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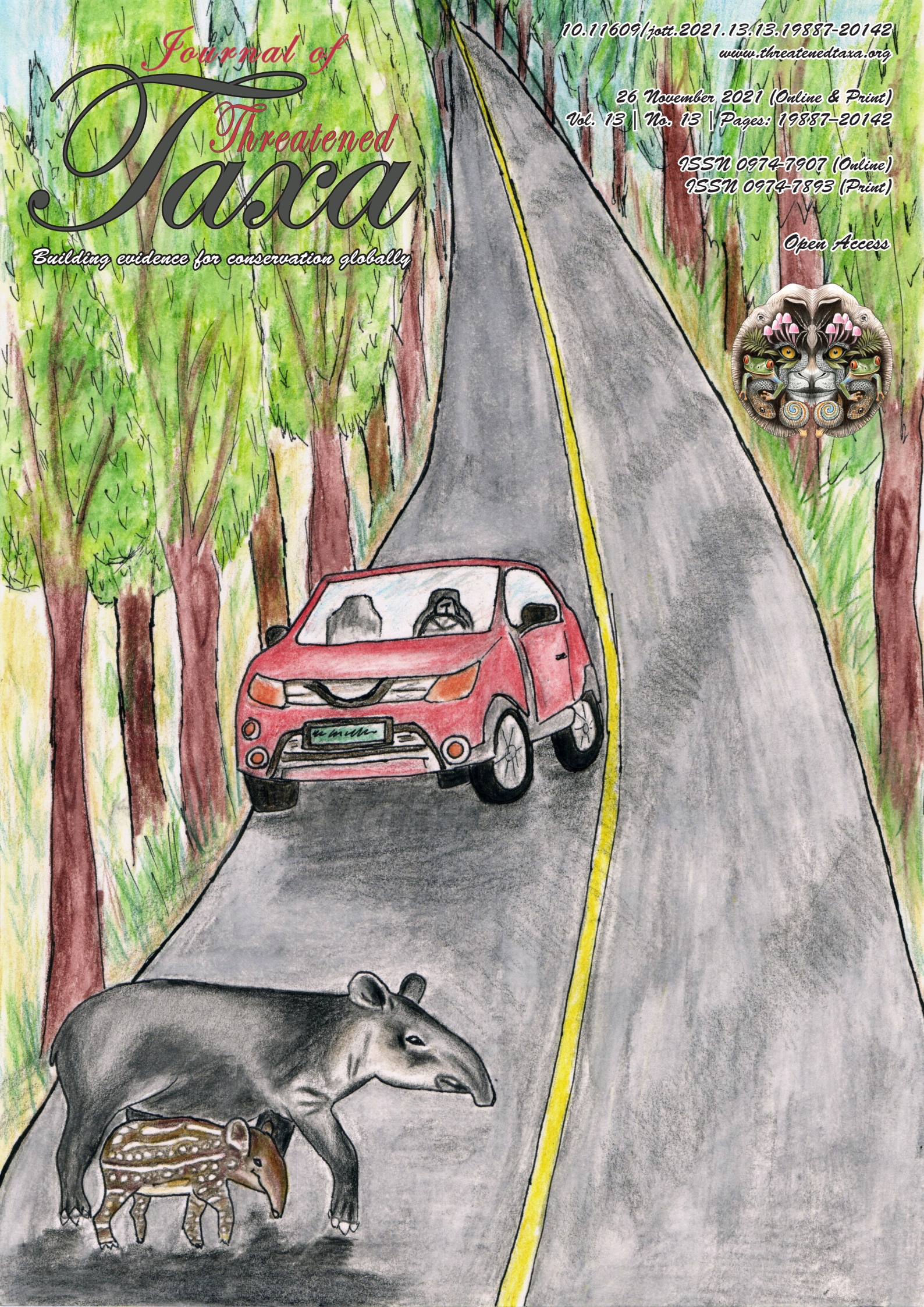

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Caption: Lowland Tapir *Tapirus terrestris* (Medium—watercolours on watercolour paper) © Aakanksha Komanduri.

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COMMUNICATION

Roadkills of Lowland Tapir *Tapirus terrestris* (Mammalia: Perissodactyla: Tapiridae) in one of its last refuges in the Atlantic Forest

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Abstract: Highways limit the movement and dispersion of wild animals and contribute to their loss due to roadkills, leading to the isolation and decline of populations, increasing the risk of local extinction. The Lowland Tapir *Tapirus terrestris* is the largest neotropical herbivore-frugivore, and despite its wide distribution in South America it is threatened with extinction. In this study we report six roadkill events of tapirs between 2014 and 2019 in a section of a federal highway crossing the mosaic of Atlantic Forest reserves called Sooretama, one of the last tapir refuges in southeastern Brazil. The traffic in this area is heavy with inadequate speed control, while exotic fruit trees growing along the highway attract wild animals. Water drainage tunnels serve as passageways for some species, including tapirs. However, the tunnels located under the highway are not continuously maintained, reducing its effectiveness. The loss of at least one tapir per year can have serious long-term consequences for one of the last viable lowland tapir populations in the entire Atlantic Forest. Emergency measures are required to avoid vehicle-tapir collisions.

Keywords: Brazil, mitigation measures, road ecology, Sooretama, threatened species.

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INTRODUCTION

Roads and highways lead to habitat loss and fragmentation, create barriers that limit the movement and dispersion of organisms, limit genetic flows, prevent wildlife from accessing resources that are vital for their survival, and cause direct animal mortality due to roadkill incidents, all with negative effects on biodiversity (Forman & Alexander, 1998; Trombulak & Frissell 2000; Coffin 2007; Laurance et al. 2009; Holderegger & Di Giulio 2010). Large mammal populations are among the most negatively affected by the presence of roads, mainly because they travel long distances, cross different roads, and have low reproductive rates and population densities (Fahrig & Rytwinski 2009).

In Brazil, one of the large mammal species affected by highways is the Lowland Tapir *Tapirus terrestris* (Linnaeus, 1758) (Grilo et al. 2018), the largest terrestrial mammal of Neotropics, with a body length of 1.70 to 2.00 m and weight up to 300 kg (Padilla & Dowler 1994; Eisenberg & Redford 1999; Medici 2011). This species presents the largest distribution within the genus and is found in the lowland regions of northern and central South America (Padilla & Dowler 1994; Eisenberg & Redford 1999; Varela et al. 2019). Despite its wide geographic distribution, the species is currently classified as Vulnerable, both globally (Varela et al. 2019) and in the Brazilian territory (Medici 2018). Nevertheless, in the Atlantic Forest, one of the most threatened biodiversity hotspots in the world (Myers et al. 2000), the conservation status of the Lowland Tapir is even more worrying because its habitat has been reduced to a few fragments and its population is extremely small, being reduced to a small number of areas (Medici et al. 2018).

The main conservation threats to the Lowland Tapir are habitat loss, poaching and competition with livestock (García et al. 2012; Medici et al. 2012, 2018; Varela et al. 2019). However, in recent years, roadkill incidents with tapirs have attracted increasing attention due to their negative consequences. In Brazil, tapirs killed by collisions with vehicles have been reported in the Amazon (Carvalho et al. 2014; de Freitas et al. 2017), Pantanal (de Souza et al. 2015), Cerrado (Ascensão et al. 2017), transitional areas between Cerrado and the Atlantic Forest (Cáceres et al. 2010; Cáceres 2011), and the southwestern region of the Atlantic Forest (Medici & Desbiez 2012). These events are even more severe for tapir populations when combined with other threats, especially in the Atlantic Forest, where very few areas support viable populations of more than 200 individuals (Medici et al. 2012).

Here we report tapir roadkills and relate them to the species' high locomotion ability combined with poor road management in one of the last areas with viable Lowland Tapir populations, located in the north of Espírito Santo State, southeastern Brazil (Flesher & Gatti 2010; Gatti et al. 2011; Medici et al. 2012; Ferreguetti et al. 2017), in a complex of protected areas known as Sooretama. Sooretama, which means "land of the animals of the forest" in the Brazilian native language Tupi Guarani (Instituto Brasileiro de Desenvolvimento Florestal 1981), consists of a group of four protected areas amount approximately 53,000 ha. These areas have been recognized as one of the best preserved large lowland forests with high priority for the conservation of large mammals in the biome (Galetti et al. 2009).

METHODS

Study area

We conducted the study in a forest complex formed by Sooretama Biological Reserve (SBR; 27,858 ha), a federal protected area; the Vale Natural Reserve (VNR; 22,711 ha), a private protected area; the Private Natural Heritage Reserves (PNHR) Recanto das Antas (2,212 ha) and the PNHR Mutum-Preto (379 ha) (Figure 1). This contiguous protected areas complex is one of the 77 Atlantic Forest remnants with more than 10,000 ha (Ribeiro et al. 2009), located between the coordinates -18.905458, -40.212713 and -19.244815, -39.945269, in the northern part of the Espírito Santo state, southeastern Brazil, hereon referred as Sooretama (Figure 1).

The Sooretama reserves form one of the largest remnants of Tabuleiro Atlantic Forest, a lowland forest (formed on sedimentary plains originated in the Pliocene) intersected by wide and shallow valleys (Rolim et al. 2016). The climate is tropical with dry winter (Aw) according to Köppen's system (Alvares et al. 2013). Since the 1960's, the Sooretama forest complex has been bisected by the busiest highway in Brazil, the federal BR-101 highway (Instituto Brasileiro de Desenvolvimento Florestal 1981) (Figure 1). Approximately 23 kilometers of BR-101 intersects the SBR buffer zone, with 5 kilometers crossing the interior of SBR (Figure 1).

Data collection

We obtained data on tapirs killed by collisions with vehicles on the section of BR-101 crossing Sooretama between 2014 and 2019. The roadkill events were reported to us by the SBR staff. We visited the sites,

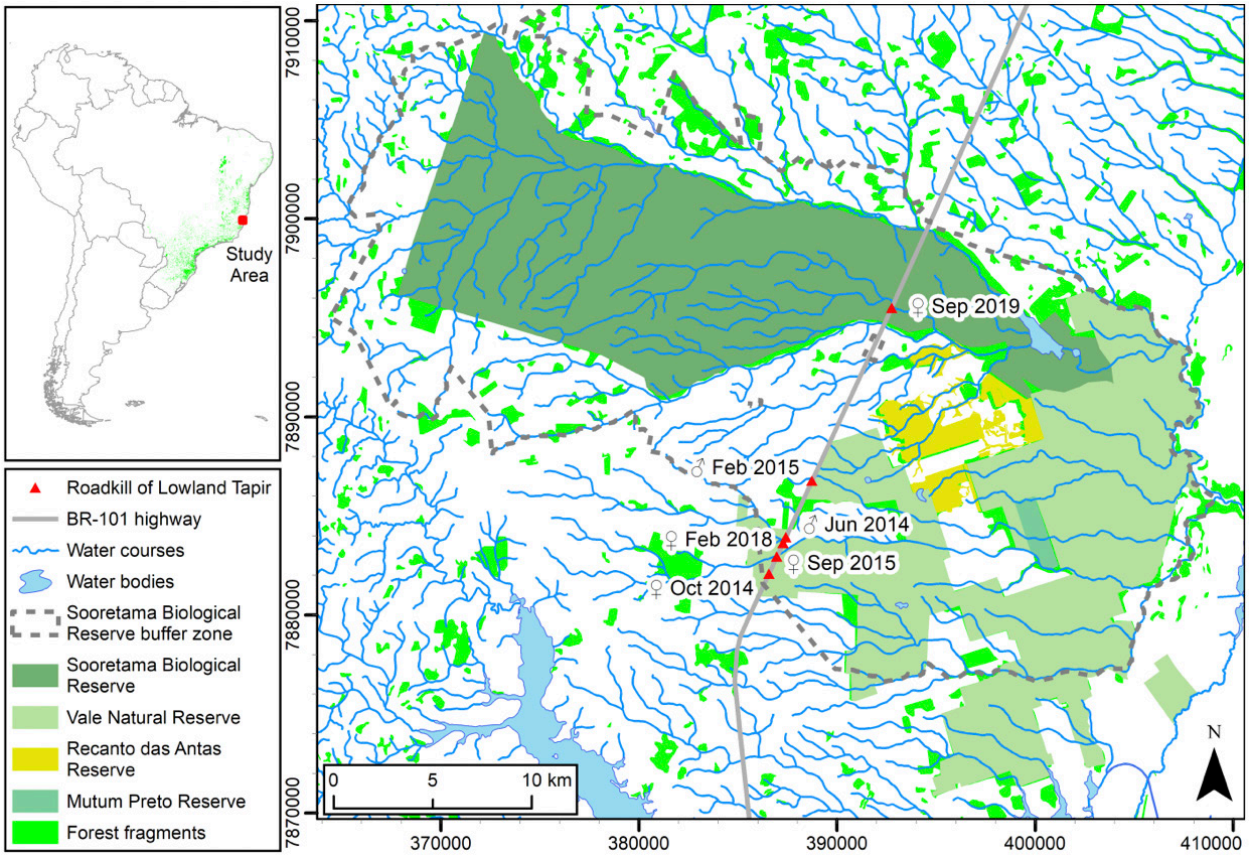

Figure 1. Records of six roadkill events of lowland tapirs in a section of BR-101 highway, crossing the Sooretama complex, in southeastern Brazil.

recorded the date, the location on the highway, and the age class and sex of each animal. Necropsies were performed on individuals that were not in an advanced stage of decomposition. The tapir bones and heads were collected and deposited at the Museu de Ciências da Vida (Museum of Life Sciences), Federal University of Espírito Santo.

RESULTS

We recorded six events of tapir roadkills in the study area: two males (an adult and another juvenile) and four females (three adults and juvenile) (Figure 1; Table1; Image 1). The second roadkilled tapir was a pregnant adult female with a well-developed male fetus (Últimos Refúgios 2014a; Image 2). Two other tapirs were found on the roadside in an advanced stage of decomposition, one on 17 September 2015, and another on 15 September 2019 (Table 1). The roadkill of the last tapir was reported by a highway user who saw the moment of the collision in the late afternoon, days before the animal being found dead. Four confirmed roadkills occurred at night and one afternoon, caused by two cars, two trucks, and one bus (Table 1). Five tapirs were roadkill on the stretch of the highway that cuts through the VNR, in the SBR buffer zone (Figure 1). Only the last roadkill happened within the SBR area (Figure 1).

Table 1. Records of roadkill events of lowland tapirs in a section of BR-101 highway that crossing the Sooretama complex, in southeastern Brazil.

Date	Sex	Life stage	Km	Period	Vehicle type
30.vi.2014	male	adult	119	night	truck
24.x.2014	female	adult	121	night	car
08.ii.2015	male	juvenile	116	night	car
17.ix.2015	female	adult	120	unidentified	unidentifield
17.ii.2018	female	adult	119	night	bus
15.ix.2019	female	juvenile	105	afternoon	truck

Image 1. Photo of juvenile male Lowland Tapir roadkilled at km 116 of the BR-101 highway in Sooretama, on 8 February 2015.

Image 2. Photo of a fetus of a pregnant Lowland Tapir roadkilled at km 121 of the BR-101 highway in Sooretama, on 24 October 2014.

DISCUSSION

In the six decades since its construction, many animals of various species have been killed on this portion of the BR-101 (Instituto Brasileiro de Desenvolvimento Florestal 1981; Klippel et al. 2015; Srbek-Araujo et al. 2015; Damásio et al. 2021). Since 2014, we have followed roadkill records of tapirs to understand their negative effects on the conservation of the species in the forest complex of Sooretama. Roadkill records described in this study are extremely worrisome for the lowland tapir conservation on Espírito Santo, as well as on the Atlantic Forest biome as a whole. There is only one known record from before the monitoring period of a Lowland Tapir killed via a vehicle collision in the neighboring area of Sooretama. This occurred in 1997, when a school bus hit a tapir on an unpaved road located south of Sooretama reserves, in Córrego Farias, municipality of Linhares (Lorenzutti & Almeida 2006). Unlike this isolated record, this study shows that the loss of Lowland Tapir due to vehicle collisions is an old problem in the region, emphasizing the role of this threat in removing individuals of reproductive age from the population of Sooretama.

It is possible that some tapir deaths due to collisions were not recorded. Animals may have died in the forest due to injuries resulting from a collision, or carcasses may have been lost for other reasons. For instance, two tapirs were found only days after they were roadkilled, when the presence of vultures and decaying animal smell near the highway was noticed. Nonetheless, on 21 July 2019 we received notification of another tapir roadkill on BR-101 but its carcass was not found. Thus it is likely that we underestimated the number of tapir roadkills.

Tapir roadkills occurred most often at night and outside of the SBR area, on a stretch of highway within VNR fragmented forest. These factors must be considered in designing mitigation strategies. In addition to tapirs, other large mammals have been killed within the SBR area, including a Jaguar *Panthera onca* in 2000 (Srbek-Araujo et al. 2015) and two Pumas *Puma concolor*, one in 2009 (Srbek-Araujo et al. 2015) and another in 2015 (Últimos Refúgios 2015).

Roadkill events can rapidly reduce tapir population growth and increase the probability of local extinction, especially when adults and sub-adult females are lost (Medici & Desbiez 2012). Tapirs are long-lived and have slow reproductive rates, which makes the species more vulnerable to anthropogenic pressures (Medici & Desbiez 2012; Medici et al. 2012; Varela et al. 2019). In Sooretama, of the six recorded tapir kills, four were adult and sub-adult females. According to Ferreguetti et al. (2017), the population size in Sooretama was 200± 33 individuals, which suggests that the local population is genetically and demographically viable, based on the population viability analysis for the species in the Atlantic Forest (Gatti et al. 2011; Medici & Desbiez 2012). However, the incidence of female roadkill can be a warning for the long-term survival of the population. Tapir population reduction and even extinction can result in the loss of ecological services, such as seed dispersal (Barcelos et al. 2013; Bueno et al. 2013; Giombini et al. 2016; Paolucci et al. 2019), since they are responsible for dispersing seeds of high wood density trees that store tons of carbon, thus providing an ecological service with an estimated worth of billions of dollars (Bello et al. 2015; Peres et al. 2015).

Wildlife underpasses and their use by tapirs on the BR-101 highway

The stretch of the BR-101 that intercepts Sooretama is a straight paved road with 23 water drainage culverts (hereafter "tunnels"), and some of them are used by wild species (Banhos et al. 2020). Five of these tunnels are tall and wide (more than 2 m in diameter) and are frequently used by mammals, such as lowland tapirs. Since 2014, the use of these tunnels by wild animals has been monitored using camera traps, and tapirs were registered using the crossings (Video 1). Despite this, the six killed tapirs were found close to the big tunnels (between 5 m and 800 m away), at km 106, 116, 119, and 120.

Although wild animals are using the tunnels in the area, the lack of maintenance and cleaning of the structures results in tunnels completely obstructed by sediments, branches, and tree trunks, often precluding the use by of wildlife. During the camera trap monitoring period, we did not witness any event of tunnel maintenance or cleaning. Occasionally, we cleaned the tunnels ourselves. On 22 September 2015, a camera recorded an attempt by a tapir to cross the tunnel at km 120, which was blocked by fallen bamboo branches (Video 2). We confirmed in the images of the cameras that the blockade happened on 11 September 2015 and that a tapir went through the tunnel days before, on 8 September 2015. Five meters from the tunnel entrance, a tapir was found dead on 17 September 2015.

Tunnels are often used as wildlife passages and are therefore one of the measures used to mitigate roadkill incidents. Even though the tunnels in BR-101 were not originally installed as a mitigation measure, they are often used for crossings by some species. Thus, these tunnels make the highways less risky for wildlife (Clevenger et al. 2001; Goosem et al. 2001; Cain et al. 2003; Taylor & Goldingay 2003; Dodd Jr. et al. 2004; Ascensão & Mira 2007; McCollister & Manen 2010; Lesbarrères & Fahrig 2012). However, periodic maintenance of the tunnels is necessary so that they can be effectively used by fauna.

Video 1. Video of Lowland Tapir crossing the tunnel at km 106 of the BR-101 highway in Sooretama.

Video 2. Video of Lowland Tapir to cross the tunnel at km 120 of the BR-101 highway in Sooretama, which was blocked by fallen bamboo branches, on 22 September 2015.

Socioeconomic impacts and risks for highway users

The high speed of vehicles is one of the factors that increases the risk of roadkill events (Forman & Alexander 1998; Fahrig & Rytwinski 2009), and the large-sized vertebrates killed along the BR-101 highway in Sooretama in recent years are indicatives of that. It was not uncommon to observe reckless drivers that ignored the speed cameras when they were operating.

From June 2014 and October 2016, we measured the speed of vehicles (including cars and trucks) driving between the 102 and 107 km stretch of the BR-101 that intercepts Sooretama, in both directions, using a hand-held speed camera (Bushnell®). In addition, in February 2020, we measured speeds at km 102 and km 107. Measurements were conducted in the morning, afternoon, and evening on different days. The maximum speed limit allowed along the 23 km of the BR-101 that intercepts Sooretama is 80 km/h (from km 101 to 102 and km 107 to 124) or 60 km/h (from km 102 to 107, the stretch that intercepts the SBR). From 2011 to 2017 there were electronic speed monitoring devices (radars) at the beginning and end of the 60 km/h stretch, but in 2017, the radars were removed. The speed of 580 vehicles was measured in the 80 km/h limit stretch of the BR-101 that intercepted Sooretama, 70% of the vehicles exceeded the speed limit, the lowest recorded speed was 48 km/h, the highest recorded speed was 170 km/h, and the average speed was 92 ± 20 km/h. In the 60 km/h limit stretch, we measured the speed of 662 vehicles, of which 80% exceeded the speed limit, the lowest recorded speed was 36 km/h, the highest recorded speed was 138 km/h, and the average speed was 76 ± 18 km/h. In February 2020, the speed of 40

vehicles was measured between km 102 and 107, of which 87% exceeded the speed limit. Here, the lowest recorded speed was 54 km/h, the highest recorded speed was 132 km/h, and the average speed was 80 ± 17 km/h. The radars were reinstalled in 2021 and the speed limit was raised to 80 km/h, but we do not assess the speed of vehicles.

Wildlife-vehicle collisions are a huge threat against biodiversity, but they can also cause a great impact on human health and safety because they can result in serious accidents, which risk human health/life and come at high economic costs (Seiler 2005; Huijser et al. 2009; Freitas & Barszcz 2015). For example, accidents with large-sized animals, such as tapirs, can result in serious human injury or death (Freitas & Barszcz 2015). Between 2014 and 2020, over 30 human deaths occurred in accidents at 23 km of the BR-101 in Sooretama. However, it was not possible to confirm whether these accidents involved animals on the road. In a collision with a tapir in Sooretama (on 24 October 2014), the car driver obtained severe injuries and was hospitalized. The resulting costs from vehicle-animal collisions are high, but these accidents can be avoided or reduced by implementing mitigation measures that increase the safety of roads and reduce the damage caused by this type of accident (Huijser et al. 2009).

Emergency measures

The BR-101 poses one of the major threats to the biodiversity of the Sooretama region because of its negative effect on species. In addition, there are concerns about the duplication plan for the BR-101 highway, which could be implemented in the coming years, including the duplication of the stretch that intercepts the protected areas (Srbek-Araujo et al. 2015). Among the proposals to mitigate the impacts of the BR-101 duplication, there is the construction of viaducts for cars and wildlife bridges, or the relocation of the vehicle flow to areas with a lower conservation priority (Srbek-Araujo et al. 2015). However, until the mitigation of the highway expansion is resolved, accidents will continue to kill animals, including lowland tapirs. Thus, due to pending permanent mitigation measures for the highway expansion, emergency measures must be taken to avoid wildlife accidents.

There are several commonly used mitigation measures for reducing wildlife-vehicle collisions (see Goosem et al. 2001; Clevenger 2005; Glista et al. 2009; van der Ree et al. 2009; Lesbarrères & Fahrig 2012; van der Grift et al. 2013; Rytwinski et al. 2016), and high-cost mitigation measures are reported to be more effective in reducing accidents with large mammals (Rytwinski et al. 2016), although they require more planning and time to implement. However, some mitigation measures can be implemented quickly and without high costs, which would substantially reduce fatal accidents (Lester 2015). In 2014, during the workshop "*Impactos da rodovia BR-101 na Reserva Biológica de Sooretama: Estudos, Alternativas e Mitigação*", a multidisciplinary team of experts (see Últimos Refúgios 2014b) recommended the following emergency measures: (1) the maintenance of the drainage culverts to serve as wildlife passages; (2) the elimination of jackfruit trees *Artocarpus heterophyllus*, mango trees *Mangifera indica*, and other exotic fruit trees that grow on the margins of the highway and attract wildlife; (3) a speed limit reduction to 60 km/h along the whole stretch; (4) the installation of speed bumps and electronic speed monitoring devices along the whole stretch; (5) the installation of warning signs informing about the possibility of wildlife crossings and risk of wildlife accidents; and (6) the monitoring of the effectiveness of the implemented mitigation measures (Universidade Federal do Espírito Santo 2014). The mitigation measures were discussed with the Federal Public Prosecution Ministry and agreed upon with the other regulatory bodies, including the National Land Transport Agency and Chico Mendes Institute for Biodiversity Conservation, as well as representatives of the company responsible for the highway administration. However, more than seven years have passed and only one recommendation has been implemented (the removal of fruit trees from km 119 to 123 in August 2018). If all measures had been implemented as proposed, fatal accidents involving wildlife that have occurred in the following years of the workshop could have been avoided. From the proposal of the measures until the conclusion of this article, an average of one tapir died per year.

We agree that the relocation of the BR-101 highway from Sooretama is the best measure to guarantee the conservation of the landscape and local biodiversity for the long term. Sooretama has a long history of protection that precedes the existence of the highway, with all administrative acts that guarantee its conservation documented (Instituto Chico Mendes de Conservação da Biodiversidade 2019; Instituto Brasileiro de Desenvolvimento Florestal 1981). The highway was built across the protected area in the late 1960s, even though this was prohibited by the Forest Code (Instituto Brasileiro de Desenvolvimento Florestal 1981). Furthermore, no documents were found that show the administrative act that allowed the construction of this

highway within Sooretama. As a result, the preservation of the local biodiversity is jeopardized because one of Brazil's busiest highways crosses the interior of this protected areas complex.

CONCLUSION

The BR-101 highway represents a great threat for the conservation of the lowland tapir and many other species in the forest complex of Sooretama, one of the last regions that harbors viable tapir populations in the Atlantic Forest. The maintenance of tunnels used by fauna is necessary to mitigate the impact of road, but it is not a definitive solution for the fauna roadkill. In addition to the loss of biodiversity, vehicle collisions with tapirs result in risk to human life, economic losses, and loss of valuable ecological services. Emergency mitigation measures must be implemented to avoid further losses due to the chronic impact of the highway on biodiversity along the stretches that cross the protected areas of Sooretama region. Furthermore, we suggest building a detour to remove the BR-101 highway from within Sooretama.

REFERENCES

Alvares, C.A., J.L. Stape, P.C. Sentelhas, G. de Moraes, J. Leonardo & G. Sparovek (2013). Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711–728. https://doi.org/10.1127/0941-2948/2013/0507

Ascensão, F. & A. Mira (2007). Factors affecting culvert use by vertebrates along two stretches of road in southern Portugal. *Ecological Research* 22: 57–66. https://doi.org/10.1007/s11284-006-0004-1

Ascensão, F., A.L.J Desbiez, E.P. Medici & A. Bager (2017). Spatial patterns of road mortality of medium–large mammals in Mato Grosso do Sul, Brazil. *Wildlife Research* 44: 135–146. https://doi.org/10.1071/wr16108

Banhos, A., B.L. Fontes, D.R. Yogui, M.H. Alves, N.C. Ardente, R. Valls, L.M. Barreto, L. Damásio, Á.C. Ferreguetti, A.S. Carvalho, V.R. Schettino, A.R. Santos, H.G. Bergallo, A.C. Srbek-Araujo, E.P. Medici & A.L.J. Desbie (2020). Highways are a threat for giant armadillos that underpasses can mitigate. *Biotropica* 52: 421–426. https://doi.org/10.1111/btp.12778

Barcelos, A.R., P.E.D. Bobrowiec, T.M. Sanaiotti & R. Gribel (2013). Seed germination from lowland tapir (*Tapirus terrestris*) fecal samples collected during the dry season in the northern Brazilian Amazon. *Integrative Zoology* 8: 63–73. https://doi.org/10.1111/1749-4877.12003

Bello, C., M. Galetti, M.A. Pizo, L.F.S. Magnago, M.F. Rocha, R.A.F. Lima, C.A. Peres, O. Ovaskainen & P. Jordano (2015). Defaunation affects carbon storage in tropical forests. *Science Advances* 1: 1–11. https://doi.org/10.1126/sciadv.1501105

Bueno, R.S., R. Guevara, M.C. Ribeiro, L. Culot, F.S. Bufalo & M. Galetti (2013). Functional redundancy and complementarities of seed dispersal by the last neotropical megafrugivores. *PLoS ONE* 8(2): e56252. https://doi.org/10.1371/journal.pone.0056252

Cáceres, N.C. (2011). Biological characteristics influence mammal road kill in an Atlantic Forest–Cerrado interface in south-western Brazil. *Italian Journal of Zoology* 78: 379–389. https://doi.org/10.1080/11250003.2011.566226

Cáceres, N.C., W. Hannibal, D.R. Freitas, E.L. Silva, C. Roman & J. Casella (2010). Mammal occurrence and roadkill in two adjacent ecoregions (Atlantic Forest and Cerrado) in south-western Brazil. *Zoologia* (Curitiba) 27: 709–717. https://doi.org/10.1590/S1984-46702010000500007

Cain, A.T., V.R. Tuovila, D.G. Hewitt & M.E. Tewes (2003). Effects of a highway and mitigation projects on bobcats in Southern Texas. *Biological Conservation* 114: 189–197. https://doi.org/10.1016/S0006-3207(03)00023-5

Carvalho, A.S., F.D. Martins, F.M. Dutra, D. Gettinger, F. Martins-Hatano & H.G. Bergallo (2014). List Large and Medium-Sized Mammals of Carajás National, Pará State, Brazil. *Check List* 10: 1–9. https://doi.org/10.15560/10.1.1

Clevenger, A.P. (2005). Conservation value of wildlife crossings: Measures of performance and research directions. *Gaia* 14: 124–129. https://doi.org/10.14512/gaia.14.2.12

Clevenger, A.P., B. Chruszcz & K. Gunson (2001). Drainage culverts as habitat linkages and factors affecting passage by mammals. *Journal of Applied Ecology* 38: 1340–1349. https://doi.org/10.1046/j.0021-8901.2001.00678.x

Coffin, A.W. (2007). From roadkill to road ecology: A review of the ecological effects of roads. *Journal of Transport Geography* 15: 396–406. https://doi.org/10.1016/j.jtrangeo.2006.11.006

Damásio, L., L.A. Ferreira, V.T. Pimenta, G.G. Paneto, A.R. dos Santos, A.D. Ditchfield, H.G. Bergallo & A. Banhos (2021). Diversity and Abundance of Roadkilled Bats in the Brazilian Atlantic Forest. *Diversity* 13: 335. https://doi.org/10.3390/d13070335

de Freitas, M.A., R.C. Printes, E.K. Motoyama, A.E. Fucks & D. Veríssimo (2017). Roadkill records of Lowland Tapir *Tapirus terrestris* (Mammalia: Perissodactyla: Tapiridae) between kilometers 06 and 76 of highway BR-163, state of Pará, Brazil. *Journal of Threatened Taxa* 9(11): 10948–10952. https://doi.org/10.11609/jott.3227.9.11.10948-10952

de Souza, J.C., V.P. da Cunha & S.H. Markwith (2015). Spatiotemporal variation in human-wildlife conflicts along highway BR-262 in the Brazilian Pantanal. *Wetlands Ecology and Management* 23: 227–239. https://doi.org/10.1007/s11273-014-9372-4

Dodd, Jr. C.K., W.J. Barichivich & L.L. Smith (2004). Effectiveness of a barrier wall and culverts in reducing wildlife mortality on a heavily traveled highway in Florida. *Biological Conservation* 118: 619–631. https://doi.org/10.1016/j.biocon.2003.10.011

Eisenberg, J.F. & K.H. Redford (1999). Mammals of the Neotropics, Volume 3: Ecuador, Bolivia, Brazil. University of Chicago Press, Illinois. https://doi.org/10.4067/S0716-078X2005000200017

Fahrig, L. & T. Rytwinski (2009). Effects of Roads on Animal Abundance: an Empirical Review and Synthesis. Ecology and Society 14: 21. http://www.ecologyandsociety.org/vol14/iss1/art21/ Electronic version accessed 20 May 2020.

Ferreguetti, A.C., W.M. Tomás & H.G. Bergallo (2017). Density, occupancy, and detectability of lowland tapirs, *Tapirus terrestris*, in Vale Natural Reserve, southeastern Brazil. *Journal of Mammalogy* 98: 114–123. https://doi.org/10.1093/jmammal/gyw118

Flesher, K.M. & A. Gatti (2010). *Tapirus terrestris* in Espírito Santo, Brasil. *Tapir Conservation* 19/1: 16–23.

Forman, R.T.T. & L.E. Alexander (1998). Roads and their major ecological effects. Annual Review of Ecology and Systematics 29: 207–231. https://doi.org/10.1146/annurev.ecolsys.29.1.207

Freitas, S.R. & L.B. Barszcz (2015). A perspectiva da mídia online sobre os acidentes entre veículos e animais em rodovias brasileiras: uma questão de segurança? *Desenvolvimento e Meio Ambiente* 33: 261–276. https://doi.org/10.5380/dma.v33i0.36910

Galetti, M., H.C. Giacomini, R.S. Bueno, C.S.S. Bernardo, R.M. Marques, R.S. Bovendorp, C.E. Steffler, P. Rubim, S.K. Gobbo, C.I. Donatti, R.A. Begotti, F. Meirelles, R.A. Nobre, A.G. Chiarello & C.A. Peres (2009). Priority areas for the conservation of Atlantic forest

large mammals. *Biological Conservation* 142: 1229–1241. https://doi.org/10.1016/j.biocon.2009.01.023

García, M.J., E.P. Medici, E.J. Naranjo, W. Novarino & R.S. Leonardo (2012). Distribution, habitat and adaptability of the genus *Tapirus*. *Integrative Zoology* 7: 346–355. https://doi.org/10.1111/j.1749-4877.2012.00317.x

Gatti, A., D. Brito & S.L. Mendes (2011). How many lowland tapirs (*Tapirus terrestris*) are needed in Atlantic Forest fragments to ensure long- term persistence? *Studies on Neotropical Fauna and Environment* 46: 77–84. https://doi.org/10.1080/01650521.2011.562086

Giombini, M.I., S.P. Bravo & D.S. Tosto D.S. (2016). The key role of the largest extant Neotropical frugivore (*Tapirus terrestris*) in promoting admixture of plant genotypes across the landscape. *Biotropica* 48: 499–508. https://doi.org/10.1111/btp.12328

Glista, D.J., T.L. DeVault & J.A. DeWoody (2009). A review of mitigation measures for reducing wildlife mortality on roadways. *Landscape and Urban Planning* 91: 1–7. https://doi.org/10.1016/j.landurbplan.2008.11.001

Goosem, M., Y. Izumi & S. Turton (2001). Efforts to restore habitat connectivity for an upland tropical rainforest fauna: A trial of underpasses below roads. *Ecological Management & Restoration* 2: 196–202. https://doi.org/10.1046/j.1442-8903.2001.00084.x

Grilo, C., M.R.Coimbra, R.C. Cerqueira, P. Barbosa, R.A.P. Dornas, L.O. Gonçalves, F.Z. Teixeira, I.P. Coelho, B.R. Schmidt, D.L.K. Pacheco, G. Schuck, I.B. Esperando, J.A. Anza, J. Beduschi, N.R. Oliveira, P.F. Pinheiro, A. Bager, H. Secco, M. Guerreiro, C.F. Carvalho, A.C. Veloso, A.E.I. Custódio, O. Marçal, G. Ciocheti, J. Assis, M.C. Ribeiro, B.S.S. Francisco, J.J. Cherem, T.C. Trigo, M.M.A. Jardim, I.C. Franceschi, C. Espinosa, F.P. Tirelli, V.J. Rocha, M.L. Sekiama, G.P. Barbosa, H.R. Rossi, T.C. Moreira, M. Cervini, C.A. Rosa, L.G. Silva, C.M.M. Ferreira, A. César, J. Casella, S.L. Mendes, J. Zina, D.F.O. Bastos, R.A.T. Souza, P.A. Hartmann, A.C.G. Deffaci, J. Mulinari, S.C. Luzzi, T. Rezzadori, C. Kolcenti, T.X. Reis, V.S.C. Fonseca, C.F. Giorgi, R.P.Migliorini, C.B. Kasper, C. Bueno, M. Sobanski, A.P.F.G. Pereira, F.A.G. Andrade, M.E.B. Fernandes, L.L.C. Corrêa, A. Nepomuceno, A. Banhos, W. Hannibal, R. Fonseca, L.A. Costa, E.P. Medici, A. Croce, K. Werther, J.P. Oliveira, J.M Ribeiro, M. de Santi, A.E. Kawanami, L. Perles, C. do Couto, D.S. Figueiró, E. Eizirik, A.A. Correia, F.M. Corrêa, D. Queirolo, A.L. Quagliatto, B.H. Saranholi, P.M. Galetti, K.G. Rodriguez-Castro, V.S. Braz, F.G.R. França, G. Buss, J.A. Rezini, M.B. Lion, C.C. Cheida, A.C.R. Lacerda, C.H. Freitas, F. Venâncio, C.H. Adania, A.F. Batisteli, C.G.Z. Hegel, J.A. Mantovani, F.H.G. Rodrigues, T. Bagatini, N.H.A. Curi, L. Emmert, R.H. Erdmann, R.R.G.F. Costa, A. Martinelli, C.V.F. Santos & A. Kindel (2018). Brazil road-kill: a data set of wildlife terrestrial vertebrate road-kills. *Ecology* 99: 2625. https://doi.org/10.1002/ecy.2464

Holderegger, R. & M. Di Giulio (2010). The genetic effects of roads: A review of empirical evidence. *Basic and Applied Ecology* 11: 522–531. https://doi.org/10.1016/j.baae.2010.06.006

Huijser, M.P., J.W. Duffield, A.P. Clevenger, R.J. Ament & P.T. McGowen (2009). Cost-benefit analysis of mitigation measures aimed at reducting collisions with large ungulates in the United States and Canada, a decision support tool. *Ecology and Society* 14: 15. http://www.ecologyandsociety.org/vol14/iss2/art15/ Electronic version accessed 20 May 2020.

Instituto Brasileiro de Desenvolvimento Florestal (1981). Plano de Manejo Reserva Biológica de Sooretama. http://www.icmbio.gov.br/portal/images/stories/docs-planos-de-manejo/rebio_sooretama_pm.pdf Electronic version accessed 13 March 2019.

Instituto Chico Mendes de Conservação da Biodiversidade (2019). Plano de Manejo Reserva Biológica de Sooretama. https://www.icmbio.gov.br/portal/images/stories/docs-planos-de-manejo/plano_de_manejo_rebio_sooretama_2020.pdf Electronic version accessed 20 May 2020.

Klippel, A.H., P.V. Oliveira, K.B. Britto, B.F. Freire, M.R. Moreno, A.R. Santos, A. Banhos & G.G. Paneto (2015). Using DNA barcodes to identify road-killed animals in two Atlantic Forest nature reserves, Brazil. *PLoS One* 10: e0134877. https://doi.org/10.1371/journal.pone.0134877

Laurance, W.F., M. Goosem & S.G.W.W. Laurance (2009). Impacts of roads and linear clearings on tropical forests. *Trends in Ecology & Evolution* 24: 659–669. https://doi.org/10.1016/j.tree.2009.06.009

Lesbarrères, D. & L. Fahrig (2012). Measures to reduce population fragmentation by roads: what has worked and how do we know? *Trends in Ecology & Evolution* 27: 374–380. https://doi.org/10.1016/j.tree.2012.01.015

Lester, D. (2015). Effective Wildlife Roadkill Mitigation. *Journal of Traffic and Transportation Engineering* 3: 42–51. https://doi.org/10.17265/2328-2142/2015.01.005

Lorenzutti, R. & A.P. Almeida (2006). A coleção de mamíferos do Museu Elias Lorenzutti em Linhares, Estado do Espírito Santo, Brasil. *Boletim do Museu de Biologia Mello Leitão (Nova Série)* 19: 59–74.

McCollister, M.F. & F.T. van Manen (2010). Effectiveness of Wildlife Underpasses and Fencing to Reduce Wildlife-Vehicle Collisions. *The Journal of Wildlife Management* 74: 1722–1731. https://doi.org/10.2193/2009-535

Medici, E.P. (2011). Family Tapiridae (Tapirs), pp. 182–204. In: Wilson, D.E. & R.A. Mittermeier (eds.). *Handbook of the Mammals of the World: Vol. 2: Hoofed Mammals*. Lynx Edicions, Barcelona. https://doi.org/10.1515/mammalia-2012-0032

Medici, E.P. & A.L.J. Desbiez (2012). Population viability analysis: using a modeling tool to assess the viability of tapir populations in fragmented landscapes. *Integrative Zoology* 7(4): 356–372. https://doi.org/10.1111/j.1749-4877.2012.00318.x

Medici, E.P., K. Flesher, B.M. Beisiegel, A. Keuroghlian, A.L.J. Desbiez, A. Gatti, A.R.M. Pontes, C.B. de Campos, C.F. de Tófoli, E.A. Moraes Junior, F.C. de Azevedo, G.M. de Pinho, J.L.P. Cordeiro, T.S. Santos Júnior, A.A. de Morais, P.R. Mangini, L.F. Rodrigues & L.B. de Almeida (2012). Avaliação do Risco de Extinção da Anta brasileira *Tapirus terrestris* Linnaeus, 1758, no Brasil. *Biodiversidade Brasileira-BioBrasil Ano* II: 103–116.

Medici, E.P., K. Flesher, B.M. Beisiegel, A. Keuroghlian, A.L.J. Desbiez, A. Gatti, A.R.M. Pontes, C.B. de Campos, C.F. de Tófoli, E.A. Moraes Junior, F.C. de Azevedo, G.M. de Pinho, J.L.P. Cordeiro, T.S. Santos Júnior, A.A. de Morais, P.R. Mangini, L.F. Rodrigues & L.B. de Almeida (2018). *Tapirus terrestris* (Linnaeus, 1758), pp. 59–68. In: Instituto Chico Mendes de Conservação da Biodiversidade (ed.). Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Vol 2: Mamíferos. Instituto Chico Mendes de Conservação da Biodiversidade, Brasília.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A. da Fonseca & J. Kent (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858. https://doi.org/10.1038/35002501

Padilla, M. & R.C. Dowler (1994). *Tapirus terrestris*. *Mammalian Species* 481: 1–8. https://doi.org/10.2307/3504109

Paolucci, L.N., R.L. Pereira, L. Rattis, D.V. Silvério, N.C.S. Marques, M.N. Macedo & P.M. Brando (2019). Lowland tapirs facilitate seed dispersal in degraded Amazonian forests. *Biotropica* 51: 245–252. https://doi.org/10.1111/btp.12627

Peres, C.A., E. Thaise, J. Schietti, S.J.M. Desmoulieres & T. Levi (2015). Dispersal limitation induces long-term biomass collapse in overhunted Amazonian forests. *Proceedings of the National Academy of Sciences USA* 113: 892–897. https://doi.org/10.1073/pnas.1516525113

van der Ree, R., D. Heinze, M. McCarthy & I. Mansergh (2009). Wildlife tunnel enhances population viability. *Ecology and Society* 14: 7. http://www.ecologyandsociety.org/vol14/iss2/art7/ Electronic version accessed 20 May 2020.

Ribeiro, M.C., J.P. Metzger, A.C. Martensen, F.J. Ponzoni & M.M. Hirota (2009). The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142: 1141–1153. https://doi.org/10.1016/j.biocon.2009.02.021

Rolim, S.G., L.F.T. Menezes & A.C. Srbek-Araujo (2016). *Floresta Atlântica de Tabuleiro: Diversidade e Endemismo na Reserva Natural Vale*. Editora Rona, Belo Horizonte.

Rytwinski, T., K. Soanes, J.A.G. Jaeger, L. Fahrig, C.S. Findlay, J. Houlahan, R. van der Ree & E.A. van der Grift (2016). How effective is road mitigation at reducing road-kill? A meta-analysis. *PLoS One* 11: 1–25. https://doi.org/10.1371/journal.pone.0166941

Seiler, A. (2005). Predicting locations of moose-vehicle collisions in Sweden. *Journal of Applied Ecology* 42: 371–382. https://doi.org/10.1111/j.1365-2664.2005.01013.x

Srbek-Araujo, A.C., S.L. Mendes & A.G. Chiarello (2015). Jaguar (*Panthera onca* Linnaeus, 1758) roadkill in Brazilian Atlantic Forest and implications for species conservation. *Brazilian Journal of Biology* 75: 581–586. https://doi.org/10.1590/1519-6984.17613

Taylor, B.D. & R.L. Goldingay (2003). Cutting the carnage: wildlife usage of road culverts in north-eastern New South Wales. *Wildlife Research* 30: 529–537. https://doi.org/10.1071/WR01062

Trombulak, S.C. & C.A. Frissell (2000). Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. *Conservation Biology* 14: 18–30. https://doi.org/10.1046/j.1523-1739.2000.99084.x

Últimos Refúgios (2014a). Riquezas Perdidas. Electronic version accessed 20 May 2020. https://youtu.be/yv2t5qQVAPk

Últimos Refúgios (2014b). Workshop - Impactos da Rodovia BR-101 na Reserva Biológica de Sooretama. https://youtu.be/XQl2VPPqAcg Electronic version accessed 20 May 2020.

Últimos Refúgios (2015) Uma Estrada no Caminho. Electronic version accessed 20 May 2020. https://youtu.be/U6io6QdAVhQ

Universidade Federal do Espírito Santo (2014). Workshop Impactos da Rodovia BR-101 na Reserva Biológica de Sooretama: Estudos, Alternativas e Mitigação. https://06860d25-8838-49fb-9e43-af80dd7048f1.filesusr.com/ugd/1573a4_68a84628f9dc4e8594b73e3698f3e368.pdf (accessed 20 May 2020).

van der Grift, E.A., R. van der Ree, L. Fahrig, S. Findlay, J. Houlahan, J.A.G. Jaeger, N. Klar, L.F. Madriñan & L. Olson (2013). Evaluating the effectiveness of road mitigation measures. *Biodiversity and Conservation* 22: 425–448. https://doi.org/10.1007/s10531-012-0421-0

Varela, D., K. Flesher, J. Cartes, S. Chalukian, S. de Bustos, G. Ayala & C. Richard-Hansen (2019). *Tapirus terrestris*, Lowland Tapir. The IUCN Red List of Threatened Species 2019. https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T21474A45174127.en

Resumo (Português): As rodovias limitam a movimentação e a dispersão de animais silvestres e contribuem para a perda de indivíduos por atropelamento, levando ao isolamento e ao declínio das populações, aumentando o risco de extinção local. A anta brasileira Tapirus terrestris é o maior herbívoro-frugívoro neotropical e, apesar de sua ampla distribuição na América do Sul, está ameaçada de extinção. Neste estudo, nós relatamos seis eventos de atropelamento de antas, entre 2014 e 2019, em um trecho de rodovia federal BR-101 que intercepta um mosaico de reservas da Mata Atlântica, denominado Sooretama, um dos últimos refúgios de antas no sudeste do Brasil. O tráfego de veículos nesta área é intenso, com controle inadequado de velocidade, enquanto árvores frutíferas exóticas crescem ao longo da rodovia atraindo animais silvestres. Túneis de drenagem de água servem de passagem para algumas espécies, incluindo antas. No entanto, os túneis localizados sob a rodovia não recebem manutenção periódica adequada, reduzindo sua efetividade. A perda de pelo menos uma anta por ano pode ter consequências graves a longo prazo para uma das últimas populações viáveis de anta brasileira em toda a Mata Atlântica. Assim, medidas emergenciais são necessárias para evitar colisões entre veículos e antas.

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