#### 1 Impact of weather conditions, seasonality and moonlight on the use of artificial canopy

### 2 bridges by nocturnal arboreal mammals

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# 11 Abstract

12 Natural and artificial canopy bridges can be used to mitigate the effects of habitat fragmentation. Understanding 13 the ecological factors that influence bridge use is imperative to the effective design and placement of this 14 potential conservation intervention. Moonlight, seasonality and weather may influence the cost and risk of using 15 bridges, potentially reducing their effectiveness. We installed five artificial waterline bridges and, between 2017 16 and 2019, monitored via camera trapping their use by Javan palm civets Paradoxurus musanga javanicus and 17 Javan slow lorises Nycticebus javanicus. We used a weather station to record microclimate data (temperature 18 and relative humidity) and calculated the illumination percentage of the moon. We tested the influence of moon 19 luminosity, relative humidity, seasonality (Julian day) and temperature on the frequency of bridge use via 20 Generalised Additive Models. Camera traps captured 938 instances of bridge use by civets, which was 21 significantly lower than the reference value at moon luminosity >90%, temperatures >20°C, humidity >90%, and 22 during the drier period (May-July). Camera traps captured 1036 instances of bridge use by lorises, which was 23 significantly lower than the reference value during the drier period and higher than the reference value at 24 temperatures >20°C. Lorises showed peaks in bridge use close to sunset and sunrise whereas civets showed 25 peaks around 2 h after sunset and 2 h before sunrise. Our study illustrates the utility of simple-to-construct 26 bridges by two sympatric nocturnal mammals facing severe habitat loss, with bridge use differing between those 27 species according to abiotic factors. In particular, less use by both taxa during the drier season could suggest 28 modifying placement of bridges or providing another intervention during that time. Camera traps were an 29 excellent mechanism to record these differences and to validate the importance of the bridges, including during 30 inclement weather and dark nights, when observations would be more difficult for human observers. By 31 understanding the influence that abiotic factors have on the use of artificial bridges, we can improve bridge 32 placement and construction to encourage use by a variety of species, particularly those threatened by habitat 33 fragmentation.

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<sup>35</sup> Key words: Paradoxurinae, Lorisinae lunarphobic, lunarphilic, wildlife crossings, fragmentation

## 37 Funding

- 38 This research was supported by funding from Augsburg Zoo, Cleveland Zoo and Zoo Society, Disney Worldwide
- 39 Conservation Fund, Henry Doorly Zoo, Lee Richardson Zoo, Little Fireface Project, Mohamed bin al Zayed Species
- 40 Conservation Fund (152511813), Margot Marsh Biodiversity Fund, Memphis Zoo, Moody Gardens Zoo, Naturzoo
- 41 Rhein, Paradise Wildlife Park, People's Trust for Endangered Species, Sacramento Zoo, and Shaldon Wildlife
- 42 Trust.
- 43

## 44 Conflicts of interest

45 The authors declare no conflicts of interest.

### 46 Availability of data and material

47 The datasets generated during and/or analysed during the current study are available from the corresponding

48 author on reasonable request.

# 49 Authors' contributions

- 50 Nekaris runs the long-term field site, conceptualized the study and procured funding. Nekaris and Campera
- 51 conducted the field work. Campera and Handby cleaned and analysed the data. All authors contributed to the
- 52 writing of the manuscript.

# 53 Ethics approval

- 54 We collected all data in compliance to guidelines and ethical practices provided by the Association of the Study 55 of Animal Behaviour and the Indonesian Ministry of Science and Technology, RISTEK 56 (802/FRP/E5/Dit.KI/VII/2018). Construction of bridges and camera trapping followed protocol approved by the 57 Animal Ethics Subcommittee at Oxford Brookes University and followed by the Association of Animal Behaviour. 58
- 59 Consent to participate
- 60 All authors consent to participate.
- 61
- 62 Consent for publication
- 63 All authors consent to publication.

#### 64 Introduction

65 Habitat fragmentation threatens biodiversity in complex ways, affecting, for example, movements of animal 66 populations (Fischer and Lindenmayer 2007). Habitat fragmentation can increase the risk of extinction due to 67 population bottlenecks, increased mortality rates and psychological stress, and also may result in home-range 68 modifications (Mimet et al. 2016). To mitigate the effects of habitat fragmentation, important management 69 techniques have been developed, including wildlife crossings in the form of canopy bridges (Teixeira et al. 2013; 70 Soanes et al. 2017). To be effective, bridges should be as close as possible to natural corridors, within a 71 favourable landscape and a suitable location and size, and ideally help multiple species (Clevenger 2005; Mimet 72 et al. 2016; Gregory et al. 2017; Birot et al. 2019). A number of studies in the tropics qualitatively or quantitatively 73 characterised whether or not artificial and natural canopy bridges are used by a variety of species including 74 brown-eared woolly opossums Caluromys lanatus, streaked dwarf porcupine Coendou ichillus, brown howler 75 monkey Alouatta guariba clamitans and Javan palm civets Paradoxurus musanga javanicus (Teixeira et al. 2013; 76 Gregory et al. 2017; Nekaris et al. 2020). Ecological factors that influence bridge use by animals, including 77 temperature, rainfall and light levels, have rarely been considered. In order to produce biologically based 78 management of wildlife crossings, including construction, placement, and monitoring, more studies are needed 79 to determine which ecological factors affect bridge use (van der Grift and van der Ree 2015).

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81 Animals adjust their behaviour in response to weather, light conditions and seasonality (Panzeri et al. 2021), 82 factors that should also apply to the use of artificial wildlife crossings. Some species avoid using crossings that 83 are not covered by some form of canopy (Soanes et al. 2017). Other species that rarely descend to the ground 84 may use bridges that provide only limited cover but may serve to reduce predation or road accidents (Das et al. 2009; Mass et al. 2011; Al-Razi et al. 2019; Birot et al. 2019). The texture of a crossing, including whether or not 85 86 it is slippery or wet, can impact an animals' speed and ability to grasp the surface or stop their movements 87 (Lammers 2009; Clark and Higham 2011), meaning some types of crossing can be risky. These complex energetic 88 costs must be balanced with the benefits of wildlife bridges, including the potential for reduction in energy 89 expenditure, increased access to feeding resources and decreased genetic isolation (Soanes et al. 2017; 90 Balbuena et al. 2019).

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92 Just as they would impact the use of any other substrate, temperature, seasonality and humidity will likely 93 impact an animal's choice to use a wildlife bridge. These abiotic factors influence the activity patterns of animals, 94 either through day-to-day changes affecting substrate choice or sleeping sites, or seasonal environmental 95 changes such as food availability (Brivio et al. 2017; Kemna et al. 2020). Temperature has a strong effect on 96 energy expenditure and may affect artificial bridge use. Many species reduce their activity in hotter 97 temperatures and during dry seasons, employing behavioural thermoregulation to reduce energy expenditure 98 (Terrien et al. 2011). Since artificial wildlife crossings may span large open areas, animals may be more exposed 99 when using them and this can increase predation risk (Das et al. 2009). Due to increased food availability, some 100 primates, rodents, amphibians and arthropods can be more active in high humidity (Rode-Margono and Nekaris

101 2014). High humidity can also influence microhabitat choice, activity, and postural behaviour in some species,

- 102 including avoidance of extreme heat (Lopes and Bicca-Marques 2017).
- 103

104 For nocturnal species, lunar cycles can have a profound impact on activity patterns, with some species being 105 more lunarphobic, where activity is reduced in brighter moonlit conditions, and others more lunarphilic, where 106 activity during brighter nights is increased (reviewed in Prugh and Golden 2014). Prugh and Golden (2014) found 107 that species relying on vision as their primary sensory system or that used vision for foraging increased activity 108 during brighter nights. The same species, however, living in a highly anthropogenic landscape with perceived 109 risk of hunting may trade foraging efficiency to reduce their activity in brighter moon periods (Lima and 110 Bednekoff 1999). For medium-sized animals that may be both predator and prey, their degree of activity during 111 different levels of moonlight may vary in relation to prey availability, improved visual detection of predators and 112 higher foraging efficiency (Nash 2007; Prugh and Golden 2014; Rode-Margono and Nekaris 2014; Pratas-113 Santiago et al. 2016; Campera et al. 2019). Thus, choosing to use a simple linear infrastructure that lacks cover 114 may put an animal at greater predation risk, meaning that using bridges during darker moon periods may provide 115 an element of safety.

116

117 Palm civets Paradoxurus spp. and slow lorises Nycticebus spp. are largely sympatric across Southeast Asia. Both 118 genera are largely tree-dwelling, often live close to human settlements, and are widely subject to wildlife trade 119 (Nijman et al. 2014; Nekaris et al. 2020). The Javan palm civet P. musanga javanicus and the Javan slow loris N. 120 javanicus are medium-sized (2-5 kg; 1 kg) small nocturnal mammals endemic to Java (Veron et al. 2015; Rode-121 Margono and Nekaris 2014). Javan palm civets are classified by the IUCN Red List as Least Concern, whereas 122 Javan slow lorises are Critically Endangered; populations of both species are dramatically declining due to illegal 123 wildlife trade for pets and commercial purposes, alongside continued habitat loss (Nijman et al. 2014; Nijman et 124 al. 2017). Asian palm civets are predominantly frugivorous, whereas Javan slow lorises are predominantly 125 exudativorous, with both also consuming small mammals, birds, molluscs, and insects, with Javan slow loris also 126 eating nectar in the wetter season (Brown and Shine 2007; Cabana et al. 2017). At the same time, both species 127 are subject to potential predation by larger felids, snakes and raptors (Joshi et al. 1995; Birot et al. 2019; Parikesit 128 et al. 2019). Despite the threat of predation, in studies of Javan palm civets and slow lorises (Rode-Margono and 129 Nekaris 2014; Parikesit et al. 2019), the former demonstrates less activity on moonless and cloudy nights or 130 remains active regardless of moonlight and the latter demonstrates more activity on darker nights. Both palm 131 civets and slow lorises can adapt well to human habitations where they are not hunted, including frequently 132 using vegetation along roadsides and motorbike tracks (Nakabayashi et al. 2014; Birot et al., 2019; Parikesit et 133 al. 2019). We have previously shown that in West Java, Indonesia, Javan palm civets and Javan slow lorises use 134 artificial canopy bridges in the form of raised waterlines used to irrigate farmers' fields (Spaan et al. 2014; 135 Nekaris et al. 2020). Such bridges could be a management solution across the large geographic range of these 136 declining genera (Nakabayashi et al. 2014), making understanding the details of their use important. 137

- 138 Here, we examine whether abiotic factors, namely moon illumination, seasonality and weather conditions
- 139 (temperature and relative humidity), influence Javan palm civets' and Javan slow lorises' use of artificial bridges,
- 140 inferred through camera trapping (Panzeri et al. 2021). The information presented is important to shed light on
- 141 the effectiveness of bridges as a conservation strategy, and how to improve planning and implementation of
- 142 bridge studies. We made the following predictions:
- 143
- 144 1) To conserve energy, we predicted bridge use would be more frequent during cooler nights. Because the drier
- season is associated with lower food availability (Cabana et al. 2017) and using bridges during hot temperatures
- could be more energetically costly, we predicted bridge use would be less frequent during the drier and hottestmonths.
- 148 2) Similarly, higher humidity is associated with periods of fruit and flying insect abundance (Rode-Margono and
- 149 Nekaris 2014). We thus predicted increased bridge use during more humid periods.
- 150 3) Because Javan leopards, feral dogs and human hunters occur at the study site as potential predators, we
- 151 predicted bridge use would increase during nights with lower lunar illumination to reduce predation risk (Lima
- and Bednekoff 1999).
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### 154 Materials and methods

- 155 Field Site
- We conducted the study near Cipaganti, West Java, Indonesia (S 7° 16' 5.9", E107° 46' 2.3"), on the foothills of Mount Puntang, part of the Java-Bali Montane Rain Forest ecoregion. The habitat is made up of a mosaic of traditional home-gardens, an agroforest management technique that includes rows of perennial crops interspersed with native trees (Nekaris et al. 2020). The area is described as ever-wet tropical forest, with the annual temperatures averaging 26–29°C. The area experiences a drier period between May and October and an annual rainfall between 2000-3000 mm (Rode-Margono and Nekaris 2014).
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#### 163 Artificial Bridges

164 We installed five artificial bridges and monitored them between 2017 and 2019. In order to choose locations for 165 bridges, we held focus groups with farmers who agreed to have bridges placed on their land and agreed to 166 maintain the waterline bridges When assessing where to assemble waterlines, the main criteria were presence 167 of study animals in the farm, alongside access to a water source and a positive slope to allow the water to flow 168 to the farms. The bridges were installed by attaching wire to a waterline, securing them to trees or bamboo on 169 either side of the crop fields at a mean height of  $4.2 \text{ m} \pm 2.2$  (SD) (range: 1–8 m), and with a mean length of 57.9 170 m ± 24.6 (range: 17.4–74.5 m). We placed bridges at a minimum distance of 67 m and a maximum distance of 171 1033 m to each other in the home ranges of different study groups. Details of construction are provided by 172 Nekaris et al. (2020). We installed 10 camera traps at the ends of the bridges for monitoring the use by wildlife, 173 with one on either side of each bridge. We inserted camera traps in metal cases oriented towards the bridge, 174 tied to trees with wire and locked the cases. We used motion-triggered infrared cameras (Bushnell HD, model 175 119836), set to take three photographs per capture with a 3 second delay. We checked that camera traps were

functional and in position at least biweekly. We swapped batteries and SD cards every 2–3 weeks, at which time
we downloaded photographs and videos.

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### 179 Data Collection and Analysis

180 During July 2017 to December 2019, we collected data on the use of the bridges by Javan palm civets and Javan 181 slow lorises. The data collected were based on instances of bridge use (i.e., crossing). We considered a crossing 182 as a single individual event temporally independent, considering a threshold of 1 hour (Cusack et al. 2017). When 183 more than one individual was on the bridge at the same time, each of them was considered as an instance of 184 bridge use. We collected climate data including mean ambient temperature (°C) and mean relative humidity 185 using a Hobo U30 weather station (Birot et al. 2019). We collected data on the moon phase and the illumination 186 percentage at midnight through Moontool (v. 2.0). These were collected for each night during the study period. 187 We carried out statistical analysis using R v 4.0.3 (R Core Team 2019). We used Generalised Additive Models 188 (GAMs) with the number of crossings per night for each species as the dependent variable, moon luminosity, 189 relative humidity, seasonality (Julian date), and temperature as independent variables. We fitted the dependent 190 variable to a Poisson distribution for count data with the number of active bridges with camera traps installed 191 as the offset in the analysis. We used a fully restricted maximum likelihood method for model selection via gamm 192 command in the package 'mgcv' (Wood 2018). For Julian date, we manually selected cyclic cubic regression 193 splines to take into account the circularity of the variable (Wood 2017). We used GAM as they provide a flexible 194 approach because they do not assume a linear or other parametric form of relationship a priori and can be used 195 to reveal and estimate non-linear effects of the covariate on the dependent variable (Wood 2017). We 196 considered significant values when the smooth term ± 95% confidence interval was higher or lower than the 197 reference value (i.e., not crossing the reference line).

198

# 199 Results

We analysed 938 instances of use by Javan palm civets on waterline bridges. Bridge use by civets was significantly influenced by humidity, moon luminosity, seasonality and temperature (Table 1; Figure 1). Bridge use was significantly more frequent than the GAM reference value in the wet period, while it was significantly less frequent than the reference value in the dry period (May-July). Bridge use was significantly less frequent than the reference value at high humidity (>90%), and very high luminosity (>90%). At moderately high moon luminosity (55-80 %), bridge use was significantly more frequent than the reference value. There was a significant negative linear relationship between bridge use and mean temperature.

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We analysed 1036 instances of use by Javan slow lorises on waterline bridges. Bridge use by lorises was significantly less frequent than the GAM reference value in the dry period (May-July), while it was significantly more frequent than the reference value at hot temperatures (>20.5°C) (Table 1; Figure 2). There was a trend towards a significant negative relationship between bridge use by lorises and moon luminosity (p=0.081), while humidity did not influence loris bridge use. Lorises and civets had peaks of bridge crossings at different times of the night. Lorises showed peaks close to sunset and sunrise whereas civets showed peaks around 2 h after sunset and 2 h before sunrise (Figure 3). Despite these peaks, both species regularly used bridges during all hours ofthe night.

216

#### 217 Discussion

218 Here we present details on the use and potential competition of use by two nocturnal species in relation to 219 several abiotic factors. Javan palm civets and Javan slow lorises regularly used artificial bridges, but their use 220 varied based on temperature, season and moon phase. For Javan palm civets, three out of four of our predictions 221 were supported, namely that Javan palm civets used waterline bridges significantly more during cooler 222 temperatures, less during the drier season and less during the brightest moon illumination, but less in high 223 humidity. For Javan slow lorises, however, the only supported hypothesis was that lorises used bridges less in 224 the drier period. Contrary to our prediction of increased bridge use during cooler nights in order to conserve 225 energy, we found they used bridges more in warmer temperatures. We also showed potential competition for 226 use of bridges by the two species. Other studies on wildlife crossings have reported the frequency of their use 227 by species (Mass et al. 2011; Texeira et al. 2013; Gregory et al. 2017); sex differences in use (Dexter et al. 2018); 228 changes in home range size and access to food trees (Birot et al. 2019); and impact on gene flow (Soanes et al. 229 2018). Ours is the first study to examine impact of abiotic factors on bridge use for tropical dwelling species. 230 Collection of these data with camera traps for a two-year period enables insights into factors mitigating their 231 use of bridges (c.f. Teixeira et al. 2013; Gregory et al. 2014). These data may inform the use of wildlife crossing 232 for conservation of arboreal mammals, including advocating the use of camera traps to understand use in all 233 seasons, light and weather conditions. This is important as some bridge studies relied on human observers alone 234 to monitor use, and such monitoring may not be carried out in inclement weather (e.g., Mass et al. 2011). Our 235 long-term monitoring data also demonstrates how artificial bridges can be integrated completely into the 236 habitat of a species.

237

238 We previously showed that Javan palm civets and Javan slow lorises used raised waterlines erected by villagers 239 (Spaan et al. 2014). With this knowledge, we built an additional five waterline bridges as part of a conservation 240 programme (Birot et al., 2019). Through monitoring their use, we showed that civets used them within 1-74 days 241 of their installation, and on average, within 36 days (Nekaris et al. 2020). Slow lorises used them within 2-22 242 days, and on average, within 10 days (Nekaris et al. 2020). Palm civets and slow lorises in general are considered 243 to adapt well to human modified landscapes, and for example, frequently may be seen crossing roads, making 244 them vulnerable to road accidents or capture for pet trade (Nakabayashi et al. 2014; Nijman et al. 2014; Al-Razi 245 et al. 2019; Parikesit et al. 2019). The ability of palm civets and lorises to adapt to human infrastructures means 246 that appropriate placement of bridges could help mitigate these risks. Although considered Least Concern, civet 247 populations are in serious decline for the pet trade and civet coffee industries (Nijman et al. 2014), whereas 248 capture for pet trade is considered the main threat for the Critically Endangered Javan slow lorises (Nijman et 249 al. 2017). Indeed, many species that live commensally with humans are less common in less disturbed forest, 250 and densities on habitat edges are often much higher than within the forest (Hansen et al. 2019). The bridges in

our study were used by at least 20 other species (Nekaris et al. 2020), and, if current trends continue could be a vital tool to connect habitat for edge dwelling species, especially on an island like Java, with little natural forest remaining.

254

255 Despite the potential mitigation value of artificial bridges for multiple species (Clevenger 2005; Mimet et al. 256 2016), we also need to consider that these resources could become a source of competition (Oberosler et al. 257 2017). Interestingly, both lorises and civets regularly used the bridges throughout the night. We found, however, 258 that the peak of bridge use was different between the two species, indicating a possible interspecific competition 259 for bridge use. We might consider the bridge and the nearby environment as a habitat and the species using the 260 bridge as competing for this niche. Practitioners and conservationists should consider the complexity of the 261 ecological and social interactions within and between species that can arise from building bridges prior to their 262 installation. Monitoring their use can unveil new patterns or confirm expected trends, and mitigation measures 263 can be modified accordingly

264 (c.f. Andersen et al. 2017).

265

266 Javan palm civets more frequently used bridges on cooler nights, whereas Javan slow lorises used them more 267 on warmer nights. Being active at a time suitable to aid in regulating body temperature can help animals avoid 268 excessive energy loss (Vickery and Bider 1981). Palm civets are widely distributed throughout Asia, including in 269 areas where temperatures drop to freezing (Veron et al. 2015). In a study of masked palm civets Paguma larvata 270 in China, civets were equally active in the cold winter months as in the summer months (Zhou et al. 2014). 271 Although largely arboreal, for Javan slow lorises and Javan palm civets, moving along the relatively long and 272 open waterline bridges can be more energetically costly than typical branches by exposing animals directly to 273 air temperatures. In the case of slow lorises, however, many animals decrease their activities at lower 274 temperatures, maintaining still postures that help them to preserve warmth. Javan slow lorises in Cipaganti 275 regularly enter torpor on cold nights and reduce their activity in general (Rode-Margono and Nekaris 2014). 276 Thus, less frequent use of bridges during this time accords with an energy strategy very different from palm 277 civets. For species already potentially energetically compromised living in a dynamic anthropogenic landscape, 278 conservationists must ensure that they do not place them under additional negative energetic constraints.

279

280 We found that civets and lorises both used bridges least during the driest months, which is also the coldest 281 period. Javan palm civets are primarily frugivorous and fruit availability is lower during the dry months at our 282 study site (Cabana et al. 2017). Nakishima et al. (2013) also suggested that fruit availability was one of the main 283 drivers of palm civet behaviour. Indeed, during periods of low fruit availability, palm civets in their study 284 increased their home range size to find additional food resources. As we did not radio collar or track palm civets 285 in this study, the reduction of use of bridges during the drier season may also be linked to an overall increase in 286 their home range size, with a subsequent decrease in bridge use in those periods. We have previously shown 287 that Javan slow lorises increase their feeding and foraging behaviour during the coldest periods, except during 288 phases of brighter luminosity (Rode-Margono and Nekaris 2014; Reinhardt et al. 2016). In addition, the bridges

provided Javan slow lorises with direct access to new feeding trees (Birot et al. 2020). Consideration of how bridges provide the species of interest access to food resources or restricts neighbouring groups who may have previously had sole access to those resources, is something that can be investigated in future bridge studies.

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293 Humidity did not affect slow loris bridge use, whereas palm civets used bridges less during periods of high 294 humidity. Previous studies on carnivores using camera traps found temporal differences in activity related to 295 seasonal availability of food (Kemna et al. 2020). A supplement to fruits for civets could come in the form of 296 molluscs, amphibians or insects, which might be expected to be of higher availability during humid periods 297 (Brown and Shine 2007; Rode-Margono and Nekaris 2014). Most of these foods would be available on the 298 ground, potentially leading to less bridge use by civets. Furthermore, the bridges themselves may be more 299 slippery during periods of higher humidity. This aspect would be expected to affect clawed civets more so than 300 slow lorises, as lorises can grasp the bridge tightly with their prehensile hands (Birot et al. 2020). The waterlines 301 are smooth low friction surfaces that can be more slippery when wet (Clark and Higham 2011). Although we 302 never observed an animal fall from one of the bridges, this risk still exists, especially in humid periods. This 303 difference in use between the two taxa has relevance not only for projects wanting to place the bridges relevant 304 to appropriate food sources, but also to assess the suitability of the materials of their bridges across seasons.

305

306 The final indicator of bridge use in our study was lunar illumination. Civets avoided the brightest nights, but still 307 used the bridges when moderate moonlight was available; although insignificant, there was a trend for slow 308 lorises also to avoid the brightest nights (Huck et al 2017). Avoiding the brightest nights could be an anti-predator 309 strategy (Nash 2007; Prugh and Golden 2014; Pratas-Santiago et al. 2016; Campera et al. 2019). Potential 310 predators to civets and slow lorises include leopards, snakes, raptors, feral dogs, and humans, all of which occur 311 at our study site (Joshi et al. 1995; Rode-Margono and Nekaris 2014; Parikesit et al. 2019). Only the latter two 312 occur at high density, with hunting by humans for both species confirmed, and hunting lorises by feral dogs also 313 confirmed (Nekaris unpublished data). For this latter predator, raised waterlines place civets and lorises out of 314 reach. Our results also support the visual acuity hypothesis, in that being active in moderate moonlight still 315 allows civets and lorises to see their own prey items (Huck et al. 2017).

316

317 In conclusion, we showed here that camera traps were an excellent method to examine bridge use continuously 318 for a two-year period. Many studies directly count species use of bridges (e.g., Das et al. 2009; Mass et al. 2011), 319 and by potentially avoiding periods of rain, high humidity or low lunar illumination, human observers may miss 320 species with a bias to using the substrate during particular periods. Furthermore, by understanding the influence 321 that abiotic factors have on the use of artificial bridges, we can scrutinise how we can improve them to 322 encourage use most favourable to the species. These factors along with others, like bridge location and 323 infrastructure, will affect the overall success of bridges (Gregory et al. 2017). For example, social interactions, 324 resource availability, predation risk, and habitat connectivity nearby the bridges can potentially affect bridge 325 use. By including multiple parameters in the study, these may also help in constructing bridges for other tropical 326 arboreal mammals (van der Grift and van der Ree 2015). In particular, factors such as providing habitat cover to

- 327 provide safety from predators and the elements may ensure maximum use of the bridges (Soanes et al. 2017).
- 328 Even without these factors, here we have further illustrated that simple to construct bridges were integrated
- into the niche of Javan palm civets and Javan slow lorises, with use of bridges similar to how they use other
- 330 structures in their natural habitats. For commensal species like civets and lorises that adapt well to living near
- human habitations (Nakabayashi et al. 2014; Birot et al. 2019), artificial bridges could prove vital to their future
- 332 conservation.
- 333

# 334 Acknowledgements

335 We would like to thank Indonesian RISTEK (386/SIP/FRP/E5/Dit.KI/XI/2017, S/476/E5/E5.4/SIP/2020) and the

regional Perhutani and BKSDA for authorising this study. We thank the Little Fireface Field team for their help

- 337 with the field work. We thank Dr Emiliano Mori and another anonymous reviewer for the important suggestions
- 338 given during the review process.
- 339

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Table 1 Results of the Generalised Additive Models to explain the influence of environmental and climatic
 variables on the use of the bridges by the Javan palm civet (*Paradoxurus musanga javanicus*) in Cipaganti, West
 Java. The data are based on crossing from five artificial canopy bridges between 2017 and 2019. The smooth
 terms are plotted in Figure 1.

Response variable	Predictor	Intercept Value (SE)	Smooth term		
			Edf	χ²	p-value
Civet bridge use	Illumination (%)		4.295	18.4	0.004
	Julian day	-1.165	6.403	170.5	<0.001
	Relative	(0.037)	3.520	28.9	<0.001
	humidity				
	Temperature		1.001	19.5	<0.001
Loris bridge use	Illumination (%)	-0.961	1.009	15.7	0.081
	Julian day	(0.032)	1.525	6.6	0.012
	Relative		1.525	0.4	0.772
	humidity				
	Temperature		2.347	15.7	0.001

# 496 Figure Heading

**Figure 1** Smooth terms estimated via Generalised Additive Models to explain the influence of moon illumination (%), seasonality (Julian date), temperature (°C), relative humidity on artificial waterline bridge use by the Javan palm civet *Paradoxurus musanga javanicus* in Cipaganti, West Java. The data are based on crossing from five artificial canopy bridges monitored with camera traps between 2017 and 2019. The dashed lines indicate the reference value, and the shaded area indicates the 95% confidence interval of the smooth term. The double

arrow in the Julian date indicates the dry period (May-July).







- 514 Figure 2 Smooth terms estimated via Generalised Additive Models to explain the influence of moon illumination
- 515 (%), seasonality (Julian date), temperature (°C), relative humidity on artificial waterline bridge use by the Javan
- 516 slow loris *Nycticebus javanicus* in Cipaganti, West Java. The data are based on crossing from five artificial canopy
- 517 bridges monitored with camera traps between 2017 and 2019. The dashed lines indicate the reference value,
- 518 and the shaded area indicates the 95% confidence interval of the smooth term. The double arrow in the Julian
- 519 date indicates the dry period (May-July).



- **Figure 3** Percentage of bridge crossings in relation to the time of the day by Javan palm civet *Paradoxurus*
- 538 musanga javanicus and Javan slow loris Nycticebus javanicus in Cipaganti, West Java. The peak of their bridge
- 539 crossings differed by around 2 hours.

