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COMMENTARY

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Removal from the wild endangers the once widespread long-tailed macaque

Lief Erikson Gamalo[1,2,3] | Kurnia Ilham[1,3,4] | Lisa Jones-Engel[1,5] | Mike Gill[1,6] | Rebecca Sweet[1,7] | Brooke Aldrich[1,3,8,9] | Phaivanh Phiapalath[1,10] | Tran Van Bang[1,11] | Tanvir Ahmed[1,3,12] | Sarah Kite[1,13] | Sharmini Paramasivam[1,3,14] | Hun Seiha[1,15] | Muhammad Z. Zainol[1,16,17] | Daniel R. K. Nielsen[1] | Nadine Ruppert[1,10,16,17] | Agustin Fuentes[1,18] | Malene F. Hansen[1,3,10,18,19,20]

[1]The Long-Tailed Macaque Project, Broerup, Denmark

[2]Department of Biological Sciences and Environmental Studies, College of Science and Mathematics, University of the Philippines Mindanao, Davao City, Philippines

[3]IUCN SSC Primate Specialist Group, Section for Human-Primate Interactions, Gland, Switzerland

[4]Museum Zoology, Department of Biology, Andalas University, Padang, West Sumatra, Indonesia

[5]People for the Ethical Treatment of Animals, Norfolk, Virginia, USA

[6]Technological Primates Research Group, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

[7]Animal Management Department, East Durham College, Peterlee, UK

[8]Asia for Animals Coalition, Torpoint, UK

[9]Neotropical Primate Conservation, Torpoint, UK

[10]IUCN SSC Primate Specialist Group, Section for South and South East Asia, Gland, Switzerland

[11]Southern Institute of Ecology, Vietnam Academy of Science and Technology, Ho Chi Minh, Vietnam

[12]Nature Conservation Management, Dhaka, Bangladesh

[13]Action for Primates, London, UK

[14]School of Veterinary Medicine, Faculty of Health and Medical Sciences, University of Surrey, Surrey, UK

[15]Conservation International, Phnom Penh, Cambodia

[16]School of Biological Sciences, Universiti Sains Malaysia, Penang, Malaysia

[17]Malaysian Primatological Society, Kulim, Malaysia

[18]Department of Anthropology, Princeton University, Princeton, New Jersey, USA

[19]Behavioural Ecology Group, University of Copenhagen, Copenhagen, Denmark

[20]Oxford Wildlife Trade Research Group, Oxford Brookes University, Oxford, UK

Abbreviations: CITES, Convention on International Trade in Endangered Species of Wild Fauna and Flora; IUCN, International Union for the Conservation of Nature; NGO, Nongovernmental Organization; USFWS, US Fish and Wildlife Service; VRBC, Vanny Bio Research (Cambodia) Corporation Ltd.

This Commentary, which was submitted for review and publication in the American Journal of Primatology, is part of a special issue titled "Scientific Activism and Primate Conservation." The goal of the special issue is to identify important issues in primate conservation and provide readers with a set of actions they can take to help protect primates and their habitats.

Lief Erikson Gamalo and Kurnia Ilham are joint first authors.

Correspondence
Malene F. Hansen, The Long-Tailed Macaque Project, Broerup, Denmark.
Email: malenefriishansen@gmail.com

Abstract

In 2022, long-tailed macaques (*Macaca fascicularis*), a once ubiquitous primate species, was elevated to Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. In 2023, recognizing that the long-tailed macaque is threatened by multiple factors: (1) declining native habitats across Southeast Asia; (2) overutilization for scientific, commercial, and recreational purposes; (3) inadequate regulatory mechanisms; and (4) culling due to human–macaque conflicts, a petition for rulemaking was submitted to the United States Fish and Wildlife Service to add the species to the US Endangered Species Act, the nation's most effective law to protect at risk species. The long-tailed macaque remains unprotected across much of its geographical range despite the documented continual decline of the species and related sub-species and the recent IUCN reassessment. This commentary presents a review of the factors that have contributed to the dramatic decline of this keystone species and makes a case for raising the level of protection they receive.

KEYWORDS
Afro-Eurasian primate, biomedical trade, conservation, synanthropy

1 | INTRODUCTION

Historically, the long-tailed macaque/crab-eating macaque/cynomolgus monkey (*Macaca fascicularis*, [Raffles, 1821]), has been viewed as one of the most widely distributed primates; surpassed by only rhesus macaques and humans in their ability to thrive in diverse habitats. However, habitat disturbance and negative interactions with humans have resulted in long-tailed macaque populations declining in numbers over the past several decades. In the early 1980s, it was estimated that five million individuals were distributed across the long-tailed macaque's range (Fooden, 1995). Two decades later a conservative estimate, noting the tendency to overestimate population size based on the species' enhanced visibility in anthropogenic landscapes, reported that three million individuals remained, a decline of approximately 40% (Fooden, 2006). Based on the additional population decline and high levels of exploitation, in 2022, the International Union for Conservation of Nature (IUCN) elevated the species' status from 'Vulnerable' to 'Endangered A3cd' on the IUCN Red List of Threatened Species (Hansen et al., 2022a). Recognizing that the threats fueling the decrease (e.g., environmental impacts and removal from the environment) have increased over time, the IUCN assessment concluded that the long-tailed macaque population decline would likely surpass 50% over the next three generations. In less than three macaque generations this once ubiquitous, keystone species, who for centuries defined ecological success in anthropogenically altered habitats, where other seed dispersers, predators and prey are not able to survive, has traced an ominous population trajectory from Lower Risk/Near Threatened (1996, 2000), to Least Concern (2008), to Vulnerable (2020, 2021), and to Endangered (2022). It is imperative that the global community acts immediately to reverse this trend. In this paper, we discuss the importance of this species, the multiple factors currently threatening their populations, and the actions necessary to ensure their long-term survival.

2 | THE COMPLEX AND CRITICAL ROLES OF LONG-TAILED MACAQUES IN THEIR ECOSYSTEMS

Long-tailed macaques are naturally distributed across Southeast Asia, in a patchy, noncontinuous distribution in the Nicobar Islands and Bangladesh in South Asia, and have been introduced to Mauritius, Palau, and northeastern Papua (Fooden, 1995). They can be found in various habitat types including in evergreen forests, mangrove forests, swamp forests, riparian forests, forest edges, and even in urban settings (Ong & Richardson, 2008). The long-tailed macaque is synanthropic, highly adaptive to niches that humans create when altering the environment, and it has coexisted with humans across most of its distributional range for millennia (Fuentes et al., 2007, 2008; Gumert et al., 2011; Hansen et al., 2021; Thierry, 2007) resulting in shared ecologies (Fuentes, 2010; Southwick et al., 2005).

However, long-tailed macaque populations are routinely negatively impacted, often persecuted, trapped and/or culled in the anthropogenically modified ecosystems they share with humans and other animals (Asia for Animals, 2022; Azhar et al., 2013).

Southeast Asia is grappling with escalating habitat destruction and conversion of habitats suitable for long-tailed macaques leading to decreased available habitat and increased human–macaque contact and conflict (Estoque et al., 2019; Mermoz et al., 2021; Sodhi et al., 2004).

In Bangladesh, the species is already considered locally extirpated after extensive surveys during 2021 and 2022 failed to locate any individuals (pers. obs. Tanvir Ahmed, 2022). In Lao PDR, the remaining number of individuals has declined precipitously; a recent survey estimated only 500 remaining individuals, a reduction of almost 400% in the last 10 years, with possibly only one subpopulation remaining that has not hybridized with rhesus macaques (*Macaca mulatta*) (pers. obs. Phaivanh Phiapalath, 2021; Hamada et al., 2011). Cambodia has also experienced major population declines, with one area reporting a 50% decline in long-tailed macaque abundance between 2010 and 2020 (Nuttall et al., 2022). Recent publications from Vietnam indicate a dramatic decline in group sizes and local extirpations (Hoang et al., 2019).

Although data are scarce regarding the effects on ecosystems when macaques are removed, available data indicate that the long-tailed macaque fills vital ecological roles as a seed disperser and in predator and prey relationships (Corlett & Lucas, 1990; Gumert & Malaivijitnond, 2012; Seidensticker & Suyono, 1980). In some areas, the long-tailed macaque may be one of few remaining larger seed dispersers, such as on the smaller islands where endemic long-tailed macaque subspecies are found (Gumert, 2011). In addition, in some areas, long-tailed macaques may help to mitigate flooding by contributing to the maintenance of mangrove and beach forests (Menéndez et al., 2020). Removing such a central contributor to ecosystem regeneration could have detrimental long-term effects on native habitats and sympatric wildlife species, and thereby also impact human populations who use these ecosystems for resources.

The loss of long-tailed macaques, particularly those populations that share their ecosystem with humans, may also have One Health consequences (Cianfagna et al., 2021; Fornace et al., 2016). Researchers continue to explore and characterize spill-over infections of *Plasmodium knowlesi* in areas with long-tailed macaque populations and mosquito vectors that can and do feed on humans if macaques are not available (Lee et al., 2022; Stark et al., 2019). Between 2010 and 2020 the detection of *P. knowlesi*, the malaria parasite associated with long-tailed and pig-tailed macaques in Malaysian Borneo, surged among humans living and working near towns, while the prevalence of infections caused by the "human" malaria parasites *P. vivax*, *P. falciparum*, *P. malariae*, *and P. ovale* plummeted (Yunos et al., 2022). Assuming that the number of mosquitos in an ecosystem does not change, a reduction in the number of macaques in a location could lead to higher mosquito biting frequency per macaque and/or human (Lee et al., 2022). Active host seeking by *Anopheles balabacensis*, a primary *P. knowlesi* vector has been identified more often near long-tailed macaque sleeping sites (Brown et al., 2022). The transmission of *P. knowlesi* is influenced by the abundance and distribution of vectors and hosts in the environments, and the removal of macaques, the natural hosts, likely diminishes a buffer to human infections (Fornace et al., 2019; Scott, 2020; Voinson et al., 2022).

3 | CULLING DUE TO CONFLICTS

The ability of long-tailed macaques to utilize anthropogenic spaces makes them highly visible, creating the illusion of ubiquity even when their numbers are steeply declining inside forests and native habitats (Eudey, 2008; Hansen et al., 2019; Kyes et al., 2011). This misperception and/or overstatement of their abundance can negatively affect the possibility of coexistence or tolerance, and diminish the potential appreciation of the local community for the critical role that long-tailed macaques play in the ecosystem. It becomes even more challenging when people perceive that the monkeys' presence impacts their livelihoods through damage to property or crops (Fuentes & Gamerl, 2005; Marchal & Hill, 2009; Sha et al., 2009; Tsuji & Ilham, 2021). Negative interactions between humans and long-tailed macaques are difficult to manage and some mitigation techniques include the killing/culling or capturing of individuals for the pet, meat, and/or biomedical trade. Deliberate killing and/or capture or mass relocation may result in critical changes in macaque group dynamics and demography and lead to local population extinctions (Enari, 2021; Erinjery et al., 2017).

Across their range, as humans have converted macaque habitats to anthropogenic landscapes, crop-foraging by long-tailed and other macaque species has resulted in persecution, poisoning, and shooting by local farmers and government officials (Kaur, 2022; Perhilitan, 2018; pers. obs. Kurnia Ilham, 2021; The Star, 2022; GMA News, 2022). However, such culling activities are rarely based on scientific population surveys as population data are widely lacking across the range of these species (Eudey, 2008; Gamalo et al., 2021; Hansen et al., 2021). Thus it is unclear if these actions are sustainable. Urban development and encroachment on natural habitats continue to increase shared habitats and conflict potential, threatening the survival of the species in all habitat countries (Estrada et al., 2017).

4 | OVERUTILIZATION

The long-tailed macaque is considered the "most highly traded species of primate." Overutilization in combination with culling and extraction for the biomedical trade has resulted in local extirpations (Hansen et al., 2022a; Nijman et al., 2017; Shepherd, 2010). Trade in long-tailed macaques takes many forms including the capture and export of whole animals and/or their biological specimens for biomedical and toxicology research, skulls for ornamental accessories, skin for hats, meat for traditional medicine and food, and pets for private owners and for entertainment use, especially for the growing trend of abuse in social media. This is exemplified by primates, especially long-tailed macaques, being one of the most common species seen in online animal cruelty content (Gunter et al., 2023;

Hansen et al., 2021; Moloney et al., 2021; Social Media Animal Cruelty Coalition, 2021).

One of the most visible forms of the biomedical experimentation trade in long-tailed macaques involves the export of tens of thousands of these monkeys each year from Cambodia, Mauritius, Viet Nam, Indonesia, and Philippines, with international demand coming from the United States, Japan, China, and the European Union (see Tables 1 and 2). During the 21st century, the United States (the leading importer of live long-tailed macaque trade) has imported more than 500,000 live long-tailed macaques labeled, correctly or incorrectly, as captive-bred. Additionally, between 2008 and 2022, over 700,000 specimens (a catch-all designation that can include tissues, blood samples, body parts, or hair) from an unknown number of long-tailed macaques, were exported to countries around the globe (Hansen et al., 2021). The trade in live long-tailed macaques has traditionally overshadowed the trade in biological specimens, facilitating the global movement of samples with obscured provenance (Anton, 2023).

A few global corporations including Charles River Laboratories, Inotiv, and World Wide Primates Inc, dominate the international trade in long-tailed macaques for research and testing, with demand primarily coming from the United States, Japan, China, and the EU (Table 2). While China, in response to uncertainty about the potential zoonotic source of the SARS-CoV2 virus banned all exports of wildlife at the onset of the COVID-19 pandemic in early 2020 (Tian, 2021; Vanderklippe, 2020), and apparently had already stopped exporting monkeys by 2019 (Hansen et al., 2022b) (Table 1), they did not ban imports of wildlife and continued to import long-tailed macaques, both legally and illegally (CITES Trade Database, 2022; Tian, 2021; Zhu, 2022). The export ban from China, which has numerous large-scale long-tailed macaque breeding colonies holding an estimated 250,000 animals, effectively changed the patterns of the international trade in long-tailed macaques and further exerted pressure on the species as habitat countries took over as international suppliers (CITES Trade Database, 2022; Hansen et al., 2021, 2022b). According to an article in Wee (2021), when US-based researchers began calling for more monkeys in 2020, neither the origin of the monkeys supplied to meet this demand, the impact on the welfare of the individuals and their troops, infectious disease risks posed to local people by capturing, handling and transporting these monkeys, nor the effects of their removal on the ecosystems from which they were taken were considered.

5 | INADEQUATE REGULATORY MECHANISMS

From 2019 to 2022, demand for long-tailed macaques for biomedical research has increased the price of individual macaques worldwide (UN Comtrade, 2021; NASEM workshop, August 25th 2022). The demand and competition for macaques is so intense that facilities in the U.S. are purchasing macaque "futures" before infants are even born; essentially contracting to secure the animal at a future set date and for a set price (NASEM, 2022, August 25). This has further incentivized long-tailed macaque habitat countries to increase supply. CITES stipulates that wild-caught long-tailed macaques should be traded internationally only if wild-capture/export quotas based on scientifically derived population estimates have been developed and are enforced, ensuring the capture rate is sustainable (CITES Trade Database, 2022). In response to international concerns relating to the accurate reporting of the volume and provenance of long-tailed macaques, the species was included in the Review of Significant Trade at the 25th meeting of the CITES Animals Committee beginning in 2011 and has subsequently been subject to additional scrutiny (UNEP-WCMC, 2013). Still, the change in trade patterns, moving from China as the aggregate exporter (see Zhu, 2022 for a detailed description of long-tailed macaque breeding, import and export in China) to individual habitat countries exporting on their

TABLE 1 Long-tailed macaque (*Macaca fascicularis*) exports by country from 2010–2019 (number of individuals) data from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Trade Database.

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Cambodia	3095	9050	3930	7039	5081	3661	6567	7025	0	13,922	59,370
China[a]	21,428	13,375	12,580	14,785	25,122	19,306	22,342	21,940	30,450	0	181,328
Indonesia	1587	1391	20	568	336	0	0	0	0	1569	5471
Laos	2	2000	0	0	0	0	0	0	0	0	2002
Mauritius	7063	6356	6214	6916	8533	8569	7860	8277	0	6550	66,338
Myanmar	0	0	0	0	0	0	0	0	0	0	0
Philippines	1494	1487	758	770	804	676	0	0	140	1053	7182
Thailand	0	0	0	0	0	165	1415	3016	9854	16,362	30,812
Vietnam	5843	1922	6258	6290	3854	4912	4672	5313	7968	11,911	58,943
Total	40,512	35,581	29,760	36,368	43,730	37,289	42,856	45,571	48,412	51,367	411,446

[a]Long-tailed macaques are not free-ranging in China.

TABLE 2 Long-tailed macaque (*Macaca fascicularis*) imports by country from 2010–2019[a] (number of individuals) data from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Trade Database.[b]

Country	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Canada	2990	2343	1972	1892	2698	2249	3130	3090	3270	82	23,716
China	1002	8000	0	1	0	120	0	0	3156	8080	20,359
France	2624	1487	2365	2248	2179	1447	1982	1891	1451	1514	19,188
Germany	818	432	186	1070	1288	600	292	734	309	395	6124
Italy	416	208	0	0	0	0	0	0	0	0	624
Japan	5736	5540	5146	6748	7207	5637	6435	6719	2596	4108	55,872
Netherlands	216	109	108	0	720	960	0	323	720		3156
Singapore	890	528	660	823	525	261	70	44	34	0	3835
South Korea	781	408	740	440	793	746	714	690	1697	933	7942
Spain	1578	1109	720	919	1128	1686	1417	2419	700	1988	13,664
United Kingdom	1416	1377	1741	1935	1404	2299	1942	1841	570	1523	16,048
USA	22,174	15,242	17,463	20,966	27,629	23,336	28,936	29,968	36,356	32,611	254,681
Total	40,641	36,783	31,101	37,042	45,571	39,341	44,918	47,719	50,859	51,234	425,209

[a]EU imports of CITES Appendix II (EU Annex BG) species are only recorded at the point of entry to the EU country. Any trade between EU member states is not monitored by CITES.

[b]Data from 2020 are available, but the US has not yet recorded their imports in the database.

own, suggests that the current increase in demand, which rose from 39,341 in 2015 to 51,234 by 2019 (Table 2), and the subsequent reported trade numbers, could not have been met with captive-bred or legally sourced individuals alone (CITES Trade Database, 2022; Hansen et al., 2022b; Warne et al., 2023). Warne and colleagues provide a sobering analysis, showing that it would be biologically impossible for the six commercial breeding facilities in Cambodia to have ramped up their production of captive-bred long-tailed macaques to account for the dramatic increase in animals exported "captive-bred" in 2018 ($n = 10{,}000$) to the 30,000 "captive-bred" macaques exported in both 2019 and 2020 (Warne et al., 2023). There can be no further denying that the laundering of wild-caught individuals as captive-bred is an ongoing practice (Species Survival Network [SSN], 2017). For example, there is evidence from Laos, Cambodia, Vietnam, and China (Mingyi, 2020; Pasha, 2023) that individual long-tailed macaques have been moved across the borders of habitat countries to launder them into the legal trade (pers. obs. Phaivanh Phiapalath, 2020; Daily Sabah, 2021).

Recently, US officials have begun to address the demand side of the primate trade. On November 16, 2022, following a 5-year investigation undertaken by the US Department of Justice (DoJ) and the US Fish and Wildlife Service (FWS), the DoJ indicted Cambodian government officials and the Cambodian owner and staff of Vanny Bio Research (Cambodia) Corporation Ltd (VBRC)—a macaque breeding center—for alleged involvement in laundering wild-caught monkeys as captive-bred. The DoJ indictment also references two unindicted coconspirators identified as US companies located in Miami, Florida and Alice, Texas. Charles River laboratories, one of the largest importers of long-tailed macaques is currently under federal civil and criminal investigations with possible violation of the Endangered Species Act and the Lacey Act (the US law that combats illegal trafficking and trade of plants and animals) related to their importation of long-tailed macaques from Cambodia who may have been falsely labeled as captive bred (Reuters, 2023).

The true number of long-tailed macaques traded during the COVID-19 pandemic is not available in the CITES Trade Database. Data from 2020 are available, but the United States has not yet recorded their imports in the database. However, publicly available data from the United States Centers for Disease Control and Prevention show that between fiscal years 2019 and 2021 Cambodia increased their export of live long-tailed macaques to the United States by 120% (from 8571 in 2019 to 18,870 in 2021) and that long-tailed macaque importation into the US increased during the first 5 months of fiscal year 2021 ($n = 11{,}399$) compared to the first 5 months of fiscal year 2020 ($n = 11{,}184$) (Galland, 2022).

To provide perspective on the ramifications of the increased demand, we examined the prepandemic trade. From 2010 to 2019, approximately 412,000 individual long-tailed macaques were traded internationally (Hansen et al., 2021; Table 1). These macaques were received by 12 different countries (Table 2), and traded individuals were marked in the database with a source code of either W (wild) or F (captive-born). Overall, 11% of reported individuals ($n = \sim 45{,}000$) were marked as wild-caught. However, these figures are from the monitored, legal international trade. Illegal trade (trade without CITES export permits or with falsified CITES permits) and trade within habitat countries, including wild capture to supply domestic laboratories and to upkeep breeding companies that export to the global research industry are not included. A recent study on animal

products entering the US found that the illegal trade adds an estimated 28% to legal imports (Tittensor et al., 2020), meaning that for every 100 animal products (i.e., shells, skulls, cavier, skins, ivory, and body parts) imported legally into the United States, another 28 products are imported illegally. Although the data collected by Tittensor et al. (2020) focuses on specimens and does not include primate products, it highlights that with legal trade comes illegal trade. Indications of illegal trade closely following the legal trade has been reported for long-tailed macaques, especially by the Species Survival Network (SSN, 2012, 2015a, 2015b). The illegal trade here refers to falsified CITES trade permits, where wild-caught individuals are laundered into the legal trade.

6 | A ONCE THRIVING SPECIES IS NOW ON THE EDGE

It is estimated that the current wild global population of long-tailed macaques has decreased by at least 40% over the past 30 years and a further 50% decline from the current population is predicted (Fooden, 2006; Hansen et al., 2022a). However, there is still time for action unless depletion of wild populations continues. For example, a population of Nicobar long-tailed macaques was able to bounce back after a tsunami devastated their habitat (Velankar et al., 2016). The Nicobar Islands long-tailed macaques' ability to adapt to environmental changes and especially the effects of climate change, as reflected in their flexible diet and tool use abilities, can serve as a model species for understanding how to conserve biodiversity during the Anthropocene (Lane et al., 2010). Scientists studying long-tailed macaques have only just begun to glimpse the rich cultural behaviors that populations of these remarkable monkeys exhibit in Bali, Myanmar, Thailand, and the Nicobar Islands (Gumert & Malaivijitnond, 2012; Malaivijitnond et al., 2007; Peterson et al., 2022).

The conservation actions required to maintain the long-tailed macaque meet many of the Sustainable Development Goals (United Nations, 2022), notably targets in Goals 11, 13, 14, and 15. Goal 15, which focuses on land restoration and species protection, as well as a reduction of invasive species and wildlife trafficking. The long-tailed macaque is both a threatened and an invasive-introduced species (Hansen et al., 2021). However, all introduced populations were introduced by humans, such as the population on Tinjil Island for the purpose of supplying the biomedical trade and therefore all populations of long-tailed macaques are deserving of protection and conservation (Hansen et al., 2022a; Nijman et al., 2017).

In April 2023, stakeholders from around the globe submitted a petition to the US Fish and Wildlife Services (UWFWS) urging the Service to list the long-tailed macaque as an "endangered" or "threatened" species under the US Endangered Species Act (ESA, 1973). At the time of writing, this petition is under active review and once a 90-day "substantial" finding has been made a 12-month status review will be initiated by USFWS to determine whether the species will be ESA listed. As the leading importer, year-after-year, in the live long-tailed macaque trade, the United States has an obligation to act swiftly and protect these animals. Under current rules, ESA protections can be granted to species who face just one threatening factor. Long-tailed macaques face at least four, including overuse for scientific purposes. With certain exceptions, the ESA makes it illegal to import, export, take, possess, sell, or transport any endangered or threatened species (see ESA Section 9. Prohibited Acts).

7 | CONSERVATION ACTIONS

The threats to the long-tailed macaque are numerous and substantial, and it is imperative that we act now and collaborate across disciplines to conserve this nonhuman primate species.

Given the conservation concerns and evidence of recent population declines of long-tailed macaques in response to (1) declining native habitats across Southeast Asia; (2) overutilization for scientific, commercial, and recreational purposes; (3) inadequate regulatory mechanisms; and (4) culling due to human–macaque conflicts, here is how primatologists, field and laboratory researchers, government and management officials, local communities and tourists can help:

1. Work to change the public narrative regarding long-tailed macaques and other synanthropes to portray a species that needs protection and concerted conservation efforts. Even if we see them more often than many other species in certain areas, it does not mean that they are not threatened. Understand that these are intelligent, innovative, and flexible animals that are trying to survive the Anthropocene alongside us. Appreciate their behaviors and skills and conserve them in their habitats, which we often share with them.
2. If you work with long-tailed macaques in captivity or biomedical research, verify their origin and take responsibility for sustainably and transparently sourcing them, ensuring that you are not contributing to the loss of wild populations.
3. Request to visit breeding centers, farms, and quarantine stations and help to ensure that all needs of the animals are met, high welfare standards maintained and breeding populations sustained without the intake of wild individuals.
4. Consider contributing to NGOs and scientific research projects that focus on the conservation of long-tailed macaques. There are several relevant NGOs such as: JAAN (Jakarta Animal Aid Network) (https://www.jakartaanimalaid.com/); International Animal Rescue Indonesia (https://www.internationalanimalrescue.or.id/); Wildlife Alliance (https://www.wildlifealliance.org/); HUMAIN Program University Philippines Mindanao (https://liefgamalo.com/research-conservation.html); The Macaque Coalition (https://www.macaquecoalition.com/); The Animal Neighbors Project (https://animalneighboursproject.org/); The Jane Goodall Institute Singapore (https://janegoodall.org.sg/), The Long-Tailed Macaque Project (https://theltmproject.org/) and many more.

Please contact contact@theltmproject.org for information on local grassroots organizations.

5. Mind your behavior around synanthropic primates and understand your effect on their behavior, their ecosystems and the local human communities. If you live alongside them, try to learn from indigenous communities how to coexist with them, and follow local cultural and traditional customs that often respect all life. If you are only visiting, do not provision and always maintain an appropriate distance of at least 7 m.
6. Urge your country representatives/government to include long-tailed macaques in their list of protected and/or endangered species, ensuring that they have protection in all countries, whether native or not.

AUTHOR CONTRIBUTIONS

Lief Erikson Gamalo: Conceptualization (equal); investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Kurnia Ilham**: Conceptualization (equal); investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Lisa Jones-Engel**: Conceptualization (equal); investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Mike Gill**: Conceptualization (equal); data curation (equal); formal analysis (equal); investigation (equal); writing—review and editing (equal). **Rebecca Sweet**: Project administration (equal); writing—original draft (equal); writing—review and editing (equal). **Brooke Aldrich**: Conceptualization (equal); investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Phaivanh Phiapalath**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Tran Van Bang**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Tanvir Ahmed**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Sarah Kite**: Conceptualization (equal); investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Sharmini Paramasivam**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Hun Seiha**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Muhammad Z. Zainol**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Daniel R. K. Nielsen**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Nadine Ruppert**: Investigation (equal); writing—original draft (equal); writing—review and editing (equal). **Agustin Fuentes**: Conceptualization (equal); supervision (equal); writing—original draft (equal); writing—review and editing (equal). **Malene F. Hansen**: Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); project administration (equal); supervision (equal); writing—original draft (equal); writing—review and editing (equal).

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the CITES Trade Database at https://trade.cites.org/#.

ETHICS STATEMENT

Not applicable.

ORCID

Lisa Jones-Engel http://orcid.org/0000-0001-6912-494X
Nadine Ruppert http://orcid.org/0000-0002-9760-0058
Malene F. Hansen https://orcid.org/0000-0002-4152-7947

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