



OVERVIEW

Conservation and ecology of the neglected slow loris: priorities and prospects

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ABSTRACT: Slow lorises *Nycticebus* spp. have one of the widest distributions of any nocturnal primate species, occurring in 14 Asian countries; yet, in terms of their taxonomy, ecology and distribution, they remain amongst the least known of any primate taxa. Eight species are now recognised; 5 of these have been listed in the IUCN Red List as Vulnerable or Critically Endangered, with 3 Not Assessed. Threats to these primates not only include habitat loss, but the illegal wildlife trade. Slow lorises are highly desired in traditional medicines, and as pets both nationally and internationally. In this Theme Section (www.int-res.com/journals/esr/esr-specials/conservation-and-ecology-of-slow-lorises), we bring together 13 studies on several key topics. We present survey data from the Indonesian island of Java, from Malaysian Sabah on the island of Borneo, from northeast India and from Singapore. All of these studies concur that slow lorises occur at low abundance, but that, where they are left alone, they can also persist in anthropogenically modified habitats. We present novel data on the feeding ecology of slow lorises, reifying that these primates are obligate exudativores. Such data are vital for keeping lorises in captivity; in 3 studies, an exudate-based diet is shown to improve health and reduce behavioural abnormalities. We show that local knowledge can provide vital data regarding slow loris distribution and in helping with conservation programmes for these taxa. The illegal trade for slow lorises is consistently brought up as a threat, and another contribution shows that a similar trend is also occurring with their phylogenetic relatives in Africa, the pottos. We highlight several areas where more research is needed and provide suggestions to fill those gaps.

KEY WORDS: Primate conservation · *Nycticebus* · *Perodicticus* · *Arctocebus* · Loris · Illegal wildlife trade · Census techniques · Ethnozoology

BACKGROUND

Catastrophic forest decline coupled with a rampant illegal wildlife trade poses a serious threat to biodiversity in most Southeast Asian countries (Sodhi et al. 2010). The impact of these factors on mammalian groups has been stated broadly, but also studied for many taxa at a more specific level, especially for charismatic ones such as elephants (Wittemyer et al. 2014), tigers (Nijman & Shepherd 2015) and orang-utans (Cattau et al. 2014). To conserve such animals, many conservation organisations have attempted to

give these threats to biodiversity loss a 'face' that can be associated with it—such as golden lion tamarins for forest fragmentation, elephants for human wildlife conflict, or orang-utans for forest loss due to palm oil plantations (Dietz et al. 1994, Leader-Williams et al. 2000, Bandara & Tisdell 2005).

The slow lorises *Nycticebus* spp. are another heavily threatened group of Asian mammals. Forest loss plays a role in the decline of these nocturnal primates, yet it is illegal trade that is rapidly devastating their numbers throughout their range (Shepherd et al. 2005, Starr et al. 2010a), and some organisations

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have already begun to recognise slow lorises as the 'face' representing illegal wildlife trade. Slow lorises are used for multiple purposes in trade. In many Asian countries, they are considered to cure up to 100 ailments, and, as such, animals are caught and killed for their perceived medicinal value (Starr et al. 2010a). The pet trade in slow lorises thrives both nationally and internationally. Not only are they kept in private homes, but captive lorises are also used as 'photo-props', whereby tourists in bars, clubs and on beaches may take their photo with wild-caught animals. Until recently, these primates were virtually unknown to the general public, but in the last few years a phenomenon has grown around slow lorises on the Internet, where videos of mostly wild-caught and illegally obtained slow lorises kept as pets are viewed by millions. These 'cute' slow loris videos are among the most viewed wild animal videos on social networking sites, which, in turn, increases the desirability of owning a slow loris as a pet (Nekaris et al. 2013a). Despite the risk of such a platform, there is now great potential for harnessing this medium to raise awareness of the plight of slow lorises and for providing education to the public about the threat of the illegal wildlife trade. The appeal of these teddy-bear like primates with forward-facing eyes has the potential to create empathy, making slow lorises a suitable animal to put a 'face' to the increasing international threat of the illegal pet and photo-prop trade (Nekaris & Campbell 2012).

It is the illegal trade that finally brought slow lorises to the attention of the conservation community. The large number of slow lorises observed in illegal trade has resulted in changes over the last 10 yr in the way international bodies and organisations view slow lorises. In 2007, the genus *Nycticebus* was transferred to Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), precluding all international trade in the species, their parts, or their derivatives (Nekaris & Nijman 2007). In 2008, the 5 then-recognised species were all listed as Vulnerable or Endangered on the IUCN Red List, whereas prior to that time the only 3 species recognised were listed as Near Threatened. In 2013, one new species of slow loris (the Kayan slow loris *N. kayan*) was described and 2 other earlier described forms (Sody's slow loris *N. bancanus* and Bornean slow loris *N. borneanus*) were elevated to the species level (Munds et al. 2013b). These 3 species still have to be formally assessed according to IUCN threat criteria, but, in 2013, a reassessment of the Javan slow loris *N. javanicus* concluded it should be considered as Critically Endangered (Nekaris et al.

2013c). All countries where slow lorises occur provide some level of legal protection for these species (Table 1), yet, in most of them, slow lorises continue to be traded openly, with little evident enforcement (Starr et al. 2010a, Nijman et al. 2014).

Illegal trade has a multitude of implications that highlight our lack of understanding of slow lorises in the wild. First, sparse data on the species' distribution and abundance make understanding the impact of trade challenging (Nekaris & Nijman 2007). Secondly, a lack of ecological field data impedes optimum husbandry in captive facilities, which may be required for caring for rescued animals, as well as developing insurance populations. Information required includes basic data such as what to feed slow lorises, how to house them and knowledge of what type of habitat is best for releasing them (Streicher 2004). Thirdly, limited understanding of slow loris taxonomy confounds attempts to reintroduce these animals or hold them or breed them in captive facilities (Schulze & Groves 2004). In this Theme Section, the first ever edited contribution dedicated to slow loris conservation, we attempt to fill some of these gaps and to highlight areas where further research is necessary.

Perhaps because of their nocturnal nature or their occurrence in areas where study is difficult due to nocturnal predators or human insurgence, the family Lorisidae remains amongst the least known of all the primates (Nekaris & Bearder 2007), with only a handful of published studies in recent years (Fig. 1). Currently Lorisidae comprises 3 species of potto (*Perodicticus*), 2 species of golden potto or angwantibo (*Arctocebus*), and 2 species of slender loris (*Loris*), all of which probably contain unrevealed diversity, even at the family level (Pozzi et al. 2014). In terms of the slow lorises, 1 genus (*Nycticebus*) comprises a group of 8 currently recognized species that range in 14 Asian countries (Table 1) (Groves 2001, Munds et al. 2013b). Again, evidence for multiple genera and species within slow lorises is mounting, and revisions are expected (Nekaris & Jaffe 2007, Pozzi et al. 2014). Morphologically unique (Fig. 2), the lorisids are characterised by large forward-facing eyes, a vice-like grip with a shortened second digit, a short tail, species-specific facial markings, and short woolly fur, a suite of characteristics that has long been of interest to morphologists (Ishida et al. 1992, Kingston et al. 2010, Nekaris 2014). Classified as arboreal slow climbers, lorises and pottos cannot leap, but instead bridge between gaps in the forest canopy and dense underbrush in tree fall zones (Sellers 1996). Despite their extreme arboreal adaptations, lorises and pottos

Table 1. *Nycticebus* spp. Currently recognised slow loris species including their conservation status on the IUCN Red List, their range countries and the laws governing their protection in each country

Name(s)	Conservation status	Range countries	Legislation
Javan slow loris (<i>N. javanicus</i>)	Critically Endangered (CR)	Indonesia (Java)	Protected by the Act of the Republic of Indonesia No. 5 of 1990 Concerning Conservation of Living Resources and Their Ecosystems which prohibits to catch, injure, kill, store, possess, nurture, transport and trade protected animals in live or dead condition. Exceptions from prohibition can only be made for the purpose of research, science, salvage of the animal species, or in cases when the animal endangers human life.
Bengal/northern/ashy slow loris (<i>N. bengalensis</i>)	Vulnerable (VU)	Bangladesh Bhutan Cambodia China	Protected by the Bangladesh Wildlife (Prevention) Order of 1973 (Amendment 1974) in its Third Schedule of protected animals that shall not be hunted, killed, or captured. Protected by the National Environment Protection Act (2007) that penalizes any direct or indirect harm to the environment involving removal, destruction of, or damage to indigenous animals. Protected by Declaration 359 of the Ministry of Forestry and Fishery on Wildlife Species to be Prohibited for Hunting (1994). Protected by the Law of the People's Republic of China on the Protection of Wildlife (1989) as First Class Protection. Catching of slow lorises can only be done for necessary scientific research, domestication and breeding, exhibition, or other special purposes with a license given by the Wildlife Administration of the State Council.
		India	Protected by the Indian Wildlife Protection Act of 1972 (amended 2002) in its Schedule I, Part I, corresponding to the species of absolute protection.
		Laos	Protected by the Wildlife and Aquatic Law (2007) that classifies slow lorises under the 'prohibition' category. Hunting wildlife from the 'prohibition category' is totally banned without previous authorisation from the Ministry of Agriculture and Forestry.
		Myanmar	Protected by the Protection of Wild Life, Wild Plants and Conservation of Natural Areas Law that bans hunting without a license.
		Thailand	Protected by the Wildlife Protection of 1992 that regulates hunting, propagating, possessing and trading wildlife or their carcasses.
		Vietnam	Protected by the Decree 32 Group IB (2006) that prohibits their commercial exploitation and use. A permit is required for scientific and conservation purposes.
Philippine slow loris (<i>N. menagensis</i>)	Vulnerable (VU)	Brunei Darussalam Indonesia Malaysia (Sabah) Philippines	Wildlife Protection Act (1981) states that slow lorises are protected species that cannot be hunted without a license. In Wildlife Sanctuaries shooting, hunting, killing, capturing, or taking any animal is completely prohibited. As for Indonesia above. Totally Protected Species as stated in the Wildlife Conservation Act (2010) Act 716. Zoos, commercial captive breeding, circus, wildlife exhibition, research and hunting of slow lorises of individuals or parts of them also needs a special permit. Protected by the Wildlife Resources Conservation and Protection Act (2001). Only accredited individuals can possess slow lorises for scientific, conservation, or breeding purposes. Commercial breeding may be allowed if minimum requirements are provided. Killing wildlife is prohibited unless it is for rituals of indigenous communities. Trading of wildlife is prohibited. Collecting, hunting, or possessing wildlife and derivatives is prohibited.

Table 1. (continued)

Name(s)	Conservation status	Range countries	Legislation
Sunda, greater slow loris (<i>N. coucang</i>)	Vulnerable (VU)	Indonesia Malaysia (Peninsular)	As for Indonesia above. The primary wildlife legislation for Peninsular Malaysia is the Protection of Wild Life Act 1972 (Act No. 76), which is enforced by the Department of Wildlife and National Parks Peninsular Malaysia. Slow lorises are protected under Schedule 1 (Totally Protected Wild Animals) of the Protection of Wild Life Act 1972 (as revised 2007).
Pygmy, lesser slow loris (<i>N. pygmaeus</i>)	Vulnerable (VU)	Singapore Thailand Cambodia China Laos Vietnam Indonesia	Prohibited as pets by the Agri-food and Veterinary Authority of Singapore. Trading is illegal without a permit as stated in the Endangered Species (Import and Export) Act (2006). Hunting without a license is penalized as stated in the Wild Animals and Birds Act. As for Thailand above. As for Cambodia above. As for China above. As for Laos above. As for Vietnam above. As for Indonesia above.
Sody's slow loris (<i>N. bancanus</i>)	Not assessed	Indonesia	As for Indonesia above.
Bornean slow loris (<i>N. borneanus</i>)	Not assessed	Indonesia	As for Indonesia above.
Kayan slow loris (<i>N. kayan</i>)	Not assessed	Indonesia Malaysia (Sabah, Sarawak)	As for Indonesia above.

are found in numerous habitats, from primary forest to coastal forests, montane forests, disturbed agroforests and suburban gardens (Nekaris 2014). How these traits function ecologically is slowly being revealed based on several long-term field studies (Wiens 2002, Streicher 2004, Pimley et al. 2005, Nekaris 2006, Starr & Nekaris 2013, Das et al. 2014, Rode-Margono & Nekaris 2014) and a handful of short-term observations (e.g. Pliosungnoen et al. 2010, Swapna et al. 2010, Rogers & Nekaris 2011).

Of all the lorises, the number of studies of slow lorises has increased the most rapidly in recent years (Fig. 1), in part in response to their dire conservation status (Nekaris 2014). Slow lorises are relatively gregarious primates, living in pairs with 1 to 4 offspring, covering home ranges from 3 to 35 ha (Nekaris 2014). In terms of diet, slow lorises are gouging specialists, and their lower front teeth comprise a unique toothcomb that allows them to anchor their teeth into bark to produce holes from which exudates emerge and are licked by a long tongue (Nekaris et al. 2010, Streicher et al. 2012). The long tongue also facilitates consumption of nectar, whereas the toothcomb is related to another unique slow loris feature — they are the only venomous primates (Alterman 1995). By mixing oil from the brachial gland in their mouth, slow lorises use their powerful toothcomb to inject venom into their victims (usually another slow loris), or lick their fur with the compound, seemingly to reduce ectoparasites (Nekaris et al. 2013b, Grow et al. 2015).

Locating suitable field sites to study slow loris ecology is often challenging. Barrett (1981), who attempted the first systematic study of slow lorises in the wild, spent >15 mo before finding a study site, at which he still could not easily see or catch slow lorises. Wiens (2002) spent several periods in Malaysia over 4 yr simply attempting to trap slow lorises in order to radio collar them, and managed to observe animals for just 600 h, and with many individuals being followed continuously for <3 mo. Starr et al. (2010b) spent 12 mo surveying both for the Bengal slow loris *N. bengalensis* and the pygmy loris *N. pygmaeus* before finding a site with enough animals to study; even in

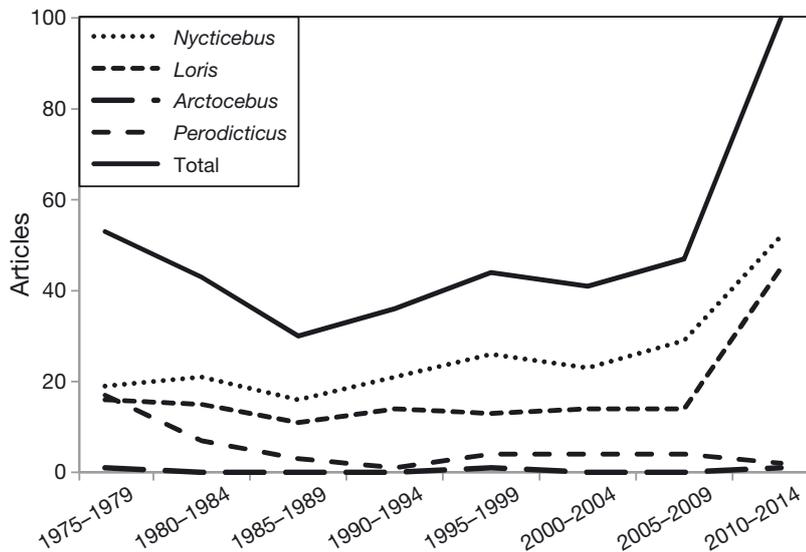


Fig. 1. Lorisidae remain amongst the least-studied primate family. Based on a Web of Science search since 1975 of any type of publication dealing with these primates (including morphological, molecular and captive work), on average only 6 publications per year per genus have been published, and for some genera and species, still virtually nothing is known



Fig. 2. *Nycticebus javanicus*. Slow lorises display numerous unique morphological characteristics. Some of these, illustrated by the Javan slow loris, include (clockwise from top left): a strong pincer-like hand with reduced second digit; stout sharp toothcomb used for gouging, grooming and injecting venom; a unique posture, whereby the arms are clasped above the head, allowing the animal to combine brachial oil and saliva to produce venom; dark facial markings that are species specific

this case, an additional 6 to 8 mo was required to capture animals successfully, and numerous tagged animals were lost to the illegal medicine trade.

Many early surveys of slow lorises merely reported presence or count data (e.g. Fitch-Snyder & Vu 2002). Nekaris et al. (2008) reviewed quantified survey re-

sults until 2007 including survey data from 36 sites in Indonesia, Laos, India and Malaysia (see also Evans et al. 2000). Since then, numerous research groups have published their survey results, including results from India (Radhakrishna et al. 2006, 2010, Das et al. 2009, 2015, Nandini et al. 2009), Thailand (Pliosungnoen et al. 2010) and Cambodia (Starr et al. 2010a,b, Coudrat et al. 2011). Most of these surveys cover only single sites or a small number of sites within a restricted part of each respective species' range, thus leaving gaps in our knowledge of their distribution. Slow loris populations in several countries remain virtually unknown, and surveys of Bhutan, Bangladesh, China, Myanmar, Vietnam, the Philippines and the islands of Sumatra (Indonesia) and Borneo (Indonesia, Malaysia and Brunei) are urgently needed. Several questions remain unanswered, including where the range of the greater slow loris *N. coucang* ends and is replaced by the Bengal slow loris; which species of slow lorises are sympatric with each other and where; whether some of the populations that live isolated on the many islands (including some relatively large ones) represent distinct species and what their phylogenetic relationships with the other slow lorises are and what are realistic estimates of population sizes in the wild for each of the slow loris species.

CURRENT KNOWLEDGE AND CONTRIBUTION OF THE THEME SECTION

In this the section, contributors provide the first population data for slow lorises in several parts of their range. Voskamp et al. (2014, this Theme Section) found Javan slow lorises at 9 out of 14 sites across the island of Java. These authors not only increased the known range of the Javan slow loris *Nycticebus javanicus* to include eastern Java, but also found that this Critically Endangered species can persist in areas heavily dominated by humans, particularly agro-

forests. Also on Java, Nekaris et al. (2014, this Theme Section) focused on a single area on Mount Gede Pangrango; they make recommendations on how to conduct further surveys, including taking into account the speed at which surveys are conducted as this factor can influence the number of animals seen. Munds et al. (2013a, this Theme Section) provide the first abundance estimates of Philippine slow lorises *N. menagensis* in Sabah, from the Lower Kinabatangan Wildlife Sanctuary. Along with reviewing the scanty abundance data available in areas where slow lorises and tarsiers (*Tarsius*) occur allopatrically or sympatrically, they conclude that competition may not only drive slow lorises to higher levels of the canopy when these genera occur in sympatry, but also that the abundance of tarsiers seems to decrease when the 2 genera are together. The poor visibility of nocturnal animals in the high Bornean canopy may explain why previous surveyors (Nekaris et al. 2008) had difficulty in detecting slow lorises there. Fam et al. (2014, this Theme Section) provide the first concerted effort to ascertain if wild slow lorises still occur in the island nation of Singapore. Despite field observations and collated data collected between 2008 and 2013, only 1 potential wild greater slow loris was seen, as well as an individual of the non-native pygmy loris, highlighting the concerns about the release of invasive species by people who no longer want the illegal animals as pets or by the authorities after the confiscation of such animals. All of these studies are first efforts to understand slow loris abundance and distribution, but they also show that slow loris species are not as widespread and abundant as previously assumed.

When trying to study a species for the first time in the wild, local people remain an excellent source of information to understand species distribution, ecology and how conservation programmes should be conducted. For example, Starr et al. (2010a) showed that local ecological knowledge of pygmy loris strongly corroborated ecological field data in eastern Cambodia. In the case of the nocturnal slow loris, they are often surrounded by myth and intrigue, are considered human-like or imp-like and are rarely seen (Nekaris et al. 2010). Svensson & Friant (2014, this Theme Section) use local knowledge to examine the plight of slow lorises' African relatives, pottos and angwantibos. Despite all African lorises currently considered Not Threatened according to IUCN threat criteria, Svensson & Friant (2014) showed that they face parallel threats to those of Asian lorises, including their use in traditional medicine and as a non-targeted hunted animal. As with slow lorises, this incessant hunting means that animals are killed throughout the

year, without respect to birthing or rearing seasons, as well as without respect to off-take, making them one of the most commonly hunted primates in parts of West Africa, just as slow lorises are in parts of Indochina (Starr et al. 2010a). Nijman & Nekaris (2014, this Theme Section), who worked with 12 Sundanese communities in West Java, also use local knowledge to gain insight into the biology and conservation of slow lorises. They found that beliefs about slow lorises differ throughout the region, with some areas having taboos against catching them as pets, others having strong beliefs about the venomous properties of slow lorises and yet others seeing slow lorises as vital commodities. Nijman & Nekaris (2014) suggested that such data, and understanding local differences in attitudes, are vital for establishing conservation projects. Local knowledge can also lead to intriguing hypotheses about the behavioural ecology of animals. In the case of slow lorises, just as has been shown for the poisonous pitohuis of New Guinea (Dumbacher et al. 2004), local people are very familiar with the unusual venomous nature of these primates, impacting their conservation.

Das et al. (2014, this Theme Section) also considered the ecology of Bengal slow lorises from the Gibbon Wildlife Sanctuary in Assam, northeast India, in light of local knowledge. Based on >18 mo of field data, they show that Bengal slow lorises predominantly consume exudates from 5 species of trees that are also used in local Ayurveda medicinal practices. They suggest that the association of Asian lorises with various medicinal plants may have been the starting point of the rampant use of slow lorises in traditional medicines in Asia (cf. Starr et al. 2010a). Their study also reaffirms the vital importance of exudates in the diet of slow lorises (Nekaris et al. 2010). Replicating an animal's natural diet in captivity is vital for its health; however, despite numerous studies providing irrefutable evidence that slow lorises are specialized exudate feeders, most captive facilities have not yet changed their traditional practices of feeding lorises a largely fruit-based diet. In their study, Cabana & Plowman (2014, this Theme Section) show that by feeding pygmy lorises reared at a UK zoo a diet based on field evidence, abnormal behaviour decreased and desirable behaviours such as travelling and feeding increased, and that the study subjects found the naturalised diet far more palatable. Similarly Gray et al. (2015, this Theme Section) also examined exudate consumption in wild-caught slow lorises (*N. javanicus*, *N. coucang*, *N. menagensis*) confiscated from the pet trade. Because of a destructive and cruel practice, whereby traders clip out the gouging teeth of slow

lorises to prevent them from biting, many confiscated animals no longer have the faculty to gouge. Gray et al. (2015) thus trialled a series of gum-based enrichments also designed to suit animals that no longer had teeth. They found that the enrichment devices prolonged feeding and foraging times, and also gave the animals more opportunities to spend time off the floor, where they were more likely to exhibit stereotypic behaviours. Finally, Fuller et al. (2014, this Theme Section) reviewed 30 yr of mortality data of pottos and slender and slow lorises in North American zoos. The taxonomy of lorises in captivity has still not caught up with genetic and morphological assessments of the diversity within the Lorisidae (Nekaris 2014); it is thus not surprising that the majority of deaths in North American zoos were of neonates, which were likely to be hybrids between various species. Amongst older animals numerous pathologies occurred that again link back to a poor-quality diet in these animals, not excluding severe dental trauma (see also Streicher 2004). All of the above researchers point towards the extreme importance of consulting field data when attempting to keep animals in captivity. Further studies should examine if species-specific protocols are needed, or if a general captive regime is suitable across *Nycticebus* spp.

Understanding the behaviour of slow lorises is also vital when considering the fate of the many animals confiscated from the pet trade. The thought of reintroducing these animals back to wild habitats is appealing, but, until now, assessment of slow loris releases has been minimal (but see Streicher et al. 2003, Collins & Nekaris 2008), and media reports indicate that hard releases of slow lorises are rampant. For example, the misconception that these animals are slow and solitary has led to their release in very small forest areas in large numbers, release with no monitoring, solitary release, release of non-endemic species, release into areas where no ecological assessment has been made, and/or release into areas where no health checks have been made of the releasees or of the wild slow lorises in the local area. Moore et al. (2014, this Theme Section) reviewed the difficult choices to be made when releasing slow lorises, and also provide data on survival rate from Javan and greater slow lorises from Indonesia. Similarly, Kenyon et al. (2014, this Theme Section) provided an overview of 2 yr of releases of pygmy lorises in Vietnam. Both these studies showed the intensive amount of work needed for a reintroduction programme in terms of funds, manpower and time, yet both studies showed high death rates despite careful attendance to various aspects of the IUCN Guide-

lines for Translocations (IUCN/SSC 2013). In both cases, at the time of the study, no data were available from wild populations of the species that were released, one of the most important suggestions made by the IUCN when releasing an animal to the wild. In northeast India, Kumar et al. (2014, this Theme Section) provide >15 yr of data of Bengal slow lorises confiscated from private gardens or from private owners. Their study shows that it is vital to understand the distribution of wild slow lorises. We now know that many slow loris populations live in home gardens; yet these animals were translocated with no follow up into an environment they had never known. For many years, slow lorises have not been considered priority species, and such 'mercy releases' have become common, yet are probably as deadly a threat as the trade itself; thus, understanding the rate at which this happens is the first step to halting such releases. We highly encourage that releases should follow recommended international protocols for release and that any organisation releasing lorises should report their successes as well as failures so that practices can be improved.

The 13 contributions in this Theme Section cover new field studies in 5 of the 13 countries in the range of slow lorises. We hope that this work will inspire researchers throughout Asia, as well as elsewhere, to help us further our understanding of slow loris taxonomy, geographic range, behaviour in the wild and the ever-increasing threats to their conservation. We encourage those interested in slow lorises to use similar methodologies to collect data, and to take advantage of the Internet to work together to share knowledge. Only after these factors are understood can we truly begin a conservation plan for these unique and threatened primates.

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