*Freedom of choice*: The local society should be informed about the reintroduction project. Ideally, an environmental education program would be in place to involve the local society and, if possible, receive their support.	*Fair treatment:* Right to be informed and have the opportunity to vote and give their opinions regarding the reintroduction project if possible and if not, at least for a democratic government with policies related to this aspect.

or wildlife species, conflicts between the reintroduced individuals and resident free-ranging monkeys of the same or other species, and conflicts between the reintroduced monkeys and human communities living closely or at the release site. Nonetheless, we found that primate reintroductions also might yield benefits, not only for the released monkeys, but for the conservation of their species and biodiversity and for local human communities.

In our discussion, we explore these potential ethical issues and benefits and perform a deeper situation analysis considering certain aspects of the 22 studies reviewed and other relevant studies. This analysis focused on conservation, individual animal wellbeing, and local human communities, thus reflecting the identified stakeholders.

Biodiversity conservation

Platyrrhines, as well as other nonhuman primates, play an important ecological role in tropical forests, acting as seed dispersers over long distances (Link & Di Fiore, 2006; Bufalo *et al*., 2016). However, little is known about the ecological benefits of reintroducing primates back into the wild. A recent study found that the reintroduction of howler monkeys (*Alouatta guariba*) and black capuchin monkeys (*Sapajus nigritus*) has contributed to the restoration of vital ecological processes in a fragmented area of the Atlantic Forest in Brazil (Landim *et al*., 2022). Moreover, it has been argued that the reintroduction of certain primate species, such as orangutans, may aid in the conservation of tropical forests by promoting the acquisition of funding and attracting public attention (Palmer, 2020). More research is needed to fully understand the benefits of the reintroduction of trafficked primates for the conservation of biodiversity in different areas.

Species conservation

Practices designed to benefit the conservation of the species of interest may harm individuals from the same species (Biasetti & de Mori 2021); thus, individual monkeys and their species as a whole stand as separate stakeholders in our Ethical Matrix. Moreover, individual monkeys may come from two sources: rescued and confiscated monkeys that are part of the reintroduction project, and free-ranging monkeys that already live in the release area. Nine of 22 studies (41%) that we reviewed reported releasing monkeys in areas with free-ranging conspecifics (Brockett & Clark, 2000; Vogel *et al*., 2002; Milton & Hopkins, 2006 in Beck, 2018; Brockett, 2008 in Beck, 2018; de Palomino, 2013; Beaver, 2017 in Beck, 2018; Tricone, 2018; Pottie *et al*., 2021). In those cases, there could be potential for conflicts to arise between the stakeholders: *(B) platyrrhine species of concern, (C) reintroduced individual monkeys,* and *(D) free-ranging individual monkeys living at the release site*. These potential conflicts mainly include those associated with a risk of harming the long-term viability of the species such as the accidental introduction of pathogens or individuals of a different species or subspecies. Nonetheless, almost 60% (13/22) of platyrrhine reintroduction studies that we reviewed reported

performing health screening. Specific tests included those for tuberculosis, hepatitis B, toxoplasmosis, intestinal parasites, and arboviruses (Brockett & Clark, 2000; Suárez *et al*., 2001; Centro de Primatología Araguatos, 2004; Sita, 2016; Tricone, 2018, Cezimbra *et al*., 2021). We have not found evidence of spillover of infectious agents from trafficked platyrrhines to free-ranging populations. More research is needed to understand the risks of introducing pathogens to naïve populations from trafficked primates and how to avoid it.

The reintroduction of trafficked individuals from non-native primate species could lead to hybridization and threaten the conservation of other primate species native to the release site. An example of hybridization related to the illegal pet trade is the case of marmosets (*Callithrix* sp.) in Brazil (Beck, 2018; Malukiewicz, 2019). Some marmosets are native to the Atlantic rainforest in southeastern Brazil, such as the buffy-tufted-ear marmoset (*Callithrix aurita*) and the buffy-headed marmoset (*Callithrix flaviceps*). Other marmoset species, namely black-tufted marmosets (*Callithrix penicillata*) and common marmosets (*Callithrix jacchus*) are native to the northeast of Brazil and are frequently traded illegally. Hybridization has resulted after escape during transport and abandonment of trafficked individuals (i.e., individuals kept as pets and abandoned by their "owners" in local areas) from these northeastern species in southeastern Brazil and subsequent mixing with *Callithrix* species native to this area or between nonnative *Callithrix* species (Beck, 2018; Malukiewicz, 2019). This has led to the establishment of hybrid populations who are phenotypically and genetically different from their parental species (Malukiewicz, 2019). Uncontrolled escapes of individuals because of trafficking are likely but hard to locate, making it difficult to measure the impacts on local populations. The effects of hybridization are not clear, and it can lead to positive or negative consequences for reproduction and survival (Palmer, 2020; Palmer *et al*., 2021). Marmoset hybrids, potentially, could have increased fitness because of genetic adaptation and novelty, but hybridization also could lead to further endangerment of already threatened marmoset species if hybrid offspring are less viable or fit than their parental species (Malukiewicz, 2019).

Genetic testing could be used to mitigate the risk of hybridization after the release of rehabilitated individuals, as recommended by IUCN (Baker, 2002). Nonetheless, it does not seem to be frequently performed, at least for platyrrhine reintroduction projects. This may be related to its high cost as well as its difficulty or the potential conflicts that may arise from the results obtained (e.g., being unable to separate animals from different subspecies), as is the case of other primate species (Palmer, 2020). Only one of the 22 studies that we reviewed reported using genetic testing (Centro de Primatología Araguatos, 2004). Furthermore, a recent study on primate reintroduction reported that only four of 17 howler monkeys originated from the same genetic cluster to which they were reintroduced (i.e., to their native populations) (Oklander *et al*., 2020). Introducing animals from different genetic clusters may lead to the introduction of nonlocal genetic variability, because these individuals are not native to those primate populations (Oklander *et al*., 2020). This may result in an artificial mixture of different evolutionary lineages and homogenization of diversity and biogeographic patterns, which could negatively affect the long-term viability of the species (Oklander *et al*., 2020). However, isolated populations also

may face inbreeding, and introducing new individuals could help to counteract this (Groombridge *et al*., 2012, Palmer *et al*., 2021). Examples of this form of species management include the recovery of the Mauritius kestrel (*Falco punctatus*) and the Seychelles warbler (*Acrocephalus sechellensis*) (Nicoll *et al*., 2004; Richardson *et al*., 2006; Groombridge *et al*., 2012). Thus, it is important to investigate the potential effects of hybridization, where it might occur, in species already heavily affected by anthropogenic pressures and influences, as is the case of many primate species (Estrada *et al*., 2017; Palmer *et al*., 2021). Ideally, the potential of hybridization and its effects on species conservation will be considered on a case-by-case basis (Palmer *et al*., 2021). Furthermore, more research is needed on the effects of the reintroduction of trafficked platyrrhines on the genetic variability of their species as well as the potential for hybridization and its consequences.

Despite their potential for ethical conflicts, platyrrhine reintroduction projects also may yield positive conservation-related results when performed following strict scientific guidelines. A notable example of this is the golden lion tamarin (*Leontopithecus rosalia*) Conservation Program (Kierulff *et al*., 2012). This program, in which approximately 30 international zoological institutions collaborated, started in the 1980s and designed to protect this species by reintroducing captive-born monkeys and translocating free-ranging monkeys in severely fragmented areas (Kierulff *et al*., 2012). Considering post-release survival and reproduction, overall, this program is a good example of how primate reintroduction programs can boost free-ranging populations and ultimately help the conservation of primate taxa (Kierulff *et al*., 2012). The golden lion tamarin conservation program started with captive-born individuals and successfully established free-ranging populations. However, approximately 96% of primates that were released as part of reintroduction and translocation projects were wild-born (Beck, 2018). The percentage for trafficked primates might be lower, as the review considered the movement of free-ranging primates to other sites (i.e., "translocation") as well as the reintroduction of trafficked primates (Beck, 2018).

In some primate reintroductions, wild-born individuals reproduced more quickly and had higher survival rates than captive-born individuals (Shanee, 2007; Beck, 2018). This could be because wild-born individuals have been ontogenetically isolated but not evolutionarily isolated (Griffin *et al*., 2000). Ontogenetic isolation refers to isolation from predators only during the individual's early development. Evolutionary isolation refers to isolation from predators for several generations, which is the case of individuals who have been bred in captivity for one or more generations (Griffin *et al*., 2000). Thus, we argue that there is the potential for reintroductions of wild-born, captive-raised primates to be as successful as reintroductions of captive-born primates (e.g., golden lion tamarins), provided that enough resources and funding are allocated to these programs (Estrada *et al*., 2017, 2020).

Wellbeing of reintroduced and resident individual monkeys living at the release site

In addition to the potential of introducing pathogens, there could be other instances in which the wellbeing of the stakeholder categories *(C) reintroduced individual monkeys* and *(D) free-ranging individual monkeys living at the release site* could

be in conflict. These could include competition or fights for resources, such as food or access to females. Agonistic behaviors, including fights, are rarely observed in wild, free-ranging platyrrhine groups, and approximately 80% of social interactions in free-ranging platyrrhines are affiliative (Sussman *et al*., 2005).

Six reviewed studies (6/22 or 27%) reported positive or neutral social interactions between free-ranging and (trafficked) reintroduced platyrrhines, such as female dispersal (Brockett & Clark, 2000; Vogel *et al*., 2002; Brockett, 2008 in Beck, 2018; de Palomino, 2013; Tricone, 2018; Pottie *et al*., 2021). Aggressive encounters were reported in two studies (2/22 or 9%) (Brockett, 2008 in Beck, 2018; Pottie *et al*., 2021). Both studies were of spider monkeys (*Ateles* spp.), and in both cases, the reintroduced individuals were returned to captivity after the incidents. Severe intra- and intergroup aggression leading to injuries and death has been reported in both wild and captive spider monkeys, with resident males often being aggressive towards new males (Valero *et al*., 2006; Campbell, 2006; Aureli *et al*., 2006; Pottie *et al*., 2021; Davis *et al*., 2009). One of the studies in which aggressive encounters were reported also reported positive encounters (Pottie *et al*., 2021). Furthermore, spider monkeys were more likely to establish successfully in their release areas if there were resident conspecifics living in these areas, with several fusion events being observed between resident and released individuals, particularly during foraging sessions (Pottie *et al*., 2021). Thus, we argue that the likelihood of conflicts between resident and reintroduced platyrrhines, beyond what is normally observed in the species of concern, is low, provided the ecological capacity of the habitat has been assessed and can support the reintroduced and resident primate populations.

Although primate reintroductions are frequently performed with the goal of improving primate welfare (Guy *et al*., 2014; Beck, 2018), it often is unclear *how* these projects assess the wellbeing of the reintroduced individuals after release. Wildlife reintroduction projects which perform post-release monitoring frequently consider projects "successful" if the reintroduced individuals survive for a certain amount of time after release (e.g., de Azevedo & Young, 2021). However, equating reintroduction success with post-release survival does not take into account the wellbeing of the animals while they are being rehabilitated and after they are reintroduced. Deciding whether a primate reintroduction has been successful or not depends on the definition of success used (Beck, 2018). Encouragingly, 43% of 234 primate reintroduction and translocation projects were successful when considering "success" more broadly (Beck, 2018). In this sense, for a project to be deemed as successful, it needs to comply with all of the following requirements: (1) some releasees should survive for at least one year after release; (2) there should be some evidence of post-release reproduction or integration with free-ranging conspecifics; and (3) released individuals should be able to survive without human support and/or provisioning (Beck, 2018). Other indicators proposed to measure the success of primate reintroduction projects include similar survival rates between released and free-ranging conspecifics, establishment of a first wild-born generation, and contribution to regional conservation (Shanee, 2007).

If the final goal of a primate reintroduction project is to release animals back to the wild to improve their welfare, it makes sense to consider further indicators in addition to post-release survival (Shanee, 2007; Beck, 2018). Behavioral and

physiological indicators, such as the exhibition of stress-related behaviors and fecal glucocorticoids, which have been used to assess welfare in rehabilitant primates (Cheyne, 2006; Ferreira *et al*., 2018), also could be used after release. A study of trafficked woolly monkeys in Colombia found that the cortisol levels of rescued or confiscated individuals decreased during rehabilitation in enriched environments and increased after release compared with levels in captivity (Ramírez García, 2020). Body condition, fruit production at the release site, post-release activity patterns, and environmental enrichment during rehabilitation were identified as factors that could be potentially associated with post-release survival (Ramírez García, 2020). Another study identified the intensity (i.e., hours) of post-release monitoring as a positive factor in achieving success (Pottie *et al*., 2021). Nonetheless, performing post-release monitoring and using behavioral, health, and physiological indicators, even if they are noninvasive, may be difficult given the constraints or tracking animals, obtaining biological samples, and ensuring sufficient funding (Palmer, 2020). Furthermore, not all primate rehabilitation practitioners agree on when our moral responsibility towards released individuals ends, which makes it difficult to decide when, or even whether, to intervene (Palmer, 2020).

Local human communities living in or close to the release area

Close contact between nonhuman primates and humans may lead to the transmission of zoonotic pathogens, and the potential for occurrence of this type of events is growing as the human-primate interface grows (Lappan *et al*., 2020). Platyrrhines can carry zoonotic pathogens, such as *Leptospira* spp. (Aliaga-Samanez *et al*., 2022), *Mycobacterium tuberculosis* (Mitman *et al*., 2021), *Trypanosoma cruzi* (Mitman *et al*., 2021), hepatitis B virus (Mitman *et al*., 2021), simian foamy viruses (Muniz *et al*., 2017; Santos *et al*., 2019), and several intestinal parasites (e.g., *Ancylostoma* spp., Hernández-Cruz *et al*., 2022). Moreover, other pathogens carried by primates have the potential to produce spillovers or infection in human populations, such as *Plasmodium malariae* (Figueiredo *et al*., 2017; Sousa, 2018), Zika virus (Han *et al*., 2019), and coronaviruses, potentially including SARS-CoV-2 (Guimarães *et al*., 2020). Four of the reviewed studies (4/22 or 18%) reported performing specific health tests for zoonotic pathogens, including tuberculosis, hepatitis B, toxoplasmosis, several intestinal parasites, and arboviruses (Brockett & Clark, 2000; Suárez *et al*., 2001; Centro de Primatología Araguatos, 2004; Sita, 2016). Hence, there seems to be some awareness that reintroducing primates *must* include testing for the relevant infectious agents to protect public health. This is encouraging, considering that these tests are expensive and not easily performed in Latin American countries, mainly because of lack of funding and resources (Estrada *et al*., 2020).

Another situation in which the wellbeing of local human communities and reintroduced monkeys could be in conflict is if reintroduced individuals pose a safety risk for the local human communities. Four of the reviewed studies (4/22 or 18%) reported that the reintroduced monkeys kept trying to interact with humans at the release sites or kept returning to the rescue center (Centro de Primatología Araguatos, 2004; Beaver, 2017 in Beck, 2018; Cezimbra *et al*., 2021; Pottie *et al*., 2021). Similarly, another study reported aggression toward unfamiliar humans (Suárez

et al., 2001). These situations could be prevented by performing long-term post-release monitoring and provisioning (e.g., 12 months as proposed by Baker, 2002) in which the injured, isolated, or ill individuals are removed and taken back to captivity where possible and by involving the relevant members of the human communities in the planning and execution of the reintroduction project. In two of the studies, howler and spider monkeys who kept trying to interact with humans in their release area were subsequently recaptured and brought into captivity (Cezimbra *et al*., 2021; Pottie *et al*., 2021). More studies are needed to understand the advantages of performing long-term post-release monitoring or provisioning in primate reintroduction projects to prevent undesired human-wildlife interactions and to test the overall effectivity of these practices in improving post-release survival.

Platyrrhine reintroduction projects could lead to both positive and negative economic consequences for human communities. Centro de Primatología Araguatos (2004), for example, reported that the reintroduced monkeys used agricultural and forest areas during the first few weeks after release. This could lead to economic loses for the human communities if the released monkeys engage in behaviors, such as crop-feeding (Hockings, 2016). This behavior could be prevented by avoiding release sites close to agricultural areas or using "buffer zones" between forests and agricultural areas (Hockings, 2016). If crop-feeding did occur, it could be reduced by performing post-release monitoring and food provisioning, or by removing the individuals involved. Other potential solutions could include using deterrents, such as physical barriers, warning systems, and repellents, which have been used effectively to reduce crop-feeding in some primate species (Hill & Wallace, 2012). Monetary compensation could be used as well but often is only a short-term solution, because it does not address the root of the problem (Hockings, 2016). Overall, more research is needed to find humane solutions for crop-feeding and evaluate their effect on primate reintroduction projects.

In reintroduction projects where local human communities are involved, this could lead to economic benefits for them, such as revenue from ecotourism, as reported in a study of free-ranging bald uakaris (*Cacajao calvus calvus*) (Lebrão *et al*., 2021). One study reported economic benefits for the local community, although it did not explain how this was achieved (Bennett *et al*., 2013). Involving local communities in primate reintroduction projects also could add the benefit of protecting the reintroduced monkeys. For example, one study reported that 100% of the monkeys were still alive after 12 months of being released, in a project in which the local human community was involved (De Palomino, 2013). Ecotourism may be useful in supporting primate conservation but requires careful consideration of the costs and benefits for their populations and habitats (McKinney, 2016).

We built our Ethical Matrix by using scientific evidence obtained from 22 studies related to the reintroduction of trafficked platyrrhines. We did not consider the reintroduction or translocation of captive-born platyrrhines although we considered other platyrrhine reintroduction projects in our analysis and discussion (Kierulff *et al*., 2012). We may have overlooked both potential beneficial and negative outcomes of the rehabilitation and reintroduction of trafficked platyrrhines simply, because this information has not been published. Further research is needed to fully understand the outcomes of trafficked primate rehabilitation and reintroduction projects.

The Ethical Matrix is a straightforward tool that can be applied to the reintroduction of trafficked primates. Despite the relatively small body of literature to help understand the impact on stakeholders, in the case of platyrrhines, we found that it was sufficient to conclude that the rehabilitation and reintroduction of trafficked primates may be a viable option to manage animals as long as there is awareness and a thorough discussion and consideration of the following aspects before release back into the wild:

a) *Is the reintroduction project's decision-making team aware of current guidelines?* The decision-making team involved in the reintroduction project should have knowledge of the relevant guidelines, particularly those from the IUCN and the local, regional, and/or national government regulations. These include the Guidelines for the Management of Confiscated Live Organisms (Maddison, 2019) and the IUCN/SSC Re-Introduction Specialist Group: Guidelines for Nonhuman Primate Re-Introductions (Baker, 2002). Consideration of the likelihood of compliance with these regulations should occur where possible.
b) *Is the reintroduction ethically justified?* The objectives of and justification for the reintroduction project should be clear. Reintroduction projects can have various objectives, including enhancing animal welfare, raising awareness of primate conservation issues, or reestablishing free-ranging populations. However, this must be clear before attempting to reintroduce the animals back to the wild.
c) *Have all the relevant stakeholders been considered as well as their value demands?* A thorough analysis of all the potential stakeholders, including individual animals and humans, animal and human populations, and biodiversity as a whole, should be performed before attempting any primate reintroduction project. This should include respect for their wellbeing, autonomy, and fairness.

Unfortunately, the realities of Latin American and other primate-range countries, in which resources are already scarce for wildlife conservation (Estrada *et al*., 2020), make awareness and compliance with the IUCN guidelines difficult (Beck, 2018; Mitman *et al*., 2021).

Additional stakeholders can be included in the Ethical Matrix analysis as required by the particular problem. Parsimony can be helpful to clarify the core ethical elements but should not be at the expense of key interests. It can be helpful to draw up a long list of stakeholders initially from which to identify the main ones for further consideration. If particular individuals, such as direct caregivers, should be represented in an Ethical Matrix, then there is scope for that finer refinement.

The ethical weights and conclusions in this study reflect a consensus of the authors who are drawn from a variety of backgrounds (veterinary science, biology, animal welfare science, primate rehabilitation and reintroduction practitioners, European, Latin American, female, and male) and who each place more or less weight on individual animal welfare and species/ecosystem conservation. That our somewhat diverse group managed to obtain a consensus suggests that the conclusions about primate reintroduction could be more widely applicable;

however, we welcome further work to understand and potentially quantify the ethical weights that other human stakeholder groups or populations place on these different stakeholder value demands. This would help to determine the wider societal acceptance of practices under consideration and therefore strengthen the importance of any guidance that follows.

Acknowledgments This project was possible thanks to funding provided by the Mexican Council of Science and Technology (Consejo Nacional de Ciencia y Tecnología, CONACyT scholarship 438276) and the BBSRC Brazil Partnering Award – Welfare and health assessment of managed neotropical mammals in Brazil (grant number: BB/R021112/1; PI: Mendl). The authors thank the editor and anonymous reviewers for their very useful comments in the manuscript revision.

Data availability Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare there are no conflicts of interest.

Data sharing Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

References

Aliaga-Samanez, G. G., Lescano, J., Quevedo Urday, M. J., Salvatierra Rodriguez, G. S., Erkenswick Watsa, M., Calderon Escalante, J. E., & Erkenswick, G. A. (2022). First detection of antibodies against Leptospira among free-ranging neotropical non-human primates in the Peruvian Amazon lowland rainforest. *Transboundary and Emerging Diseases, 69*(3), 1458–1465. https://doi.org/10.1111/tbed.14112

Arango Guerra, H. L., Ballesteros Ruíz, S., García Castillo, F., & Buriticá, S. (2013). Primer proceso de rehabilitación y reintroducción de un grupo de titís cabeciblancos (Saguinus oedipus). *Revista Lasallista de investigación, 10*(1), 49–61.

Aureli, F., Schaffner, C. M., Verpooten, J., Slater, K., & Ramos-Fernandez, G. (2006). Raiding parties of male spider monkeys: Insights into human warfare? *American Journal of Physical Anthropology, 131*, 486–497. https://doi.org/10.1002/ajpa.20451

Baker, L. R. (2002). Guidelines for nonhuman primate re-introductions. *Reintroduction News, 21*, 29–57.

Beauchamp, T. L., & Childress, J. F. (2013). *Principles of biomedical ethics* (7th Ed.). Oxford University Press.

Beck, B. B. (2018). *Unwitting travelers: A history of primate reintroduction*. Salt Water Media.

Bennett, S. E., Vásquez, J. J., Sánchez, L., Sinarahua, L., Murayari, A., Martínez, A., Peláez, L., & Millán, J. (2013). Preliminary observations from a welfare release of woolly monkeys in the Colombian Amazon. *IUCN Global Reintroduction Perspectives, 2013*, 229–234.

Biasetti, P., & De Mori, B. (2021). The ethical matrix as a tool for decision-making process in conservation. *Frontiers in Environmental Science, 9*, 584636. https://doi.org/10.3389/fenvs.2021.584636

Brockett, R. C., & Clark, B. C. (2000). Repatriation of two confiscated black howler monkeys (Alouatta pigra) in Belize. *Neotropical Primates, 8*, 101–103.

Bruno, G., Giudice, A. M., Nieves, M., & Mudry, M. D. (2005). Rehabilitación y reproducción de Alouatta caraya fuera de su área de distribución natural. *Neotropical Primates, 13*(3), 21–22.

Bufalo, F. S., Galetti, M., & Culot, L. (2016). Seed dispersal by primates and implications for the conservation of a biodiversity hotspot, the Atlantic forest of South America. *International Journal of Primatology, 37*(3), 333–349. https://doi.org/10.1007/s10764-016-9903-3

Cambridge Dictionary (2021). Ecosystem. https://dictionary.cambridge.org/dictionary/english/ecosystem

Campbell, C. J. (2006). Lethal intragroup aggression by adult male spider monkeys (Ateles geoffroyi). *American Journal of Primatology, 68*(12), 1197–1201. https://doi.org/10.1002/ajp.20305

Card, D., & Smith, N. A. (2020). On consequentialism and fairness. *Frontiers in Artificial Intelligence, 3*, 34.

Centro de Primatología Araguatos (2004). Informe final: Rehabilitación y liberación de un grupo de monos cariblancos Cebus albifrons versicolor. Secretaría Distrital de Ambiente de Colombia.

Cezimbra, T., Genes, L., Landim, A., Moraes, B., Fernandez, F. A. S., Pires, A. S., de Castro, E. V., Moreira, S. B., Pissinatti A. and Rheingantz, M. L. (2021). Reintroduction of the brown howler monkey to Tijuca National Park, Rio de Janeiro, Brazil. In: Soorae, P. S. (ed.) (2021). Global conservation translocation perspectives: 2021. Case studies from around the globe. Gland, Switzerland: IUCN SSC Conservation Translocation Specialist Group, Environment Agency - Abu Dhabi and Calgary Zoo, Canada. xiv + p 353

Cheyne, S. M. (2006). Unusual behavior of captive-raised gibbons: implications for welfare. *Primates, 47*(4), 322–326.

Davis, N., Schaffner, C. M., & Wehnelt, S. (2009). Patterns of injury in zoo-housed spider monkeys: A problem with males? *Applied Animal Behavior Science, 116*(2–4), 250–259. https://doi.org/10.1016/j.applanim.2008.08.008

de Palomino, H. C. (2013). Rehabilitated spider monkeys successfully released in Peru. *International Primate Protection League News, 40*(3), 16–18.

de Azevedo, C. S., & Young, R. J. (2021). Animal personality and conservation: Basics for inspiring new research. *Animals, 11*(4), 1019. https://doi.org/10.3390/ani11041019

de Souza Fialho, M., Ludwig, G., & Valença-Montenegro, M. M. (2016). Legal international trade in live neotropical primates originating from South America. *Primate Conservation, 30*, 1–6.

Duarte-Quiroga, A., & Estrada, A. (2003). Primates as pets in Mexico City: an assessment of the species involved, source of origin, and general aspects of treatment. *American Journal of Primatology, 61*(2), 53–60.

Esmail, N., Wintle, B. C., t Sas-Rolfes, M., Athanas, A., Beale, C. M., Bending, Z., ..., & Milner-Gulland, E. J. (2020). Emerging illegal wildlife trade issues: A global horizon scan. *Conservation Letters, 13*(4), e12715. https://doi.org/10.1111/conl.12715

Estrada, A., Garber, P. A., & Chaudhary, A. (2020). Current and future trends in socio-economic, demographic and governance factors affecting global primate conservation. *PeerJ, 8*, e9816. https://doi.org/10.7717/peerj.9816

Estrada, A., Garber, P.A., Rylands, A.B., Roos, C., Fernandez-Duque, E., Di Fiore, A. …, & Baugou, L. (2017). Impending extinction crisis of the world's primates: Why primates matter. *Science Advances, 3*(1), e1600946. https://doi.org/10.1126/sciadv.1600946

Ferreira, R. G., Ruiz-Miranda, C., Sita, S., Sánchez-López, S., Pissinatti, A., Corte, S., Jerusalinsky, L., Wagner, P. G. C., & Maas, C. (2022). Primates under human care in developing countries: Examples from Latin America. In L. Robinson & A. Weiss (Eds.), *Nonhuman primate welfare* (pp. 145–168). Springer.

Ferreira, V. H. B., Da Silva, C. P. C., Fonseca, E. D. P., Chagas, A. C. C. S. D., Pinheiro, L. G. M., De Almeida, R. N., ..., & Ferreira, R. G. (2018). Hormonal correlates of behavioral profiles and coping strategies in captive capuchin monkeys (Sapajus libidinosus). *Applied Animal Behavior Science, 207*, 108-115. https://doi.org/10.1016/j.applanim.2018.07.002

Figueiredo, M. A. P., Di Santi, S. M., Manrique, W. G., André, M. R., & Machado, R. Z. (2017). Identification of Plasmodium spp. in neotropical primates of Maranhense Amazon in Northeast Brazil. *PLoS One, 12*(8), e0182905. https://doi.org/10.1371/journal.pone.0182905

Forsberg, E. M. (2004). The ethical matrix—a tool for ethical assessments of biotechnology. *Global Bioethics, 17*(1), 167–172.

Goldenberg, S. Z., Parker, J. M., Chege, S. M., Greggor, A. L., Hunt, M., Lamberski, N., ..., & Owen, M. A. (2022). Revisiting the 4 R's: Improving post-release outcomes for rescued mammalian wildlife by fostering behavioral competence during rehabilitation. *Frontiers in Conservation Science, 72*. https://doi.org/10.3389/fcosc.2022.910358

Griffin, A. S., Blumstein, D. T., & Evans, C. S. (2000). Training captive-bred or translocated animals to avoid predators. *Conservation biology, 14*(5), 1317–1326.

Groombridge, J. J., Raisin, C., Bristol, R., & Richardson, D. S. (2012). Genetic consequences of reintroductions and insights from population history. *Reintroduction Biology: Integrating Science and Management*, 395-440.

Guimarães, V. Y., Justo, A. A., Martins, L. L., Catão-Dias, J. L., & Sacristán, C. (2020). Emerging coronaviruses in neotropical primates: A new threat? *Revista de Ciência Veterinária e Saúde Pública, 7*(1), 001–012. https://doi.org/10.4025/revcivet.v7i1.55490

Guy, A. J., Curnoe, D., & Banks, P. B. (2014). Welfare based primate rehabilitation as a potential conservation strategy: does it measure up? *Primates, 55*(1), 139–147.

Han, B. A., Majumdar, S., Calmon, F. P., Glicksberg, B. S., Horesh, R., Kumar, A., ..., & Varshney, K. R. (2019). Confronting data sparsity to identify potential sources of Zika virus spillover infection among primates. *Epidemics, 27*, 59-65. https://doi.org/10.1016/j.epidem.2019.01.005

Hernández-Cruz, G., Ferreira, R. G., Rooney, N. J., Guidi, R. D. S., Rego, R. D. P. D., Costa, T. S. F., ..., & Mendl, M. (2022). Haematology, physiological parameters, morphometry and parasitological status of rescued bearded capuchin monkeys (*Sapajus libidinosus*). *Journal of Medical Primatology, 51*(4), 213-222. https://doi.org/10.1111/jmp.12584

Hill, C. M., & Wallace, G. E. (2012). Crop protection and conflict mitigation: reducing the costs of living alongside non-human primates. *Biodiversity Conservation, 21*, 2569–2587. https://doi.org/10.1007/s10531-012-0318-y

Hockings, K. J. (2016). Mitigating human–nonhuman primate conflict. In M. Bezanson, K. C. MacKinnon, E. Riley, C. J. Campbell, K. A. I. Nekaris, A. Estrada, A. F. Di Fiore, …, & A. Fuentes (Eds.). *The International Encyclopedia of Primatology*. https://doi.org/10.1002/9781119179313.wbprim0053

IUCN/SSC (2013). *Guidelines for Reintroductions and Other Conservation Translocations*. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission, viiii + 57 pp.

Kaiser, M., & Forsberg, E. M. (2001). Assessing fisheries–using an ethical matrix in a participatory process. *Journal of Agricultural and Environmental Ethics, 14*(2), 191–200.

Kaiser, M., Millar, K., Thorstensen, E., & Tomkins, S. (2007). Developing the ethical matrix as a decision support framework: GM fish as a case study. *Journal of Agricultural and Environmental Ethics, 20*, 65–80. https://doi.org/10.1007/s10806-006-9023-8

Kierulff, M. C. M., Ruiz-Miranda, C. R., De Oliveira, P. P., Beck, B. B., Martins, A., Dietz, J. M., ..., & Baker, A. J. (2012). The golden lion tamarin *Leontopithecus rosalia*: A conservation success story. *International Zoo Yearbook, 46*(1), 36-45.

Landim, A. R., Fernandez, F. A., & Pires, A. (2022). Primate reintroduction promotes the recruitment of large-seeded plants via secondary dispersal. *Biological Conservation, 269*, 109549. https://doi.org/10.1016/j.biocon.2022.109549

Lappan, S., Malaivijitnond, S., Radhakrishna, S., Riley, E. P., & Ruppert, N. (2020). The human–primate interface in the New Normal: Challenges and opportunities for primatologists in the COVID-19 era and beyond. *American Journal of Primatology, 82*(8), e23176. https://doi.org/10.1002/ajp.23176

Larry, L., & Moore, M. (2021). Deontological ethics, In E. N. Zalta (Ed.). *The Stanford Encyclopedia of Philosophy* (Winter 2021 Ed.). Available at: https://plato.stanford.edu/archives/win2021/entries/ethics-deontological/

Lebrão, C., Rosa, L. M. V., Paim, F. P., Nassar, P. M., El Bizri, H. R., & Silva, F. E. (2021). Community-based ecotourism and primate watching as a conservation tool in the Amazon rainforest. *International Journal of Primatology, 42*(4), 523–527. https://doi.org/10.1007/s10764-021-00226-2

Levacov, D., Jerusalinsky, L., & Fialho, M. D. S. (2011). Levantamento dos primatas recebidos em Centros de Triagem e sua relação com o tráfico de animais silvestres no Brasil. *A Primatologia no Brasil, 11*, 281–305.

Link, A., & Di Fiore, A. (2006). Seed dispersal by spider monkeys and its importance in the maintenance of neotropical rain-forest diversity. *Journal of Tropical Ecology, 22*(3), 235–246.

Maddison, N. (Ed.). (2019). *Guidelines for the management of confiscated, live organisms*. IUCN. Gland, Switzerland: IUCN. iv + pp 38.

Malukiewicz, J. (2019). A review of experimental, natural, and anthropogenic hybridization in Callithrix marmosets. *International Journal of Primatology, 40*, 72–98. https://doi.org/10.1007/s10764-018-0068-0

McKinney, T. (2016). Ecotourism. In M. Bezanson, K. C. MacKinnon, E. Riley, C. J. Campbell, K. A. I. Nekaris, A. Estrada, A. F. Di Fiore, …, & A. Fuentes (Eds.). *The International Encyclopedia of Primatology*. https://doi.org/10.1002/9781119179313.wbprim0120

Mepham, B. (1996). Ethical analysis of food biotechnologies: An evaluative framework. *Food Ethics* (pp. 115–133). Routledge.

Mepham, B., Kaiser, M., Thorstensen, E., Tomkins, S., & Millar, K. (2006). *Ethical matrix manual*. LEI Onderdeel van Wageningen UR.

Millar, K. (2012). Ethics and ethical analysis in veterinary science: The development and application of the Ethical Matrix method. *Veterinary & Animal Ethics: Proceedings of the First International Conference on Veterinary and Animal Ethics, September 2011* (pp. 100–112). Blackwell Publishing Ltd.

Mitman, S., Rosenbaum, M., Bello, R., Knapp, C., Nutter, F., & Mendoza, P. (2021). Challenges to IUCN Guideline Implementation in the Rehabilitation and Release of Trafficked Primates in Peru. *Primate Conservation, 35*, 87–102.

Mittermeier, R. A., Rylands, A. B., & Wilson, D. E. (2013). *The mammals of the world, part 3: primates*. Barcelona Lynx Edicions.

Mullan, S., & Fawcett, A. (2017). *Veterinary ethics: Navigating tough cases*. 5M Books Ltd.

Muniz, C. P., Cavalcante, L. T., Jia, H., Zheng, H., Tang, S., Augusto, A. M., ..., & Switzer, W. M. (2017). Zoonotic infection of Brazilian primate workers with New World simian foamy virus. *PLoS One, 12*(9), e0184502. https://doi.org/10.1371/journal.pone.0184502

Nicoll, M. A. C., Jones, C. G., & Norris, K. (2004). Comparison of survival rates of captive-reared and wild-bred Mauritius kestrels (*Falco punctatus*) in a re-introduced population. *Biological Conservation, 118*(4), 539–548. https://doi.org/10.1016/j.biocon.2003.09.028

Nijman, V., Nekaris, K. A. I., Donati, G., Bruford, M., & Fa, J. (2011). Primate conservation: measuring and mitigating trade in primates. *Endangered Species Research, 13*(2), 159–161. https://doi.org/10.3354/esr00336

Nunes, V. F., Lopes, P. M., & Ferreira, R. G. (2021). Monkeying around Anthropocene: Patterns of human-nonhuman primates' interactions in Brazil. *Ethnobiology and Conservation, 10*, 22. https://doi.org/10.15451/ec2021-05-10.23-1-32

Oklander, L. I., Caputo, M., Solari, A., & Corach, D. (2020). Genetic assignment of illegally trafficked neotropical primates and implications for reintroduction programs. *Scientific Reports, 10*(1), 1–9. https://doi.org/10.1038/s41598-020-60569-3

Palmer, A. (2018). Kill, incarcerate, or liberate? Ethics and alternatives to orangutan rehabilitation. *Biological Conservation, 227*, 181–188. https://doi.org/10.1016/j.biocon.2018.09.012

Palmer, A. (2020). *Ethical debates in orangutan conservation*. Taylor and Francis.

Palmer, A., Sommer, V., & Msindai, J. N. (2021). Hybrid apes in the Anthropocene: Burden or asset for conservation?. *People and Nature*, *3*(3), 573–586. https://doi.org/10.1002/pan3.10214

Pottie, S., Bello, R., & Donati, G. (2021). Factors influencing establishment success in reintroduced black-faced spider monkeys Ateles chamek. *Primates, 62*(6), 1031–1036. https://doi.org/10.1007/s10329-021-00945-3

Püschel, T. A., Gladman, J. T., Bobe, R., & Sellers, W. I. (2017). The evolution of the platyrrhine talus: a comparative analysis of the phenetic affinities of the Miocene platyrrhines with their modern relatives. *Journal of Human Evolution, 111*, 179–201. https://doi.org/10.1016/j.jhevol.2017.07.015

Ramírez García, M. (2020). *Physiological and ecological implications of rehabilitation and reintroduction of woolly monkeys (Genus Lagothrix) in Colombia* [Doctoral dissertation, Universidad de los Andes].

Rawls, J. (1999). *A Theory of justice: Revised edition.* Harvard University Press.

Richardson, D. S., Bristol, R., & Shah, N. J. (2006). Translocation of the Seychelles warbler Acrocephalus sechellensis to establish a new population on Denis Island, Seychelles. *Conservation Evidence, 3*, 54–57.

Ruiz-Garcia, M., & Shostell, J. M. (Eds.). (2016). *Phylogeny, molecular population genetics, evolutionary biology, and conservation of the neotropical primates*. Nova Science Publishers.

Santos, A. F., Cavalcante, L. T., Muniz, C. P., Switzer, W. M., & Soares, M. A. (2019). Simian foamy viruses in Central and South America: A new world of discovery. *Viruses, 11*(10), 967. https://doi.org/10.3390/v11100967

Shanee, S. (2007). FORUM. *Biodiversity, 8*(2), 43–45. https://doi.org/10.1080/14888386.2007.9712869

Sinnott-Armstrong, W. (2021). In E. N. Zalta (Ed.). *Consequentialism, the stanford encyclopedia of philosophy* (Fall 2021 Ed.). Available at: https://plato.stanford.edu/entries/consequentialism/

Sita, S. (2016). *Back to the wild: Individual differences in capuchin monkeys' rehabilitation and relocation* [Master's thesis, Universidade Federal do Rio Grande Do Norte].

Soorae, P. S., & Baker, L. R. (2002). *Re-introduction news: special primate issue* (12th Ed., pp. 1–60). Newsletter of the IUCN/SSC Re-introduction Specialist Group.

Soorae, P. S. (ed) (2008). Global re-introduction perspectives: re-introduction case-studies from around the globe. IUCN/SSC Re-introduction Specialist Group (pp. viii + 284).

Soorae, P. S. (ed) (2010). Global re-introduction perspectives: Additional case-studies from around the globe. IUCN/SSC Re-introduction Specialist Group, (pp. xii + 352).

Soorae, P. S. (ed) (2011). Global Re-introduction Perspectives: 2011. More case studies from around the globe. Gland, Switzerland: IUCN/SSC Re-introduction Specialist Group and Abu Dhabi, Environment Agency-Abu Dhabi. (pp. xiv + 250).

Soorae, P. S. (ed) (2013). Global Re-introduction Perspectives: 2013. Further case studies from around the globe. Gland, Switzerland: IUCN/SSC Re-introduction Specialist Group and Abu Dhabi, Environment Agency-Abu Dhabi. (pp xiv + 282).

Soorae, P. S. (ed) (2016). Global Re-introduction Perspectives: 2016. Case-studies from around the globe. Gland, Switzerland: IUCN/SSC Reintroduction Specialist Group and Abu Dhabi, Environment Agency Abu Dhabi, (pp xiv + 276).

Soorae, P. S. (ed) (2021). Global conservation translocation perspectives: 2021. Case studies from around the globe. Gland, Switzerland: IUCN SSC Conservation Translocation Specialist Group, Environment Agency - Abu Dhabi and Calgary Zoo, Canada. (pp xiv + 353).

Sousa, A. R. M. D. (2018). *Estudo da dinâmica de transmissão de malária autóctone de Mata Atlântica: análise da variação na acrodendrofilia de Anopheles cruzii (Diptera: Culicidae) e desenvolvimento de modelo matemático para a transmissão zoonótica* [Doctoral dissertation, Universidade de São Paulo].

Suarez, C. E., Gamboa, E. M., Claver, P., & Nassar-Montoya, F. (2001). Survival and adaptation of a released group of confiscated capuchin monkeys. *Animal Welfare, 10*(2), 191–203.

Sussman, R. W., Garber, P. A., & Cheverud, J. M. (2005). Importance of cooperation and affiliation in the evolution of primate sociality. *American Journal of Physical Anthropology, 128*(1), 84–97.

Svensson, M. S., Nijman, V., & Shepherd, C. R. (2023). Insights into the primate trade into the European Union and the United Kingdom. *European Journal of Wildlife Research, 69*(3), 51. https://doi.org/10.1007/s10344-023-01681-3

Tangen, R. (2014). Balancing ethics and quality in educational research—The ethical matrix method. *Scandinavian Journal of Educational Research, 58*(6), 678–694. https://doi.org/10.1080/00313831.2013.821089

Tricone, F. (2018). Assessment of releases of translocated and rehabilitated Yucatán black howler monkeys (Alouatta pigra) in Belize to determine factors influencing survivorship. *Primates, 59*(1), 69–77. https://doi.org/10.1007/s10329-017-0628-5

Valero, A., Schaffner, C. M., Vick, L. G., Aureli, F., & Ramos-Fernandez, G. (2006). Intragroup lethal aggression in wild spider monkeys. *American Journal of Primatology, 68*(7), 732–737. https://doi.org/10.1002/ajp.20263

Vogel, I., Glowing, B., Saint Pierre, I., Bayart, F., Contamin, H., & de Thoisy, B. (2002). Squirrel monkey (Saimiri sciureus) rehabilitation in French Guinea: a case study. *Neotropical Primates, 10*(3), 147.

Authors and Affiliations

Guillermina Hernández-Cruz[1] · Renata G. Ferreira[2] · Michael Mendl[1] · Nicola J. Rooney[1] · Siobhan Mullan[3]

✉ Guillermina Hernández-Cruz
g.hernandezcruz@bristol.ac.uk

[1] Animal Welfare and Behaviour Group, Bristol Veterinary School, University of Bristol, Churchill Building, Langford, Bristol BS40 5DU, UK

[2] Department of Physiology, Post-graduation in Psychology, School of Biosciences, Federal University of Rio Grande do Norte, Natal, Brazil

[3] School of Veterinary Medicine, University College Dublin, Dublin, Ireland

Terms and Conditions

Springer Nature journal content, brought to you courtesy of Springer Nature Customer Service Center GmbH ("Springer Nature").

Springer Nature supports a reasonable amount of sharing of research papers by authors, subscribers and authorised users ("Users"), for small-scale personal, non-commercial use provided that all copyright, trade and service marks and other proprietary notices are maintained. By accessing, sharing, receiving or otherwise using the Springer Nature journal content you agree to these terms of use ("Terms"). For these purposes, Springer Nature considers academic use (by researchers and students) to be non-commercial.

These Terms are supplementary and will apply in addition to any applicable website terms and conditions, a relevant site licence or a personal subscription. These Terms will prevail over any conflict or ambiguity with regards to the relevant terms, a site licence or a personal subscription (to the extent of the conflict or ambiguity only). For Creative Commons-licensed articles, the terms of the Creative Commons license used will apply.

We collect and use personal data to provide access to the Springer Nature journal content. We may also use these personal data internally within ResearchGate and Springer Nature and as agreed share it, in an anonymised way, for purposes of tracking, analysis and reporting. We will not otherwise disclose your personal data outside the ResearchGate or the Springer Nature group of companies unless we have your permission as detailed in the Privacy Policy.

While Users may use the Springer Nature journal content for small scale, personal non-commercial use, it is important to note that Users may not:

1. use such content for the purpose of providing other users with access on a regular or large scale basis or as a means to circumvent access control;
2. use such content where to do so would be considered a criminal or statutory offence in any jurisdiction, or gives rise to civil liability, or is otherwise unlawful;
3. falsely or misleadingly imply or suggest endorsement, approval , sponsorship, or association unless explicitly agreed to by Springer Nature in writing;
4. use bots or other automated methods to access the content or redirect messages
5. override any security feature or exclusionary protocol; or
6. share the content in order to create substitute for Springer Nature products or services or a systematic database of Springer Nature journal content.

In line with the restriction against commercial use, Springer Nature does not permit the creation of a product or service that creates revenue, royalties, rent or income from our content or its inclusion as part of a paid for service or for other commercial gain. Springer Nature journal content cannot be used for inter-library loans and librarians may not upload Springer Nature journal content on a large scale into their, or any other, institutional repository.

These terms of use are reviewed regularly and may be amended at any time. Springer Nature is not obligated to publish any information or content on this website and may remove it or features or functionality at our sole discretion, at any time with or without notice. Springer Nature may revoke this licence to you at any time and remove access to any copies of the Springer Nature journal content which have been saved.

To the fullest extent permitted by law, Springer Nature makes no warranties, representations or guarantees to Users, either express or implied with respect to the Springer nature journal content and all parties disclaim and waive any implied warranties or warranties imposed by law, including merchantability or fitness for any particular purpose.

Please note that these rights do not automatically extend to content, data or other material published by Springer Nature that may be licensed from third parties.

If you would like to use or distribute our Springer Nature journal content to a wider audience or on a regular basis or in any other manner not expressly permitted by these Terms, please contact Springer Nature at

onlineservice@springernature.com