

# Conservation of Long-tailed Macaques: Implications of the Updated IUCN Status and the CoVID-19 Pandemic

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**Abstract:** The often synanthropic long-tailed macaque (*Macaca fascicularis*) is listed in Appendix II of CITES and was recently updated to Vulnerable on the IUCN Red List. The update was highly anticipated, as it can have wide-reaching implications for long-tailed macaque conservation and trade. Long-tailed macaques have suffered from intensive capture for biomedical research since the 1960s. From 2008–2019, at least 450,000 live long-tailed macaques, and over 700,000 “specimens” from an unknown number of individuals were part of this trade, with over 50,000 termed as wild-caught. These official trade numbers exclude laundering of wild-caught individuals as captive bred, harvesting for breeding center upkeep, their capture for the pet trade, hunting for consumption, and culling due to human-macaque conflicts. With Fooden’s population estimate of 3 million long-tailed macaques in Southeast Asia in 2006, this is likely not sustainable. In some areas, they have already been extirpated because of this trade, as detected by a survey of 200 km of suitable habitat in Cambodia in 2008. Long-tailed macaques are one of the most geographically widely dispersed and adaptable primate species. However, their flexibility and preference for the forest edge draws them to anthropogenic habitats, where their visibility results in assumptions of overabundance, as was demonstrated on Java in 2009 and 2017. Long-tailed macaques face many threats, and there is an urgent need for systematic demographic and range surveys across Southeast Asia, as well as investigation into local, regional and national perceptions of long-tailed macaques. Current conservation foci should include dynamic widespread synanthropic species, such as long-tailed macaques, which are often targets of intensive trade and other threats. Insights from such studies may be critical for effective conservation and management in the 21<sup>st</sup> century.

**Keywords:** Primates, CoVID-19, population decline, synanthrope, trade, conservation status

## Introduction

In 2008, Ardith Eudey, co-founder of the International Primate Protection League and long-time chair of the Asia section of the IUCN Primate Specialist Group, raised concerns at the International Primatological Society’s presentation of the “World’s 25 Most Endangered Primates” regarding the declining populations and increasing threats to long-tailed macaques *Macaca fascicularis* (Raffles, 1821). This was consolidated and expanded upon in a paper “The crab-eating macaque (*Macaca fascicularis*): widespread

and rapidly declining” published by Eudey in *Primate Conservation* in 2008. In 2015, she again raised the alarm bells at another meeting of the International Primatological Society, and it is now recognized that, as a species, long-tailed macaques meet the criteria for them to be listed as Vulnerable on the IUCN Red List (Eudey *et al.* 2020). In January 2021, three of the nine *M. fascicularis* subspecies were also listed as Vulnerable on the IUCN Red List—the nominate subspecies *Macaca f. fascicularis*, the Con Son long-tailed macaque *M. f. condorensis*, and the Nicobar Islands long-tailed macaque *M. f. umbrosa*. The remaining six, all island

forms, were listed as Data Deficient (Table 1). The new update for this species has the potential to increase attention to the burgeoning plight of the species and, with that, the funding needed for urgent research initiatives and conservation measures.

A comprehensive compilation of long-tailed macaque behavior, ecology, management, and interactions with humans was published a decade ago (Gumert *et al.* 2011a). Subsequent research and anecdotal evidence suggests that long-tailed macaque populations are decreasing in various parts of their range (Kyes *et al.* 2011; Lee 2011; Hansen *et al.* 2019). For instance, in 2008 in Cambodia, a survey of suitable habitats and meat markets found no long-tailed macaques (Lee 2011), and a survey on the Indonesian island of Java found apparently suitable forests to be devoid of long-tailed macaques (Kyes *et al.* 2011). Overall, however, the species is still perceived as abundant (Eudey *et al.* 2020), but researchers have speculated that the presence of long-tailed macaques in anthropogenic areas may lead to overestimation of their population size (for example, Kyes *et al.* 2011). A recent survey in East Java did find that extrapolating road densities to non-anthropogenic areas leads to

overestimation of population size. Estimated density, when extrapolated from road and trail observations only was 1,449 individuals/km<sup>2</sup>, whereas the estimated density from a survey covering all habitats (non-anthropogenic and anthropogenic) was only 41 individuals/km<sup>2</sup> (Hansen *et al.* 2019). In anthropogenic landscapes, densities of provisioned long-tailed macaques range from 67 individuals/km<sup>2</sup> in Vietnam (Son 2004) to ~600 individuals/km<sup>2</sup> in Bali, Indonesia (Brotcorne 2014) and ~800 individuals/km<sup>2</sup> in East Java, Indonesia (Hansen *et al.* 2020a) with a mean of 100 individuals/km<sup>2</sup> across Southeast Asia (Fooden 1995). Densities of non-provisioned populations in non-anthropogenic landscapes range from 25 individuals/km<sup>2</sup> in East Java, Indonesia (Hansen *et al.* 2020a) and 70 individuals/km<sup>2</sup> in Bali (Brotcorne 2014) to 10–143 individuals/km<sup>2</sup> in Sumatra (Fooden 1995; Yanuar *et al.* 2009) with a mean across Southeast Asia of 55 individuals/km<sup>2</sup> (Fooden 1995). Semi-provisioned populations in Singapore were found to range from 1–34 individuals/km<sup>2</sup> (Sha *et al.* 2009; Riley *et al.* 2015). Comparing the above densities underlines the disparity between habitats with varying degrees of anthropogenic influence. Extrapolating densities between non-anthropogenic habitats

**Table 1.** Conservation status and distribution of the nine subspecies of long-tailed macaques (Fooden, 1995; Eudey *et al.* 2020). CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient.

Popular name	Scientific name	2008 RL status	2015 PSG Asia recommendation*	2020 RL status**	Geographic location	Population size	Population trend
Long-tailed macaque	<i>Macaca fascicularis</i>	LC	VU	VU	-	Unknown	Declining
Common long-tailed macaque	<i>M. fascicularis fascicularis</i>	LC	VU	VU	Indonesia, Malaysia, Philippines, Thailand, Cambodia, Singapore, Vietnam	Unknown	Declining
Dark-crowned long-tailed macaque	<i>M. fascicularis atriceps</i>	DD	VU	DD	Khram Yai Island, Thailand	Unknown	Unknown
Burmese long-tailed macaque	<i>M. fascicularis aurea</i>	DD	DD	DD	Myanmar, Bangladesh, Laos, western and southern Thailand near the Myanmar border	Unknown	Unknown
Con Son long-tailed macaque	<i>M. fascicularis condorensis</i>	VU	EN	VU	Con Son Island, Hon Ba Island, Vietnam	<1000 individuals on Con Son. Suspected to be the same on Hon Ba	Declining
Simeulue long-tailed macaque	<i>M. fascicularis fusca</i>	DD	LC	DD	Simeulue Island, Indonesia	Unknown	Unknown
Lasia long-tailed macaque	<i>M. fascicularis lasiae</i>	DD	DD	DD	Lasia Island, Indonesia	Unknown	Unknown
Karimunjawa long-tailed macaque	<i>M. fascicularis karimondjaware</i>	DD	CR	DD	Karimunjawa Islands, Indonesia	<500 individuals***	Declining
Maratua long-tailed macaque	<i>M. fascicularis tua</i>	DD	DD	DD	Maratua Island, Indonesia	Unknown	Unknown
Nicobar long-tailed macaque	<i>M. fascicularis umbrosa</i>	VU	EN	VU	Nicobar Islands, India	958 individuals in two of the three islands****	Declining

\*IUCN SSC PSG (2015), \*\*IUCN Red List 31 December 2020, \*\*\*Afendi *et al.* (2011), \*\*\*\*Saren *et al.* (2019)

may also be problematic as habitat preference and selection varies (for example, Hansen *et al.* 2019, 2020a) and density patterns are not continuous (for example, with most long-tailed macaques found within 1 km of river edges in Tanjung Puting National Park, Kalimantan, Indonesia: Gumert *et al.* 2012).

Incorrect extrapolations and overestimation of long-tailed macaque population sizes may be occurring across their range, and systematic surveys are needed to assess their true population size to ensure that policy makers are correctly informed when creating management plans for the species. In Thailand, researchers have called for urgent research into the status of the long-tailed macaque and for the creation of conservation measures after they found long-tailed macaque habitat preference to have changed from forests to temples and recreation areas (Malaivijitnond and Hamada 2008). In Penang National Park in Malaysia, long-tailed macaques were found to only inhabit beaches and not forests, which researchers recommended be considered in management strategies (Qiao and Ruppert 2017).

In the following, we outline the main threats faced by long-tailed macaques, and we end with an outline of what we wish to achieve in the future, and what we recommend for other long-tailed macaque researchers to focus on—all to ensure future conservation and management initiatives that are based on scientific evidence, so as to avoid that the long-tailed macaque comes to face the same fate as other abundant species, such as the Siamese crocodile (*Crocodylus siamensis*), the Black-winged Myna (*Acridotheres melanopectus*) and the Passenger pigeon (*Ectopistes migratorius*). The Siamese crocodile and the Black-winged Myna are Critically Endangered in the wild having experienced dramatic declines because of trade (Bezuijen *et al.* 2012; BirdLife International 2018) and both have captive populations in breeding facilities that outnumber the wild populations (Thorbjarnarnson 1992; Nijman *et al.* 2018). The once ubiquitous passenger pigeon began to disappear with little fanfare, or notice, until it was clearly on the path towards extinction (Schorger 1955).

## Distribution

The long-tailed macaque is distributed across Southeast Asia (Fooden 1995; Eudey *et al.* 2020) (Table 1). Formerly with 10 subspecies, the Philippine long-tailed macaque, *M. f. philippinensis* (I. Geoffroy Saint-Hilaire, 1843), listed by Groves (2001) was found to be insufficiently genetically differentiated (Smith *et al.* 2014; Liedigk *et al.* 2015) and is now considered to be a junior synonym of *M. f. fascicularis*. Information on population size and distribution and genetic and cultural diversity is insufficient or lacking for the nine remaining subspecies, yet highly needed to ensure effective conservation measures (Gumert *et al.* 2011b). Due to their synanthropic nature, long-tailed macaques are distributed in both anthropogenic and non-anthropogenic areas, and therefore often not reliant on protected areas. In

Vietnam, however, they might only be found in protected areas because of severe hunting (Son *et al.* 2009). Although we refer to the long-tailed macaque as a species in this paper, from a practical and management perspective, conservation initiatives will also have to be targeted at the smaller geographical scales including the seven insular subspecies and otherwise geographically restricted regions.

For the species' global distribution, we still largely rely on the maps published by Fooden (1995), which were based on field surveys in the 1970s and 1980s and, for many areas, on museum collections. The range map used by the IUCN Red List (Ong and Richardson 2008; Eudey *et al.* 2020) is an updated version of the Fooden map. A more recent distribution map is not available, however the Species Survival Network (2012) indicated that several populations across the range of long-tailed macaques, especially island populations may well be decimated.

## Flexibility and Ecological Roles

Long-tailed macaques are able to inhabit diverse habitats, including deciduous forests, evergreen forests, savannah, mangroves and beaches, from sea level to at least 1900 m asl (Fooden 1995; Thierry 2007; Yanuar *et al.* 2009; Gumert *et al.* 2011a). Tool use has been observed in several long-tailed macaque communities (Gumert and Malaivijitnond 2012; Gumert *et al.* 2013), and substantial behavioral and “cultural” diversity within the species reflects the significant ecological and behavioral flexibility and adaptability of long-tailed macaques (Gumert *et al.* 2011a).

This flexibility and adaptability allows them to occupy several ecological roles across diverse ecosystems, as, for example, seed dispersers as well as predators and prey (Seidensticker and Suyono, 1980; Corlett and Lucas, 1990; Gumert and Malaivijitnond, 2012), and to engage in poly-specific associations (Hansen *et al.* 2020b). It also enables them to recover from natural disasters, such as tsunamis (Velankar *et al.* 2016). They consume a wide variety of food, and can also thrive on human foods (Sha and Hanya 2013). Long-tailed macaques aid in seed dispersal and, thereby, habitat regeneration (Corlett and Lucas 1990; Lucas and Corlett 1998).

## Overlap with Humans

Long-tailed macaques are faced with numerous threats. Many are the same as those of non-synanthropic species, yet many are a direct effect of their presence in human-influenced areas. Threats vary depending on subspecies and subpopulation, and include, but not exclusively, habitat loss and degradation, logging, mining, aquaculture and agriculture, large-scale plantations and hydropower development, illegal and legal domestic and international trade, human expansion and urbanization, including dependence on human foods and conflicts with humans, hunting and poaching, genetic pollution and diseases from introduced

macaques, use in traditional medicine, persecution as pests, and tourism activities (Eudey 2008; Eudey *et al.* 2020).

Long-tailed macaques are able to exploit anthropogenic areas across much of their range. They include cities, villages, roads, tourist sites, agriculture, and temple sites (Fooden 1995; Muroyama and Eudey 2004; Gumert *et al.* 2011a). In anthropogenic areas, long-tailed macaques are often provisioned, which increases population sizes locally. In these circumstances they face human-macaque interactions, and risks of bi-directional pathogen transfer and other health issues, creating a platform for a range of conflict possibilities (Engel *et al.* 2002; Chapman *et al.* 2005; Lane *et al.* 2010; Hambali *et al.* 2012; Ilham *et al.* 2017). In urban and recreational areas, long-tailed macaques are often provisioned on roads and therefore risk collision with vehicles. In Malaysia, a study found that long-tailed macaques endured the second highest number of animal-vehicle collisions of all species surveyed (Kasmuri *et al.* 2020).

Governments in countries with human-macaque conflicts are tasked with mitigating them, often with negative consequences for the macaques. In the last ten years, both Malaysia and Singapore initiated substantive culling actions against the macaques, with Singapore culling approximately one-third of their population in 2013 and 2015 according to Agri-Food and Veterinary Authority reports (for example, Riley *et al.* 2015). In 2017, the Indonesian Ministry of Forestry and Environment created a macaque-conflict mitigation task force and called for data on conflicts across Indonesia (R. M. Wiwied Widodo pers. comm. 2018). While these data have yet to be released, the government issued a statement in 2018 allowing the culling of long-tailed macaques in conflict zones (Hardiyanto 2018). Even though population sizes of long-tailed macaques are widely unknown, culling is a reoccurring practice across their range, and the number of individuals culled is often not revealed (Riley *et al.* 2015). The long-term implications of removing individuals from groups through culling and other forms of population control, harmful human activities such as trapping, and human-macaque interactions have yet to be fully investigated and understood. Whether it be selecting individuals randomly or targeting certain personalities, it may affect the population, possibly changing group dynamics, affecting individual health, changing selection pressure and survival rates, and reducing cultural variability (Gumert *et al.* 2011b). While understanding the behaviors of individuals is believed to increase the effectiveness of certain wildlife management strategies that are destined to reduce human-wildlife conflict (Balasubramaniam *et al.* 2020), this would involve studying populations in greater detail than is common for long-tailed macaque populations in conflict situations.

Human-macaque conflict task forces have been created in Thailand and in Singapore involving governments, NGOs and researchers collaborating to resolve human-macaque conflicts and sharing knowledge on macaque behavior (Tan

2017; Jane Goodall Institute (Singapore) (JGIS) 2020; New York Times 2020). In Sumatra, researchers have called for more research into the effects of provisioning and management on urban macaque populations to avoid conflicts from escalating (Ilham *et al.* 2017).

Long-tailed macaques captured from the wild are also used in aspects of popular entertainment. As an example, the “*Topeng Monyet*” or “Masked Monkey,” which consists of the use of macaques for street performances. *Topeng monyet* is a folkloric tradition in Java, and until recently hundreds of macaques were used by its practitioners, but it is now an illegal practice in Jakarta (2013) and in East Java Province (2015) (Jakarta Animal Aid Network – JAAN 2019; Rahman 2019). What effect this specific practice has had on wild macaques is unknown, but it is likely that it either added to their capture in the wild or added to the demand for them in local animal markets, or both.

### Perception as Pests

The interface with humans has led to long-tailed macaques being classified as pests and as a ‘weed species’ (Richard *et al.* 1989; Muroyama and Eudey 2004). Richard *et al.* (1989) divided the different species of macaques into weed or non-weed species according to their ability to exploit human-influenced areas. They were aware that this could cause negative connotations yet may not have known that the classification would last. Terminology applied by researchers regarding macaques may have important psychological and practical impacts on the field, discouraging students and others from focusing on this species, and restricting access to funding for their study (in behavioral, ecological and conservation contexts). Terminology such as weeds and pests might also affect local communities and tourists, convincing them that this species is not in need of conservation efforts or attention.

Studies on the ecology of non-provisioned long-tailed macaques are few and of older origin (for example, Van Schaik *et al.* 1983; Corlett and Lucas 1990; Fooden 1995; Engelhardt *et al.* 2005). Long-tailed macaques are perceived as common, and this may reduce conservation and research efforts (Radhakrishna and Sinha 2011). Primate conservation funding tends to prioritize primates classified as threatened with extinction, and the classification as ‘Least Concern’ on the IUCN Red List until now (Ong and Richardson 2008) has undoubtedly contributed to a lack of funding for research on this species (Gumert 2011).

The use of negative terminology regarding long-tailed macaques in media, may be another important trigger of negative perceptions and connotations amongst the public. For instance, from 166 news items about long-tailed macaques collected from Indonesian media sources between 2017 and the present, only 30 were considered to invoke positive connotations (Karmele L. Sanchez pers. obs.). With the use of words in headlines such as “attack,” “bite,” and “destroy”





**Figure 1.** Female common long-tailed macaque (*Macaca fascicularis fascicularis*) grooming an infant. Baluran National Park, East Java, Indonesia. Photograph by Ventie Angelia Nawangsari.

in the interface context, media might be perpetuating a perception of macaques as dangerous pests. We are currently looking into media presentation of long-tailed macaques in Hong Kong, and so far, results are similar to those from Indonesia (Chris Pawson pers. comm. 2019).

### The Legal Trade

The international primate trade peaked in many countries across Southeast Asia in the decades up to and including the 1970s with, for instance, India alone exporting ~50,000 live wild-caught primates per year throughout the 1960s (Nijman *et al.* 2011). While the international trade in all primate species has been regulated since the ratification of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the legal and illegal trade in primates remains a significant threat to primate species throughout Southeast Asia (Nijman and Healy 2016; Estrada *et al.* 2017). In a survey conducted by Shepherd (2010) on primate trade in Indonesian wildlife markets between 1997 and 2008, long-tailed macaques were found to be the most heavily traded primate species. Similarly, Nijman *et al.* (2017) reported that this species was the most traded in Indonesian wildlife markets between 2012 and 2014. The long-tailed macaque is the predominant species in the international trade in live primates for research. From 2008–2019, at least 450,000 live long-tailed macaques (captive and wild-caught), and over 700,000 specimens (a broad-ranging term that can include tissue or blood samples,

body parts or hair) from an unknown number of long-tailed macaques were part of this trade, with over 50,000 identified as wild-caught (specimens and live) (CITES Trade Database 2021). Indonesia started the export of macaques for biomedical research in the early 1970s, peaking in the late 1980s, which motivated the establishment of farms and breeding facilities across Indonesia to supply the growing industry (Shepherd 2010). In 2009, trapping of wild-caught individuals for breeding center upkeep and national research increased, with permits to trap 15,100 individuals (5,100 in 2008) (SSN 2012). Local communities, however, said that often more individuals were caught than allowed (BUAV 2009; SSN 2012). Since 2016, the quota for wild-caught macaques in Indonesia has been zero (KLHK 2020) but, in 2019, the Ministry of Forestry and Environment in Indonesia revealed a desire to conduct the capture of wild long-tailed macaques from conflict areas to be exported abroad (Karme L. Sanchez pers. obs.). The Philippines also intends to reinstate the harvesting of wild long-tailed macaques for breeding centers (BM 2020). This may not be sustainable, and research into the population status and attempts to mitigate these conflicts should commence as soon as possible.

The trade uses biomedical purposes as the main reason for the exploitation of macaques, although trade demand in Indonesia is mostly local rather than international and most macaques may, therefore, be destined for the pet trade (Shepherd 2010). Within the domestic pet trade long-tailed macaques are usually sold as infants or juveniles

after having been trapped using nets (Nijman *et al.* 2017), sometimes in locations where macaques are considered a nuisance. Together with the pig-tailed macaque (*Macaca nemestrina*), they are the only primate species in Indonesia that are not yet included in the list of protected species (MLHKR Indonesia 2018) even though trade is one of the main causes of their exploitation.

Following a CITES review of significant trade in species, in 2014, Laos, Vietnam and Cambodia were subjected to a review of trade in long-tailed macaques (CITES 2014). In 2016, a CITES notification to all the parties recommended a suspension of trade with Laos in long-tailed macaques following unresolved concerns about its legality (CITES 2016). Vietnam has been identified as a center for the illegal laundering of wild-caught long-tailed macaques into breeding centers. It is suggested that stocks of long-tailed macaques are supplemented by a network of wholesalers that harvest wild macaques from Laos, Cambodia and Myanmar (Hoang 2008; Hamada *et al.* 2010).

The global demand for live macaques for biomedical testing and related uses inevitably provides incentives to supply this market, likely with substantive consequences for local populations of macaques. In Cambodia, the high price that dealers will pay for wild-caught macaques, which are then laundered to new commercial farms (Eudey 2008; SSN 2012) or illegally smuggled into Vietnam and China (SSN 2015a; SSN 2015b), has possibly led to the unrecorded extirpation of long-tailed macaques in much of the country (Lee 2011; SSN 2015b). The temptation to supplement low rural income with a side-line in trapped long-tailed macaques may be increasing despite the widespread global availability of captive-bred macaques. In 2004–2006, Cambodian farmers were paid about US\$50 for each live animal they sold to dealers, which at that time was more than twice the average monthly rural wage (Rawson 2010; Lee 2011). The export price was ~US\$ 460 according to industry insiders. By 2016, the international export price had increased to ~US\$2800. According to an industry insider, one potential market for these illegally traded macaques from Cambodia is the booming biomedical start up sector in China where wild-caught macaques are used for proof of concept-testing as prices undercut captive-bred specimens from Chinese farms (Mike Gill pers. obs.). Given that the same European broker reported a 25% growth in units per year in 2018, price pressure as an incentive for illegal trade in wild-caught macaques is unlikely to be alleviated anytime soon.

We urge journal editors and funding agencies to demand proof of origin for long-tailed macaques used in research to ensure their conservation and welfare and to ensure high quality results.

The European Union importers are not required to monitor nor inspect the breeding farms from which they acquire the macaques (EU Directive 2010/63), and therefore even wild-caught and illegally traded long-tailed macaques may be imported into the EU on false papers. Additionally, discrepancies in the CITES data system, as described by the

United Nations Environment World Conservation Monitoring Centre (UNEP-WCMC) CITES Trade Database Guide (UNEP-WCMC 2013), may be detrimental to this species, allowing the perpetuation of a system that legalizes potentially exploitative trade. Furthermore, animal welfare may be compromised at these breeding facilities since they lack systems to ensure they fulfil minimum welfare standards. As the need for long-tailed macaques in research does not seem to decrease, we urge practitioners to follow the three Rs (Replace, Reduce and Refine: see Understanding Animal Research. 2020), especially Reduce, and to source only from monitored and inspected high quality facilities.

## CoVID-19

Long-tailed macaques are heavily traded for biomedical research as discussed above, and with the CoVID-19 pandemic and a need for vaccines and treatment, the trade is not likely to diminish. Currently, China has ceased exportation of long-tailed macaques, and the USA is voicing concerns over problems importing long-tailed macaques through China (The Atlantic 2020; The Times 2020). However, illegal trade may have increased, as recent confiscations indicate (ABS-CBN 2021; PAREPOS 2021), possibly due to the increased demand and the lack of focus and enforcement during the pandemic. Long-tailed macaques are susceptible to SARS-CoV strains (Rockx *et al.* 2011), and are used for research into the spread of SARS-CoV2 and treatment of CoVID-19 (Rockx *et al.* 2020). Their susceptibility endangers them in terms of increased demand for laboratory research and due to their proximity to humans in many human-macaque interfaces. If infected in the wild they can infect other group members as well as become a reservoir for the virus, thus potentially infecting other humans (Liu 2020). When infected they show only mild symptoms (Rockx *et al.* 2011). Researchers now advocate to expand protection efforts of wild populations of non-human primates to include macaques (Liu 2020). An unexpected outcome of the current pandemic on long-tailed macaques has been the effects of lockdown on provisioned groups. Lockdown has decreased tourism tremendously and may be leaving many provisioned groups hungry and starving. Thailand has reported problems with aggression in formerly provisioned macaques as they search for food in and around their habitats, which for many includes villages, towns and temples (The Guardian 2020).

## Conclusion and Perspectives

In the Anthropocene, we need new lenses to understand synanthropic species such as the long-tailed macaque. We also need to reassess our way of evaluating conservation status and ecological importance. We currently focus on the smallest populations of the least adaptable species, which may not be sustainable. We are in need of species-specific and perhaps even area-specific approaches to conserve

primate species (Estrada *et al.* 2017; Bezanson and McNamara 2019). In our efforts to conserve the smallest populations of the least adaptable species, we unintentionally portray adaptable species as unimportant, as least concern, which affects human perceptions of these species.

Long-tailed macaques easily adapt to human settings. However, this is not enough to ensure their longevity in the wild as a species, especially at a time where they are being culled and harvested at high rates and experiencing diverse threats. Because of the intense use of long-tailed macaques for biomedical research and its economic impact, the demand for them will continue into the foreseeable future. Many areas inhabited by long-tailed macaques are not protected, as protected areas mostly contain habitats without human influence (Joppa and Pfaff 2009). A recent study on the bias in research sites and species, revealed that much primate research does not take the ecological complexity of species into consideration (Bezanson and McNamara 2019), and thereby reduces the foundation on which important decisions are made. Long-tailed macaques inhabit many different areas across Southeast Asia, and exhibit diverse ‘cultures’ across their range, such as for example tool use (Luncz *et al.* 2019) and ecological functions such as seed dispersal (Lucas and Corlett 1998), leading to a need for different management approaches across sites. Yet we still know very little about free-ranging long-tailed macaque behavior and population ecology, and more research is needed, especially in the form of systematic surveys on population size, and ethnographic surveys on the perception of local human communities regarding long-tailed macaques. Before effective management plans can be implemented, we need more information and we need to include all stakeholders, especially local communities (Larrosa *et al.* 2016).

It is important to change our discourse and terminology when assessing and understanding human-other animals’ relations in the Anthropocene, most especially in the case of such intensively synanthropic species as the long-tailed macaques. Words such as “natural” and “unnatural”, “endangered” and “non-endangered” may not offer sufficient nuance and scope to be relevant in this context. We encourage all researchers working in the range of long-tailed macaques to contact us if they wish to share information regarding the population ecology of long-tailed macaques at their field site, be it presence points, camera-trap footage or other useful information. Our objectives and recommendations for future research and action:

- Conduct population censuses across all habitat types including synanthropic and non-synanthropic groups of long-tailed macaques.
- Investigate the perception of long-tailed macaques with policy makers and in literature, media, and in human-macaque interfaces. This will enable the pinpointing of areas in need of macaque management, knowledge sharing and collaboration with involved agencies, institutions and local communities.

- Compare the culture and behavior of synanthropic and non-synanthropic groups.
- Research the effects of synanthropic long-tailed macaque groups on ecosystems and sympatric species. Here we also urge more research into zoonotic pathogen transfer between wild long-tailed macaques and people and wild long-tailed macaques and sympatric species, especially and urgently to SARS-CoV2.
- Develop new criteria for assessing threatened status of wildlife species, especially synanthropes. Here we propose to include human-influenced areas as well as areas without human-influence. We also propose to include both protected and non-protected areas. In all areas, we propose area-specific population censuses, ensuring that densities from human-influenced areas are not extrapolated to areas without human influence and vice versa.
- Develop a clearer and simpler way of reporting trade numbers through CITES, where actual numbers are reported and import certificates created at the same time as export certificates, also within trade regions such as the European Union. When assessing legal international trade amounts, national trade amounts should also be assessed and incorporated to ensure international trade numbers do not exceed long-tailed macaque population capacity. Urgently, we need to assess the amounts traded for biomedical research into CoVID-19 vaccines.
- Disseminate knowledge of the new conservation status of Vulnerable and divulge the results of future census surveys to policy makers in long-tailed macaque habitat countries to enable the creation of new more sustainable management initiatives and trade policies.

## Acknowledgments

We are very grateful to the governments in long-tailed macaque habitat countries for allowing us to visit, cooperate and conduct research over the past many years. We are also grateful to all local communities that have helped us, accommodated us and shown interest in our activities. Finally, we thank the importers of the EU for their cooperation and Michael D. Gumert for his careful, detailed and most helpful review.

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*Submitted for publication:* 11 September 2020  
*Revised:* 17 January 2021