Draft Terms of Reference – Red Ruffed Lemur

- **1. Provide information on the taxonomy of the species**

Kingdom: Animalia
Phylum: Chordata
Class: Mammalia (mammals)
Order: Primates (primates)
Suborder: Strepsirrhini (prosimians)
Family: Lemuridae (lemurs)
Genus: *Varecia*
Species: *rubra*
Subspecies: None

This species is not a genetically-modified organism (GMO).

Common name: Red Ruffed Lemur or Red-ruffed Lemur

Alternative common names: None

Synonyms: *Lemur ruber* E. Geoffroy St-Hilaire 1812. *Prosimia erythromela* Lesson 1840. *Lemur variegata rubra* (E. Geoffroy St-Hilaire 1812). *Varecia variegata rubra* (E. Geoffroy St-Hilaire 1812).[1,2]

Originally described by E. Geoffroy St-Hilaire in 1812 as *Lemur ruber*. Treated as a subspecies of the Black and White Ruffed Lemur *Varecia variegata* throughout most of the twentieth century (i.e. as either *Lemur variegata rubra* or *Varecia variegata rubra*), but split as a full species since 2001.[3]

The genus *Varecia* for the ruffed lemurs was originally erected by Gray in 1863 - and hence the original specific name *ruber* changed to *rubra* to match the new genus - but this taxonomic opinion did not take hold and the ruffed lemurs remained in the genus *Lemur* until 1962 when Petter reinstated *Varecia*.[4]

There are two species currently recognised for *Varecia* - the Black and White Ruffed Lemur *Varecia variegata* and the Red Ruffed Lemur *Varecia rubra*. Currently the genus *Lemur* contains solely the Ring-tailed Lemur *Lemur catta*.[5]

[1] Wilson, D.E., and D.M. Reeder (eds) (2005) "*Mammal Species of the World: a taxonomic and geographic reference*" (3rd edition), John Hopkins University Press
[2] Vasey, N., and I. Tattersall (2002) "Do Ruffed Lemurs Form A Hybrid Zone? Distribution and Discovery of *Varecia*, with Systematic and Conservation Implications." *American Musuem Novitates*, no. 3376
[3] Vasey and Tattersall (2002), *ibid*.

[4] Vasey and Tattersall (2002), *ibid*.
[5] Wilson and Reeder (2005), *op. cit*.

- **2. Provide information on the status of the species under CITES**

CITES Listing: Appendix 1
IUCN Red List Status: CR (Critically Endangered)

The Red Ruffed Lemur is included on CITES Appendix 1 (all species in the family Lemuridae).[6]

The species is listed on the IUCN Red List as CR (Critically Endangered).[7]

The Red Ruffed Lemur has a very small natural range, restricted to the Masoala Peninsula in north-eastern Madagascar. The species is protected by law in Madagascar but is severely threatened by illegal hunting (for food) and by habitat destruction for agriculture and illegal logging. The small natural range is now also threatened by extreme weather patterns. The species is "sometimes" kept as a pet locally.[8]

[6] CITES home page: https://cites.org/eng
[7] IUCN page for "*Varecia rubra*": https://www.iucnredlist.org/species/22920/115574598
[8] IUCN page for "*Varecia rubra*" as above

- **3. Provide information about the ecology of the species.**

A) Longevity: what is the average lifespan of the species in the wild and in captivity?

The longevity of Red Ruffed Lemurs in the wild has not been studied, but data from captivity suggests an average lifespan of around twenty years. Eddie *et al* (2017)[9] state that "survival statistics suggest that if a red ruffed lemur survives its first birthday, its median life expectancy is 19.9 years". For maximum lifespan in captivity, the oldest known female was a wild-caught animal at the Duke Lemur Center (USA) which was an estimated 36 years old at the time of its death.[10,11] The oldest known male is noted by Eddie *et al* (2017) as being a 34 year old animal captive-bred at San Diego Zoo and still alive at the time of publication.[12] Brockman *et al* (1988)[13] note a female Red Ruffed Lemur being still reproductively active at 24 years of age, while Eddie *et al* (2017)[14] note that the oldest female to give birth was almost 30 years of age.

B) What is the maximum length and weight that the species attains?

The Red Ruffed Lemur is one of the largest of the extant lemur species. Head-body length is 50-55cm and tail length 60-65cm.[15] Wild animals have been weighed at between 3.3kg for females and 3.6kg for males,[16] but in captivity they are prone to obesity with studies of European zoo populations (combining data for both *Varecia rubra* and *Varecia variegata*) showing an average weight of about 3.9kg and a maximum record of 8kg.[17,18]

C) Discuss the identification of the individuals in this species, including if the sexes of the species are readily distinguishable, and if the species is difficult to distinguish from other species.

The sexes of all species of lemurs (and primates in general) can be easily determined by examination of the external genitalia.[19] In Red Ruffed Lemurs the sexes have the same colouration and general appearance, other than that males average heavier in weight (in wild animals).[20] Animals in captive populations tend to have higher body-weights than individuals in wild populations because they are prone to obesity, and for these captive populations there does not appear to be a consistent correlation between sex and body-weight.[21,22]

The fur of the Red Ruffed Lemur is largely chestnut-red in colouration apart for the black tail, forehead, and underparts (belly and the insides of the limbs), and a pale white or buff patch on the nape of the neck. The bare parts of animal (i.e. face, feet and hands) are black.[23] It is easily distinguished from all other species of lemurs (and other primates) simply by colouration. Some of the *Eulemur* species (brown lemurs) may also have reddish-brown fur but otherwise are very dissimilar in size and colour-pattern. The only other member of the genus *Varecia* is the Black and White Ruffed Lemur (*Varecia variegata*) which has the same shape and size as the Red Ruffed Lemur but is completely distinct in colouration, being black and white with no red colouration at all. All species of lemurs are illustrated for comparative purposes in Garbutt (2007),[24] and all primate species are illustrated in Mittermeier *et al* (2013).[25]

D) Natural geographic range.

The Red Ruffed Lemur is found only in northeastern Madagascar, where it is restricted to the Masoala Peninsula and the northern Makira region above the peninsula.[26,27] The extent of the distribution covers approximately 6423km^2, from sea-level up to 1200m, and the species is restricted to primary forest.[28] Currently the Antainamblana River separates the range of the Red Ruffed Lemur from that of the Belted Black and White Ruffed Lemur *Varecia variegata subcincta*, although historically the two species were sympatric in this region.[29]

E) Is the species migratory?

The Red Ruffed Lemur is not migratory. Groups of animals occupy home-ranges year-round, although the size of the range and the number of individuals within groups varies depending on food availability.[30,31]

F) Does the species have the ability to hibernate in winter or aestivate (go into stasis or torpor) in the summer months?

The Red Ruffed Lemur does not hibernate or aestivate, although they are less active during specific seasons - in the southern winter months they are recorded as being about 60% less active than at other times of the year due to lower availability of fruit.[32,33]

G) Does the species have the ability to breathe atmospheric air i.e. has accessory breathing organs? (fish and other mobile aquatic animals)

Not applicable.

H) Outline the habitat requirements for all life stages of the species.

The Red Ruffed Lemur is an inhabitant of primary lowland rainforest, where they require the presence of large-crowned trees - the species is described by the IUCN as being "characterized by extremely narrow niche dimensions".[34] The part of Madagascar in which the species occurs (the tropical forests of the Masoala Peninsula) is hot year-round, but with pronounced dry and wet seasons.[35] The species is diurnal and arboreal, primarily inhabiting the upper canopy. They sleep in trees, but adults do not use a nest. However when breeding the young are stashed in nests in the canopy, usually amongst vines or epiphytes to provide security.[36,37]

I) Social behaviour or groupings.

The former opinion on the social structure of ruffed lemurs, largely based on extrapolation from how captive animals were kept and on the fact that the species is monomorphic, was that they lived in monogamous pairs or family groups. However studies of wild animals show that they actually live in large fission-fusion groups, collectively containing as many as 30+ individuals, with multiple males and females, which occupy total home-ranges of up to 60 hectares and which split up or merge depending on such factors as food availability or breeding. Sub-groups may contain only two to five individuals. They have a polygamous mating system, and related and unrelated young may be reared cooperatively, including nursing of young by unrelated females.[38,39,40,41]

The Red Ruffed Lemur occurs sympatrically on the Masoala Peninsula with another diurnal lemur species, the White-fronted Lemur *Eulemur albifrons*, from which they separate ecologically, utilising different levels of the forest and foraging on different food items.[42,43]

J) Is this species ever territorial or does it exhibit aggressive behaviour?

The Red Ruffed Lemur lives in large fission-fusion groups in the wild, with as many as 30 animals occupying a communal range of up to 60 hectares. The animals within the community use distinctive far-carrying calls to defend their range from neighbouring communities of Red Ruffed Lemurs.[44]

In captivity *Varecia* lemurs of both species are often kept successfully in mixed exhibits with other lemur species, especially the Ring-tailed Lemur *Lemur catta*. They are also considered peaceful towards other species of mammals and with birds, e.g. at Singapore Zoo the Fragile Forest exhibit has included Black and White Ruffed Lemurs in a mixed enclosure with Ring-tailed Lemur, Tree Kangaroo, Two-toed Sloth, *Pteropus* fruit bats, Lesser Mouse Deer, and birds.

K) Characteristics that may cause harm to humans or any other species.

The Red Ruffed Lemur has large teeth and powerful jaws, and thus would be capable of inflicting puncture wounds on humans. However they are inoffensive animals, and are commonly housed in walk-through enclosures in zoos (i.e. enclosures where the visiting public freely enter the living space of the animals) or are used in "animal encounters" where members of the public interact directly with an animal or animals in the presence of a keeper. The risk of serious injury to humans is minimal.

[9] Eddie, C., M. Whipple, and G. M. Ferrie (2017) "Population Analysis & Breeding and Transfer Plan: Red Ruffed Lemur (*Varecia rubra*)" *AZA Species Survival Plan*
[10] Eddie *et al* (2017), *ibid*.
[11] Zehr, S. M., R. G. Roach, D. Haring, J. Taylor, F. H. Cameron, and A. D. Yoder (2014) "Life history profiles for 27 strepsirrhine primate taxa generated using captive data from the Duke Lemur Center" *Scientific Data*, vol. 1: 140019
[12] Eddie *et al* (2017), *op. cit*.
[13] Brockman, D. K., M. S. Willis, and W. B. Karesh (1988) "Management and husbandry of ruffed lemurs, *Varecia variegata*, at the San Diego Zoo. III. Medical considerations and population management" *Zoo Biology*, vol. 7, issue 3, pp. 253-262
[14] Eddie *et al* (2017), *op. cit*.
[15] Vasey, N. (2003) "*Varecia: ruffed lemurs*" in Goodman, S., and J. Benstead (eds) "*The Natural History of Madagascar*" University of Chicago Press, pp. 1332-1336
[16] Vasey, N. (2003), *ibid*.
[17] Schwitzer, C. and W. Kaumanns (2001) "Body weights of ruffed lemurs (*Varecia variegata*) in European zoos with reference to the problem of obesity" *Zoo Biology*, vol. 20, issue 4, pp. 261-269
[18] Schwitzer, C. and W. Kaumanns (2009) "Litter size, infant mortality and female body weight in captive black-and-white ruffed lemurs *Varecia variegata*" *Endangered Species Research*, vol. 8, pp. 201-209
[19] Hubrecht, R., and J. Kirkwood (2010) "*The UFAW Handbook on the Care and Management of Laboratory and Other Research Animals*" Universities Federation for Animal Welfare
[20] Vasey, N. (2003), *op. cit*.
[21] Schwitzer and Kaumanns (2001), *op. cit*.
[22] Schwitzer and Kaumanns (2009), *op. cit*.
[23] Garbutt, N. (2007) "*The Mammals of Madagascar: a complete guide*" Yale University Press
[24] Garbutt, N. (2007), *ibid*.
[25] Mittermeier, R.A., A.B. Rylands, D.E. Wilson (eds) (2013) "*Handbook of the Mammals of the World, volume 3: Primates*" Lynx Edicions
[26] Garbutt, N. (2007), *op. cit*.
[27] IUCN page for "*Varecia rubra*": https://www.iucnredlist.org/species/22920/115574598
[28] IUCN page for "*Varecia rubra*" as above
[29] Hekkala, E. R., M. Rakotondratsima, and N. Vasey (2007) "History and Distribution of the Ruffed Lemur, *Varecia*, North of the Bay of Antongil in Northeastern Madagascar" *Primate Conservation*, vol. 22, issue 1, pp. 89-95
[30] Vasey, N. (2005) "Activity budgets and activity rhythms in red ruffed lemurs (*Varecia rubra*) on the Masoala Peninsula, Madagascar: Seasonality and reproductive energetics" *American Journal of Primatology*, vol. 66, pp. 23-44
[31] Vasey, N. (2007) "The breeding system of wild red ruffed lemurs (*Varecia rubra*): A preliminary report" *Primates*, vol. 48, issue 1, pp. 41-54
[32] Vasey, N. (2005), *op. cit*.
[33] Hekkala et al (2007), *op. cit*.
[34] IUCN page for "*Varecia rubra*": https://www.iucnredlist.org/species/22920/115574598
[35] Vasey, N. (2005), *op. cit*.
[36] Vasey, N. (2005), *op. cit*.
[37] Vasey, N. (2007), *op. cit*.
[38] Vasey, N. (2007), *op. cit*.
[39] Vasey, N. (2006) "Impact of seasonality and reproduction on social structure, ranging patterns, and fission-fusion social organization in red ruffed lemurs" in Gould, L. and M. L. Sauther (eds) "*Lemurs*" Springer, pp. 275-304

[40] Vasey, N. (2000) "Niche separation in *Varecia variegata rubra* and *Eulemur fulvus albifrons*: I. Interspecific patterns" *American Journal of Physical Anthropology*, vol. 112, issue 3, pp. 411-431
[41] Vasey, N. (2002) "Niche separation in *Varecia variegata rubra* and *Eulemur fulvus albifrons*: II. Intraspecific patterns" *American Journal of Physical Anthropology*, vol. 118, issue 2, pp. 169-183
[42] Vasey, N. (2000), *op. cit*.
[43] Vasey, N. (2002), *op. cit*.
[44] Vasey, N. (2006), *op. cit*.

- **4. Provide information on the reproductive biology of the species**

Studies in the wild show that Red Ruffed Lemurs live in large fission-fusion groups, collectively containing as many as 31 individuals, with multiple males and females. This contrasts with the former opinion on the social structure of *Varecia* lemurs, largely based on captive animals, which was that they lived in monogamous pairs or family groups. Red Ruffed Lemurs have instead been shown to have a polygamous mating system. The offspring from several mothers may be reared cooperatively, including nursing of young by unrelated females.[45,46]

In captivity male Red Ruffed Lemurs reach sexual maturity at about two years of age, while females do so at about one year of age,[47] with oestrus cycling beginning as early as nine months of age.[48]

Unlike the case with higher Primates, where a single offspring is the norm, many of the lemur species have multiple babies per birth. In the Red Ruffed Lemur there can be up to six babies to a litter, although two or three is the norm.[49] For the first two months the babies are hidden in nests in the canopy while the adults are feeding elsewhere (a behaviour dubbed "infant stashing"). Alloparenting is an integral part of the reproductive strategy in the wild, where adults other than the direct parents help rear the babies, including the nursing of the young by unrelated females.[50]

In the wild mating takes place in early July (in the southern winter), with births occurring in October. They breed only once per year.[51] In captivity the timing of breeding can differ, e.g. in Eddie *et al* (2017)[52] it is noted that in North American zoos the births mostly occur in March to June. Captive data record the gestation period as being 99-106 days.[53]

As in all Primates, males and females are distinct sexes (i.e. not hermaphroditic, and parthenogenetic births are not possible), and they cannot change sex.[54]

Congeneric hybridisation in lemurs is well-known to occur both in the wild where the distributions of two related species meet, and in captivity where species which would not meet in the wild may be housed together (e.g. see Gray 1972[55]). The website "MessyBeast" records numerous examples of congeneric hybridisation in lemurs.[56] With regards to Red Ruffed Lemurs specifically, they have been recorded on multiple occasions as hybridising with the closely-related Black and White Ruffed Lemur *Varecia variegata* in captivity, and there is evidence of hybridisation between these two taxa in the wild also (although now they no longer occur sympatrically). These hybrids are fully fertile.[57]

There is no possibility of Red Ruffed Lemurs hybridising with native Australian mammals, as there are no Primate species native to Australia.[58]

[45] Vasey, N. (2007) "The breeding system of wild red ruffed lemurs (*Varecia rubra*): A preliminary report" *Primates*, vol. 48, issue 1, pp. 41-54

[46] Vasey, N. (2006) "Impact of seasonality and reproduction on social structure, ranging patterns, and fission-fusion social organization in red ruffed lemurs" in Gould, L. and M. L. Sauther (eds) "*Lemurs*" Springer, pp. 275-304
[47] Eddie, C., M. Whipple, and G. M. Ferrie (2017) "Population Analysis & Breeding and Transfer Plan: Red Ruffed Lemur (*Varecia rubra*)" *AZA Species Survival Plan*
[48] Brockman, D. K., M. S. Willis, and W. B. Karesh (1987) "Management and husbandry of ruffed lemurs, *Varecia variegata*, at the San Diego Zoo. II. Reproduction, pregnancy, parturition, litter size, infant care, and reintroduction of hand-raised infants" *Zoo Biology*, vol. 6, issue 4, pp. 349-363
[49] Eddie *et al* (2017), *op. cit*.
[50] Vasey, N. (2007), *op. cit*.
[51] Vasey, N. (2006), *op. cit*.
[52] Eddie *et al* (2017), *op. cit*.
[53] Brockman *et al* (1987), *op. cit*.
[54] Napier, J.R. and P.H. Napier (1985) "*The Natural History of Primates*" M.I.T. Press
[55] Gray, A. P. (1972) "Mammalian Hybrids" Commonwealth Agricultural Bureaux
[56] "Hybrid Primates" http://messybeast.com/genetics/hybrid-primates.htm
[57] Vasey, N., and I. Tattersall (2002) "Do Ruffed Lemurs Form A Hybrid Zone? Distribution and Discovery of *Varecia*, with Systematic and Conservation Implications." *American Musuem Novitates*, no. 3376
[58] Menkhorst, P., and F. Knight (2010) "*A Field Guide to the Mammals of Australia*" Oxford University Press

- **5. Provide information on whether the species has established feral populations**

The Red Ruffed Lemur has never established wild populations outside of its natural range, and it has never been deliberately introduced to the wild in countries outside of its natural range.[59,60]

The species occurs in the wild only in primary rainforest on the Masoala Peninsula and is not considered a pest in any regard to the local human population.[61]

[59] Lever, C. (1985) "*Naturalized Mammals of the World*" Longman
[60] Long, J.L. (2003) "*Introduced Mammals of the World*" CSIRO
[61] Vasey, N. (2003) "*Varecia: ruffed lemurs*" in Goodman, S., and J. Benstead (eds) "*The Natural History of Madagascar*" University of Chicago Press, pp. 1332-1336

- **6. Environmental risk assessments of the species**

The Red Ruffed Lemur is not listed in the Vertebrate Pests Committee's "List of Exotic Vertebrate Animals in Australia" and hence has no assessment in that document. The closely related Black and White Ruffed Lemur *Varecia variegata* is listed in that document as "2/Serious".[62]

The number "2" in the threat rating is used to denote "limited to statutory zoos or endorsed special collections".

The rating of "serious" is qualified as "These animals may be introduced and/or should be kept only in collections approved by the relevant State/Territory authority as being primarily kept for (1) public display and education purposes, and/or for (2) genuine scientific research approved by the relevant

State/Territory authority, and as meeting Best Practice for the purposes of keeping the species concerned".

It should be noted that almost every species of exotic mammal listed in the VPC document has been categorised as either "extreme" or "serious".

Within the region, Auckland Zoo has applied for the Red Ruffed Lemur to be approved for importation as a new organism for New Zealand.[63]

The closely related Black and White Ruffed Lemur *Varecia variegata* (of which the Red Ruffed Lemur was formerly considered a subspecies) is already included on the list of exotic zoo animals allowed to be imported into Australia [64]

Quarantine requirements for live Primates have been established by Biosecurity Australia, and would cover Red Ruffed Lemurs if these were to be imported.[65]

[62] Vertebrate Pests Committee "List of Exotic Vertebrate Animals in Australia": https://pestsmart.org.au/tags/vertebrates/
[63] Application form to obtain approval for new organisms in containment (Dec 2019): https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP203982/APP203982-Application.pdf
[64] Australian Government "List of Specimens taken to be Suitable for Live Import": https://www.legislation.gov.au/Series/F2006B01053
[65] Australian Government "Captive non-human primates": http://www.agriculture.gov.au/biosecurity/risk-analysis/animal/captive-non-human-primates

- **7. Assess the likelihood that the species could establish a breeding population in Australia**

The likelihood of Red Ruffed Lemurs establishing a wild breeding population in Australia outside human control is extremely low if based on historical data. There have never been any wild populations of Red Ruffed Lemurs established outside their natural range.[66,67] Several species of lemurs have been kept in Australian zoos over the last hundred years, and currently there are c.170 animals of two species of lemurs (Black and White Ruffed Lemur and Ring-tailed Lemur) held in Australian zoos.[68] Despite this history no species of lemur (or, indeed, of any Primate species) has ever formed a wild population in Australia via escaped or released animals.[69,70]

A) Ability to find food sources. Is the species a generalist feeder or does it have specific food needs? What is the likelihood of it finding food in Australia if it was released or escaped? Describe the feeding characteristics of the species, including whether it has a similar diet to any Australian native species.

The Red Ruffed Lemur is highly frugivorous. One study from 2014 found the wild diet to consist of 61% fruit, from 56 plant species,[71] while another from 1993 found the wild diet to be 73.9% fruit, 20.9% leaves, and 5.3% flowers.[72] In that paper the study animals were recorded as feeding from 42 tree species in total, but with just seven of those species providing most of the diet (72.5% of feeding-time was from these seven tree species).[73] Leaves eaten were predominantly mature

leaves,[74] although it has also been noted that young leaves (in higher quantity) are eaten by lactating females.[75]

Because Red Ruffed Lemurs feed predominantly on fruit they would theoretically be able to find sufficient food in the Wet Tropics of Far North Queensland, but would likely find it impossible to survive in non-rainforest habitats (e.g. eucalyptus forest) due to the lack of large fruiting trees.

Arboreal mammal species native to Australia are largely folivorous (leaf-eaters), nectivorous (nectar-feeders), or exudativorous (sap-feeders).[76] Two species of native animals from the Wet Tropics feed largely on fruit - the Musky Rat Kangaroo *Hypsiprymnodon moschatus* and the Double-wattled Cassowary *Casuarius casuarius* - but both of these species are terrestrial and forage on fallen fruit.[77,78]

B) Ability to survive and adapt to climatic conditions. Describe the characteristics or behaviour that would enhance its ability to survive extreme climatic conditions (e.g. drought) and its ability to adapt to different environments.

The Red Ruffed Lemur is found only in the tropical forests of Madagascar's Masoala Peninsula and the northern Makira region above the peninsula.[79,80] This area is hot year-round, but with pronounced dry and wet seasons.[81] Studies of wild animals show that they become less active during the southern winter months when they are recorded as being about 60% less active than at other times of the year due to lower availability of fruit (i.e. they spend less time foraging and more time resting to conserve energy).[82,83]

The species is strictly arboreal and cannot survive in treeless habitats (grasslands, desert, etc). They can utilise regenerating forest, but only when it adjoins unlogged primary forest, due to their requirement for the presence of large-crowned trees.[84]

Because the diet is predominantly composed of fruit, they cannot survive in non-forested areas or under extreme climatic conditions such as drought.

Although in the wild state the Red Ruffed Lemur has a tropical distribution, in captivity they display no great discomfort to cold weather so long as they have dry and warm retreats.[85,86] Wild-living animals do not normally utilise cavities for shelter, however, so would likely not be able to survive winters in temperate parts of Australia (apart for the lack of fruit in such temperate zones).

C) Ability to find shelter. Can the species live in modified habitats? Identify if this species can live in habitats that have been modified by humans, either directly or indirectly.

The Red Ruffed Lemur is an inhabitant of primary lowland rainforest, where they require the presence of large-crowned trees - the species is described by the IUCN as being "characterized by extremely narrow niche dimensions".[87] They may utilise regenerating forest (e.g. for feeding on the fruits of native or non-native pioneer species), but only where it adjoins unlogged primary forest.[88] They also occur in the immediate vicinity of local villages, but again only where these are located directly adjacent to primary forest.[89]

As the species is a strictly arboreal inhabitant of primary forest it cannot survive in human landscapes such as farmland or cities.

D) Reproduction. Could factors such as longevity, birth rates and numbers of offspring increase the likelihood of the species to establish?

The Red Ruffed Lemur is a relatively slow breeder, reproducing only once per year with an average of two or three young per litter.[90] However they have a polygamous breeding structure in which they practice alloparenting (young being reared by multiple adults within the group)[91,92] and also have long breeding lifespans. Sexual maturity is reached at one year old for females and two years old for males, although breeding typically does not commence until three years of age, and captive data shows that they can be sexually-reproductive into their late twenties (although an average lifespan is probably around twenty years of age).[93]

E) Are there any limiting influences on the species' natural range? Predator/prey relationships, competition, availability of resources etc. Assess what similar population constraints might exist in Australia.

The Red Ruffed Lemur is restricted in the wild to Madagascar's Masoala Peninsula and the northern Makira region above the peninsula.[94,95] The northern part of this range is bordered by that of the Black and White Ruffed Lemur *Varecia variegata*, although the limiting factor between the two is unknown (and the ranges overlapped to some extent in the past).[96] On the peninsula the Red Ruffed Lemur coexists with another diurnal lemur species, the White-fronted Lemur *Eulemur albifrons*, from which they separate ecologically, utilising different levels of the forest and foraging on different food items.[97,98]

The only extant predator of the Red Ruffed Lemur in the wild is the Fossa *Cryptoprocta ferox*, a felid-like Carnivore about the size of a small dog which hunts arboreally.[99] In the recent past (pre human arrival on the island) there was also a much-larger species of Fossa *Cryptoprocta spelea* which was about the size of a Puma *Puma concolor*.[100] There was also a giant eagle *Stephanoaetus mahery* - related to the monkey-eating Crowned Eagle *Stephanoaetus coronatus* of Africa - which probably hunted lemurs, but the largest extant birds of prey in Madagascar are now too small to prey on the larger lemur species.[101]

In Australia, if occurring in the wild state, the Red Ruffed Lemur would be restricted to the geographically-limited region of the Wet Tropics (north-east Queensland) due to their reliance on a continuous rainforest canopy and their fruit-dependent diet. The only mammalian predators in Australia large enough to hunt Red Ruffed Lemurs are the Dingo *Canis dingo* and perhaps the smaller Red Fox *Vulpes vulpes*, but both these canid species are terrestrial whereas Red Ruffed Lemurs are fully-arboreal.[102] The larger eagles would be capable of taking Red Ruffed Lemurs as prey, with the Wedge-tailed Eagle *Aquila audax* in particular being large enough to do so and noted as being capable of hunting in rainforest environments (e.g. see Burnett *et al*).[103] The largest owl in Australia, the Powerful Owl *Ninox strenua*, would likely also be capable of taking young lemurs but this species of owl is found in sclerophyll forest of the southeastern coasts, with its range well to the south of the tropical rainforest, and would probably not be within the distribution of a putative population of Red Ruffed Lemurs.[104] Australia also has a number of large reptilian predators - which Madagascar mostly lacks - including pythons and goannas, both of which could take young lemurs. The larger python species in Australia take prey at least as large as wallabies, so even adult Red Ruffed Lemurs would be potential prey items.[105]

F) Address the issue of increased potential for feral population establishment if more individuals of the species were present in Australia.

Red Ruffed Lemurs in Australia would be legally restricted to licenced holders (i.e. zoos) and thus importation of additional animals past an initial import would likely not result in any increase in risk of the establishment of wild populations via escape or release. Several species of lemurs, and numerous other Primate species, have been held in captivity in Australia over the last hundred years, and currently there are about 170 animals of two species of lemurs held in Australian zoos.[106] Despite this long history and the population figures, no species of Primate has ever formed a wild population in Australia via escaped or released animals.

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- **8. Provide a comprehensive assessment of the potential impact of the species should it become established in Australia**

A. Does the species have similar niche/living requirements to native species?

Red Ruffed Lemurs are medium-sized, arboreal, group-living, diurnal mammals which feed primarily on fruit, with other plant material (flowers and leaves) making up a lesser part of the diet. They are naturally restricted to forested areas with continuous tree cover.[107]

In Australia almost all the native mammals are nocturnal or crepuscular,[108] so would not be directly in competition for space with Red Ruffed Lemurs should a wild population become established. No arboreal mammal species native to Australia feeds predominantly upon fruit. They are largely folivorous (leaf-eaters), nectivorous (nectar-feeders), or exudativorous (sap-feeders).[109] Two species of native animals from the Wet Tropics are largely frugivorous - the Musky Rat Kangaroo *Hypsiprymnodon moschatus* and the Double-wattled Cassowary *Casuarius casuarius* - but both of these species are fully terrestrial and forage on fallen fruit.[110,111]

Although Red Ruffed Lemurs utilise nest-boxes as shelter in captivity, in the wild they generally sleep on branches or amongst epiphytes rather than in tree holes[112] so would not be competing with native arboreal mammals, most of which are nocturnal and spend the daylight hours within tree cavities.[113]

B. Is the species susceptible to, or capable of transmitting any pests or diseases?

Red Ruffed Lemurs can be carriers of external parasites such as ticks and internal parasites such as nematodes, all of which can be easily and effectively treated/removed before undergoing quarantine.

There are a number of Zoonoses (protozoal, fungal and bacterial infections) transferrable in either direction between humans and non-human Primates, and these are well-covered in the medical literature due to the widespread use of Primates in laboratories where they are used for studies into human diseases. There are no cases known of lemur-to-human disease transmission, but some diseases are known to have been transferred from humans to lemurs (e.g. *Cryptosporidium hominis*).[114] Bublitz *et al* (2015)[115] note "Helminths, enteric protozoa, and enteric bacteria have been detected in wild and captive lemurs; some of these cases have been linked to human or rodent exposure".

Lemurs do not carry or transmit Herpes B which is of a concern in Old World macaques (*Macaca spp*).

Biosecurity Australia has an existing comprehensive set of quarantine requirements for the importation of live Primates, which covers disease control. Two other species of lemur (the Black and White Ruffed Lemur *Varecia variegata* and the Ring-tailed Lemur *Lemur catta*) can currently be imported into Australia.

C. Probable prey/food sources.

The Red Ruffed Lemur is highly frugivorous, with up to 73.9% of the wild diet being composed of fruit, and the rest of leaves and flowers. They do not prey upon other animal species.[116,117] They do not feed on commercial fruit species as they are restricted to primary rainforest (although they can utilise adjoining regenerating forest patches).[118]

D. Impacts on habitat and local environments.

If a wild population should become established there would be minimal impact on the local environment. As an entirely arboreal species, Red Ruffed Lemurs do not destroy ground vegetation or dig burrows. Lemurs are not considered a pest in any respect in their native country, even when living near human habitats (e.g. villages).[119] As fruit-eaters they spread seeds via their faeces or potentially on their fur, which could include those of invasive or unwanted plant species. In the wild Red Ruffed Lemurs are known to feed on the fruit of pioneer species (including species introduced to Madagascar) in regenerating forest adjoining primary rainforest.[120]

E. Discuss any control/eradication programs that could be applied in Australia if the species escaped or were released.

If a wild population were to become established in Australia, detection and capture in forest areas could potentially be extremely difficult due to their arboreal nature. However both species of Ruffed Lemurs (*Varecia variegata* and *Varecia rubra*) are noted for being group-living, noisy, and active by day. They have very loud far-carrying calls, audible up to a kilometre away, which make locating the presence of individuals or groups relatively easy.[121]

Individual escaped animals in the vicinity of zoos would likely be easily found due to their size and activity levels.

The local people in Madagascar hunt Ruffed Lemurs (illegally) using snares set on branches, or by shooting them.[122] Trapping would likely be the most appropriate options if a wild population needed to be controlled or eradicated. Red Ruffed Lemurs are critically endangered in the wild, so shooting as a control means would a less appropriate measure.

F. Behaviours that cause environmental degradation.

The Red Ruffed Lemur does not have any behaviours or physical attributes which could cause environmental degradation. Based on the known ecology of Red Ruffed Lemurs, they do not impact the ground, dig burrows, or damage or pollute waterways.[123,124]

G. Impacts on primary industries.

An established wild population of Red Ruffed Lemurs would have no impact on primary industries such as farming or agriculture. In their native range, this species is a canopy-dweller of continuous rainforests. They are not considered a pest in any respect in their native country, even when living in forest adjoining human habitats (e.g. villages).[125,126] They do feed on fruit and flowers, which could in theory bring conflict with orchardists, although given that the species solely inhabits rainforest this seems an unlikely possibility for an introduced population except in a situation where an orchard adjoins rainforest.

H. Damage to property.

The Red Ruffed Lemur is a medium-sized arboreal inhabitant of rainforest, and has not been recorded as causing damage to human properties because it does not live in human-dominated landscapes.[127,128]

I. Is the species a social nuisance or danger?

The Red Ruffed Lemur is not a species which is known to be the cause of social nuisance. In the native state lemurs are not considered to be a pest in any regard. Ruffed Lemurs do have very loud booming calls which carry for long distances (up to a kilometre) which could be considered as a social nuisance, although any possible introduced wild population would be living in forest and not in human settlements such as cities.[129]

J. Describe any potentially harmful characteristics of the species.

All lemurs have sharp teeth, and would be capable of inflicting minor wounds on humans. However the relatively small size of the animals prevents serious injuries. Containment facilities (i.e. zoos) have guidelines in place for the safe handling of Primates. Ruffed Lemurs are generally considered inoffensive animals, and are commonly housed in walk-through enclosures in zoos (i.e. enclosures where the visiting public freely enter the living space of the animals) or are used in "animal

encounters" where members of the public interact directly with an animal or animals in the presence of a keeper. The risk of serious injury to humans is minimal.

There are numerous Zoonoses capable of being transmitted in either direction between humans and non-human Primates, although this seems uncommon amongst lemurs (e.g. see Rasambainarivo *et al* (2013)[130] and Bublitz *et al* (2015)[131]). Most transmittable Zoonoses are not specific to lemurs (or, indeed, to Primates) but can be carried by any or many mammals.

Hubrecht and Kirkwood (2010)[132] also covers Primate diseases in a wider scope.

Biosecurity Australia has an existing comprehensive set of quarantine requirements for the importation of live Primates, which covers disease control.

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[132] Hubrecht, R., and J. Kirkwood (2010) "*The UFAW Handbook on the Care and Management of Laboratory and Other Research Animals*" Universities Federation for Animal Welfare

- **9. What conditions or restrictions could be applied to reduce any potential for negative impacts of the species?**

Importation and transfer of Red Ruffed Lemurs would be limited exclusively to recognised zoological facilities as licensed by their respective states and territories. As a containment species, Red Ruffed Lemurs would be specifically excluded from import by or transfer to private individuals to keep as private pets.

Measures to prevent breeding, such as limiting importation to a single sex or to de-sexed individuals, would prevent imported specimens being used to conserve the species in Australian zoos in the future.

The Red Ruffed Lemur is listed by the IUCN as Critically Endangered based on a projected 80% reduction in the wild population over the next three generations of lemurs (c.24 years) due to unsustainable hunting and habitat loss within its small native range. The worldwide captive population is a vital part of the conservation effort for the Red Ruffed Lemur.

- **10. Summary of proposed activity**

The purpose of this application is to establish the mechanism to allow the import of Red Ruffed Lemurs for a Zoo and Aquarium Association [ZAA] managed species population.

The Australasian region's zoos have developed proven skills enabling the breeding of other CITES 1 lemur species and a meeting of members of the Association's Primate Taxon Advisory Group [TAG] has endorsed the addition of Red Ruffed Lemurs to the region's management programs.

Thus, this application is to add this species to the Live Import List to enable Australian licenced zoos to import founding breeding stock for conservation breeding and exhibition.

It is expected that several pairs will initially be imported from licenced and registered overseas zoos. It is emphasised that further imports will be necessary from time to time in order to maintain and expand genetic diversity in the regional population.

The applicant, Darling Downs Zoo, proposes to import, quarantine and house two pairs. The applicant expects to be asked by other Australian licenced and registered zoos to import and quarantine specimens of this species on their behalf.

It is proposed that this species will be managed by the ZAA Animal Management Committee. The population will be overseen by a Species Coordinator who will make transfer and breeding recommendations. Non-recommended breeding can be controlled by contraception, by separation of the sexes, or by sterilising individual specimens.

It is not proposed to import this species for any purposes other than conservation breeding as a CITES 1 species and for exhibition.

Imported animals will be from overseas licenced and registered zoos and will have been captive-born.

- **11. Guidelines on how species should be kept**

The transport of imported Red Ruffed Lemurs will be by air in accordance with Container Requirement 79 of the IATA Live Animal Regulations Edition 47.

This species will be kept in accordance with the NSW Exhibited Animals Protection Act Policy on Exhibiting Primates in NSW. This policy covers the husbandry, management, and welfare of this species and has been adopted as secondary legislation by most Australian States and Territories.

Initially the species will be kept in pairs, and subsequently in family groups until the progeny are independent. It is recommended that each zoo holding this species has at least three suitable enclosures for the species, thus enabling the separate housing of animals needing to be separated for any reason.

- **12. State/Territory controls**

*The Australian Government's "List of Specimens Taken to be Suitable for Live Import" does not currently include Red Ruffed Lemur. There are two other species of lemurs currently on the list as being allowed to be imported into Australia, namely the Black and White Ruffed Lemur *Varecia variegata* - of which the Red Ruffed Lemur was formerly considered to be a subspecies - and the Ring-tailed Lemur *Lemur catta*.

https://www.legislation.gov.au/Series/F2006B01053

Because Red Ruffed Lemurs have not been kept in Australian zoos before, they are not specifically covered by state legislations. Six other lemur species are covered by the laws of the combined states, namely the Black and White Ruffed Lemur *Varecia variegata,* the Ring-tailed Lemur *Lemur catta*, the Mongoose Lemur *Eulemur mongoz*, the Black Lemur *Eulemur macaco*, the Brown Lemur *Eulemur fulvus*, and the White-fronted (or White-headed) Lemur *Eulemur albifrons*.

*In Queensland the *Exhibited Animals Act 2015* does not cover the Red Ruffed Lemur (or any species specifically) but allows a licence holder to "Exhibit and deal with animals listed on this authority in accordance with information assessed and approved in deciding the application and details listed on this authority".

https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-2015-005

*In New South Wales the *Non-Indigenous Animals Regulation 2012* does not list the Red Ruffed Lemur but does currently list five other species of lemurs under Categories 2 and 3a (species which are restricted to licenced facilities), namely the Black and White Ruffed Lemur *Varecia variegata,* the

Ring-tailed Lemur *Lemur catta*, the Mongoose Lemur *Eulemur mongoz*, the Black Lemur *Eulemur macaco*, and the Brown Lemur *Eulemur fulvus*. This regulation allows these species to be kept in zoos with a permit to be issued by the relevant state authority for possession of the species.

https://www.legislation.nsw.gov.au/regulations/2012-405.pdf

*In Victoria the *Catchment and Land Protection Act 1994* does not list the Red Ruffed Lemur but does currently list three other species of lemurs under Schedule 2 as Controlled Pest Animals, namely the Black and White Ruffed Lemur *Varecia variegata,* the Ring-tailed Lemur *Lemur catta*, and the White-headed Lemur *Eulemur albifrons*. Species listed in Schedule 2 are allowed to be kept in zoos with a permit to be issued by the relevant state authority for possession of the species. All other lemurs are included under Schedule 1 as Prohibited Pest Animals.

http://www.gazette.vic.gov.au/gazette/Gazettes2010/GG2010S399.pdf

*In South Australia the *Natural Resources Management Act 2004* does not list the Red Ruffed Lemur but does currently list five other species of lemurs under Category 1 of Schedule 1, namely the Black and White Ruffed Lemur *Varecia variegata,* the Ring-tailed Lemur *Lemur catta*, the Mongoose Lemur *Eulemur mongoz*, the Black Lemur *Eulemur macaco*, and the Brown Lemur *Eulemur fulvus*. Species listed as such are allowed to be kept in zoos with a permit to be issued by the relevant state authority for possession of the species.

https://www.pir.sa.gov.au/__data/assets/pdf_file/0003/137460/Declaration_of_Animals_and_Plants_Jan_2015.pdf

*In Western Australia the *Biosecurity and Agricultural Management Act 2007* does not list the Red Ruffed Lemur as a species allowed to be kept in that state but does currently list five other species of lemurs as Prohibited Organisms, namely the Black and White Ruffed Lemur *Varecia variegata,* the Ring-tailed Lemur *Lemur catta*, the Mongoose Lemur *Eulemur mongoz*, the Black Lemur *Eulemur macaco*, and the Brown Lemur *Eulemur fulvus*. There are provisions to allow species on this list to be kept in zoos with a permit to be issued by the relevant state authority for possession of the species.

The *Biosecurity and Agricultural Management (Prohibited Organisms) Declaration 2013* is available at the following link (species arranged alphabetically by genus rather than taxonomically): https://www.agric.wa.gov.au/sites/gateway/files/BAM%20Decl%20s22%20%28Prohibited%20Organisms%29.pdf

The Western Australian Organism List is searchable online at the following link for the most current results: https://www.agric.wa.gov.au/organisms

*In Tasmania the Red Ruffed Lemur has not been risk-assessed for the State.

The list of species which have been risk-assessed for Tasmania is at the following link, which currently includes only one species of lemur, the Ring-tailed Lemur *Lemur catta*: http://dpipwe.tas.gov.au/wildlife-management/management-of-wildlife/wildlife-imports/species-risk-assessments

*In the Northern Territory all non-native wildlife is classed as a "Prohibited Entrant" and applications for keeping these species (which would include the Red Ruffed Lemur) are assessed on a case-by-case basis.

https://nt.gov.au/environment/animals/wildlife-permits/prohibited-wildlife

*In the Australian Capital Territory there doesn't appear to be any specific legislative status of exotic zoo species.

Biosecurity Australia has an existing comprehensive set of quarantine requirements for the importation of live Primates, which would cover Red Ruffed Lemurs should they be imported.

http://www.agriculture.gov.au/biosecurity/risk-analysis/animal/captive-non-human-primates

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