To tell a different story: Unexpected diversity in local attitudes towards Endangered Aye-ayes *Daubentonia madagascariensis* offers new opportunities for conservation

Roger Doménico Randimbiharinirina¹² | Torsten Richter³ | Brigitte M. Raharivololona¹ | Jonah H. Ratsimbazafy² | Dominik Schüßler³

¹Mention Anthropobiologie et Développement Durable de la Faculté des Sciences, University of Antananarivo, Antananarivo, Madagascar
²Groupe d’Etude et de Recherche sur les Primates de Madagascar (GERP), Antananarivo, Madagascar
³Research Group Plant Ecology and Nature Conservation, University of Hildesheim, Hildesheim, Germany

**Abstract**

1. Human–wildlife interactions are usually centred on the conflict between local populations and species that are perceived as problematic. To better understand the human dimension, social science approaches are increasingly incorporated to delimit opportunities for coexistence and species conservation.

2. Here we explore local attitudes and beliefs about one of these ‘problematic’ species, the Endangered Aye-aye *Daubentonia madagascariensis*, the largest nocturnal primate on earth. We conducted a literature review on published beliefs and narratives about the Aye-aye followed by 83 semi-structured interviews in 11 villages in northeastern Madagascar.

3. The Aye-aye is generally perceived as a bad omen throughout its range. In many places it has to be killed on sight, while in others it is forbidden to be killed. We did not find any positive attitudes towards this species in the literature. However, this was not reflected by our interviews: although 47.0% of respondents held a negative attitude, more than half had a neutral or even positive attitude towards the Aye-aye (36.1 and 18.1% respectively). Positive attitudes were linked to perceived pest control services on major cash crops. Negative attitudes are mostly related to the perception that when an Aye-aye comes to a village, catastrophic things (e.g. deaths of community members) will happen, or that it destroys a village. These major narratives were mostly consistent within villages (79.5 ± 20.7% SD of respondents; range 50–100%) but considerably differed between villages.

4. Negative attitudes towards the Aye-aye were solely based on vague and generic narratives that are not reflected by its (true) ecology. Positive and neutral attitudes instead were related to observable behaviours benefitting people (i.e. pest control services) or curiosity about the species. This case study illustrates how even firm narratives can vary locally offering valuable starting points for targeted conservation or education programs. We therefore identified the Makira region of northeastern Madagascar as a potential stronghold for Aye-aye conservation if specific actions highlighting its beneficial value could be initiated. In general,
1 | INTRODUCTION

The role of human–wildlife interactions (HWI) in species conservation has been acknowledged for some decades by now, but its dimensions are still vividly shifting (Dickman, 2010; Marchini et al., 2019; Redpath et al., 2015). What was considered as human–wildlife conflicts in the beginning often emerged as human–human conflicts about wildlife (Dickman, 2010; Dickman & Hazzah, 2015; Madden & McQuinn, 2014: Skogen et al., 2017) calling for a broader implementation of social sciences into species conservation (Bennett et al., 2017; Chua et al., 2020; Glikman et al., 2019; Schultz, 2011). In this context, the role of indigenous storytelling can further offer valuable insights of how local communities try to explain external pressures surpassing their daily life experiences and resulting impacts on certain species (Fernández-Llamazares & Cabeza, 2017; Holmes et al., 2018; Lee, 2010). In Sierra Leone, for example, some rural communities attribute the erosion of collectivistic values towards increasing individualism to shapeshifters appearing as chimpanzees Pan troglodytes, leopards Panthera pardus or Nile crocodiles Crocodylus niloticus to murder young people for dark magic (locally called ‘chimpanzee business’; Richards, 2000). Under these circumstances, chimpanzee conservation was seen as a moral hazard by informants, posing a severe threat to conservation implementation (Richards, 2000). On Mozambique’s Mueda plateau, politically forced villagization led to social disruptions that are often locally attributed to sorcerers bewitching lions Panthera leo to kill people (West, 2001). Consequently, lions are prosecuted to avert the evil (West, 2001). In Germany, the common belief in werewolves (wolf-like shapeshifters killing people) contributed to the extirpation of the grey wolf Canis lupus and explains the fierceness of wolf persecution better than livestock depredation (Rheinheimer, 1995). This belief led to hunted wolves being hanged from gallows like human criminals during the 18th century and to hanging wolves alongside especially notorious criminals who were found to have transgressed on the dark side of human nature by their contemporaries (Rheinheimer, 1995).

In general, human attitudes towards wildlife are composed of nine factors ranging from utilitarian to naturalistic, from moralistic to negativistic values (see Jacobs et al., 2019). Utilitarian values are often associated with beneficial characteristics like provision of meat while naturalistic values are based on direct experiences with animals. These are, however, in many cases linked to economic losses due to crop feeding or depredation of livestock (Dickman, 2012). Negativistic values like fear or aversion are sometimes based on real threats towards people (Campbell-Smith et al. 2010; Okello et al., 2014; Packer et al., 2005), but more often on misconceptions and a lack of knowledge (Dickman, 2012; Jacobs et al., 2019; Lee & Priston, 2005). Finally, moralistic values are usually founded in spiritual reverence, myths and beliefs with varying consequences for the respective species.

Valuable examples can be found among the 500+ species of primates (Estrada et al., 2017). While being threatened by a multitude of factors (e.g. habitat loss, bushmeat hunting; Estrada et al., 2017), human attitudes towards primates have a major impact on their conservation states—for good or worse (Dickman, 2012; Estrada et al., 2017; Lee & Priston, 2005). In parts of India and Indonesia, for instance, monkeys are worshipped and protected by the local communities (Lee & Priston, 2005) allowing for high population densities around Hindu temples (Imam & Ahmad, 2013). Communal protection of ‘sacred’ Sclater’s monkeys (Ceropithecus sclateri) in Nigeria has comparably helped populations to recover after strong declines (Baker et al., 2013). In contrast, negative interactions along the human–primate interface are more commonly reported with crop feeding being a major concern in regions of Uganda (Hill, 1997; Webber, 2006), Cameroon, Guinea and Nigeria, Japan and Sulawesi (Lee & Priston, 2005; Riley & Priston, 2010; Sprague & Iwasaki, 2006), Indonesia, Brazil and Central America (Campbell-Smith et al., 2010; Lee & Priston, 2005). Crop feeding primates are often measured against the same moral background as humans and behaviours are termed with ‘stealing’ or ‘wasting’ of resources (Hill & Webber, 2010). Retaliatory measures are therefore common to treat perceived misbehaviours or to prevent further economic or subsistence losses (Dickman, 2012; Hill & Webber, 2010; Lee & Priston, 2005).

Attitudes arising from legends or tales (i.e. moralistic values) are very common concerning the lemurs of Madagascar. Many people believe—depending on the region—that ring-tailed lemurs Lemur catta, Verreaux’s sifaka Propithecus verreauxi or Perrier’s sifaka P. perrieri are humans that once transformed into lemurs and should be considered and protected as family members (Anania et al., 2018; Loudon et al., 2006). Hunting of these animals is taboo (fady in Malagasy) and provides effective protection for certain species (e.g. P. coquereli, Salmona et al., 2014; Eulemur macao, Harpert et al., 2000). The legend of the ‘Babakoto’ further tells that the indri Indri indri is the ancestor of humankind itself or related to the ancestors (Harpet, 2011; R.D. Randimbiharinirina and D. Schüßler, unpubl. data). In contrast, the Aye-aye Daubentonia madagascariensis is usually considered the opposite, being a harbinger of death or an incarnation of the evil (e.g. Simons & Meyers, 2001). The situation of the latter species is particularly detrimental due to these negative beliefs. The Aye-aye is currently listed among the 25 most threatened primates (Randimbiharinirina et al., 2019) and belongs probably to the most

 conservation practitioners should feel encouraged to look beyond the often told stories about ‘their’ target species and listen to local voices more often.

KEYWORDS
attitudes towards wildlife, endangered species, human–primate interface, human–wildlife conflict, lemurs, Madagascar
controversial species on earth—loved by the so-called ‘global north’ for its peculiarities and strange, comic-like appearance, but feared by the Malagasy population due to its enigmatic behaviours associated with evil and death. To illustrate this point: the Aye-aye was chosen for the first book in the Ako project, a series of books for conservation education by the late Alison Jolly and Hanta Rasamimanana. Ako the Aye-Aye is illustrated by artistically drawn watercolours of a young Aye-aye and its mother. Accompanying is a poster using photographs of real Aye-ayes in natural surroundings. An evaluation revealed that Malagasy children perceived the real Aye-ayes as ugly and scary but liked it from the illustrations in the book (Dolins et al. 2010).

The Aye-aye is the only living member from the family of Daubentoniidae (Herrera & Dávalos, 2016; Perry et al., 2012) and is with an average weight of about 2.5 kg and a length of 74–90 cm the biggest nocturnal primate on earth (Feistner & Sterling, 1995; Glander, 1994; Oxnard, 1981). It has a suite of unusual, derived traits including an elongated, thin, highly flexible middle finger, a pseudo thumb, continuously growing incisors, large and orange eyes, long and dark fur and tail, the largest relative brain size of any lemur and a relatively slow life history including late weaning and a protracted learning period (Figure 1; Barrickman & Lin, 2010; Hartstone-Rose et al. 2019; Jouffroy, 1975; Owen, 1863; Simons, 1995).

Here we aim to investigate local perceptions on this enigmatic species, find ecological explanations for reported behaviours, elaborate on possible origins of common beliefs, illustrate opportunities for its protection and derive implications for conservationists engaged in the field of human–wildlife interactions.

2 METHODS

2.1 Study region

This study was conducted in the forest frontier region surrounding Makira Natural Park in northeastern Madagascar (Makira NatP; Figure 2). The area is characterized by a mosaic of closely inter-twined land-use types, like differently used and partly degraded rain forests, agroforestry plots, small-scale agriculture and fallow lands after abandonment of cultivation (Llopis et al., 2019; Schüßler et al., 2020). However, the region still encompasses the largest remaining block of rainforest in Madagascar (Schüßler et al., 2020; Vieilledent et al., 2018). Makira NatP and the surrounding forests are managed by the non-governmental organization (NGO) Wildlife Conservation Society (WCS) in conjunction with local communities applying a complex zonation scheme of strictly protected areas as well as sustainable use zones (Brimont et al., 2015). The vast majority of the population lives in a rural setting characterized by only marginal infrastructure (e.g. limited radio or phone reception), a high dependence on subsistence farming (i.e. shifting cultivation) and local resource availability (Ratsimbazafy et al., 2012; Zähringer et al., 2015; Table 1). A major source of income for most households is the cultivation of cash crops like cloves Syzygium aromaticum, vanilla Vanilla planifolia or coffee Coffea robusta (Table 1) that are sold on regional markets or via middlemen on the global market (Andrihamihaja et al., 2019; Hänke et al., 2018; Llopis et al. 2019; Pfund et al., 2011). The study region is inhabited by the Betsimisaraka ethnical group that is, comparable to other ethnics across Madagascar, deeply rooted in traditional customary rights with complex sets of regulations and taboos (so-called fady; Golden & Comaroff, 2015; Harpet et al., 2000). Ancestral relationships play an overarching role and are mainly characterized by land ownership and land-use practices (Sodikoff, 2004). Human–wildlife interactions are based on utilitarian values (bushmeat hunting particularly during the lean season; Golden, 2009; Golden et al., 2019), on moralistic values like the embodiment of ancestors or human beings who got lost in the forests (i.e. Indri indri; R.D. Randimbiharinirina and D. Schüßler, unpubl. data), or on aesthetic values of animals occasionally kept as pets (e.g. black- and-white ruffed lemurs Varecia variegata, bamboo lemurs Hapalemur spp., mouse lemurs Microcebus spp.; R.D. Randimbiharinirina and D. Schüßler, unpubl. data).
The focal species of this research, the Aye-aye, is one out of about 18 different lemur species occurring in the Makira region (Radespiel et al., 2008; Rasolofoson et al., 2007) and is listed as Endangered by the IUCN (Louis et al., 2020). All lemurs and many other species (e.g. fossa, bushpig, tenrec, bats) are hunted for bushmeat by the local population while the extent of hunting varies between species and among villages (Golden, 2009; Ratsimbazafy et al., 2012). Lemur hunting is mainly practised during the cyclone season (February–May) and represents an important source of protein at times when availability of domestic meat appears to be limited (Golden et al., 2019).

2.2 | Literature review

We conducted a structured literature search using key terms and synonyms in Web of Science and Google Scholar search engines. Key terms included ‘Daubentonia’, ‘Aye-aye’, ‘perception’, ‘attitude’, ‘belief’, ‘narrative’, ‘folklore’, ‘taboo’, and ‘fady’ in various combinations. Most insightful information on this topic was, however, provided by rather anecdotal accounts published in newsletters of the IUCN/SSC Primate Specialist Group (‘Primate Conservation’ http://www.primatesg.org/primate_conservation/ and ‘Lemur News’ http://www.primatesg.org/lemur_news/) which were thoroughly scanned for articles fitting to our key terms. This search resulted in a total of 18 articles for which we then assessed the general perception on Aye-ayes by the local communities and extracted information on narratives, beliefs and behaviours as well as the location of the observation/interviewed community.

2.3 | Collection of interview data

We conducted semi-structured household and open key informant interviews in 11 different villages surrounding Makira NatP (Figure 2) in August–October 2019. The interviews were conducted in Malagasy by RDR and a guide from the local Betsimisaraka ethnic group. Answers were translated into English by RDR and DS for
their sense and not word-by-word, as this is not very promising concerning Malagasy–English translations. The number of interviews conducted in each village was chosen in accordance with village size with the maximum number of 15 households interviewed per village. The research objectives were explained to the village leader who gave permission to conduct interviews prior to the survey. Villages were chosen randomly in terms of this study as the main aim for selecting localities was to survey mouse lemurs Microcebus spp.

Participation in this study was on a voluntary basis with adults (>18a) declaring beforehand the purpose of the interviews and the possibility to deny answers or to end the interview whenever desired. All interviewees have given their informed consent to participate. This study was conducted under research permit No. 119/19/MEDD/SG/DGEF/DGRNE issued by the Direction Générale de l'Environnementet des Forêts of Madagascar and approved by the ethics committee of the University of Hildesheim (Germany). We adhered to ethical standards proposed by Wilmé et al. (2016) and the World Medical Association (2013). Village identity is coded with letters (A–K) for consistency throughout this study. Village names and location details will not be provided as they may be linked to illegal activities to warrant the highest degree of protection to our interviewees and the local communities.

We collected data on five closed questions focusing on demographic variables (age, gender, school education, origin), resource extraction from forests (wood, non-timber forest product (NTFP), gemstones) and agroforestry systems (e.g. cloves, vanilla; Supporting Information) as well as identification of the Aye-aye from a picture (see Supporting Information) and by name. We further provided participants with five open questions asking for how many lemur species are known, about experiences with and perceived problems caused by the Aye-aye and whether it is under local fady (forbidden to be killed or eaten) or allowed to be consumed. Finally, we asked for impacts on the local community with an open question giving space for further personal as well as communal perceptions. We used the proportion of forest coverage within an aerial 5-km radius surrounding a village as an indicator of how likely it is to see an Aye-aye during everyday life. In northeastern Madagascar, most activities take place within walking distances of 7–8 km around villages (see Schüßler et al., 2020).

Key informants were selected after confirming that they could identify the Aye-aye from a picture and if they wanted to share further personal experience with the species or knowledge from their communities. During an open interview, informants were asked for their perception and concernment about the Aye-aye, local narratives and general perception by the local community.

2.4 | Data analysis

Qualitative data were coded and assigned to reasonable categories. The majority of the data (except age) used in this study was taken as count data stored in categorical variables. We used chi-square-contingency tests, Student’s t-tests and Pearson correlation to investigate independence between certain pairs of variables. To capture the full complexity of the dataset and to explore the underlying interactions of the categorical variables, we used a classification and regression trees modelling approach (CART; Breiman et al., 1984) as implemented in R packages rpart and rpart.plot (Milborrow, 2019; R Core Team, 2019; RStudio Team, 2020; Therneau & Atkinson, 2019). This method allows determining important predictors for the general attitude towards Aye-ayes and is based on a binary decision tree (Moisen, 2008). The model was provided with nine input variables: village affiliation (a), whether the respondent fears the Aye-aye (b), whether the respondent knows the Aye-aye from a picture (c) or by name (d), how many lemur species the respondent knows by name (e), whether the Aye-aye is reported to do pest control (f), gender (g), age (h) and the highest level of school education (i) a respondent has. The output variable was defined as a negative, neutral or positive general attitude towards the Aye-aye.

The dataset was split into training and validation data prior to the modelling using an 80/20 split proportion. The CART model was build using training data. In a first step a maximum tree is constructed using a low complexity parameter (cp = 0.0001) and a minimum split proportion of five respondents. Based on this maximum tree, the ideal tree size was evaluated using the cp-value yielding the lowest cross-validation error. This pruning procedure weights tree complexity against its cross-validation error and determines the optimal tree size that neither over- nor underfits the data (Breiman et al., 1984; Moisen, 2008). The best tree (after pruning) was assessed for its accuracy using misclassification error and the area under the receiver operating curve (AUC; Robin et al., 2011; Swets, 1988) calculated based on the testing dataset. AUC values below 0.7 indicate poor models, between 0.7 and 0.9 indicate accurate models and above 0.9 indicate highly accurate models (Swets, 1988).

3 | RESULTS

We conducted a total of 83 semi-structured and three key informant interviews across 11 different villages surrounding Makira NatP. Participants were uniformly distributed over all age classes with a lower number of participants exceeding 55 years of age (Table 1). Most participants attended primary school (49.4%), while 26.5% have been to higher school education. About a quarter of all participants (24.1%; Table 1) has never been to school. The majority of people was originally from the respective village (83.1%) and 67.5% of all interviewees were male (32.5% female; Table 1). Subsistence activities like the extraction of forest products and shifting cultivation but also farming of cash crops (e.g. cloves, vanilla) were very high with >96% of all households (Table 1).

3.1 | General perceptions: Literature review and empirical data

General perceptions on Aye-ayes reported in the literature were mostly negative: We found a total of 17 articles describing
perceptions on Aye-ayes from 21 different locations. Twenty (95.2%) of these were negative while only one (4.8%) was neutral; none of them being positive. Reports were found from almost the entire range of the Aye-aye except the southeastern portion (Figure 2). Perceptions are closely linked to main narratives and coping strategies in case of encountering an Aye-aye. Most commonly (47.6%, \(n = 21\)) reported was that seeing an Aye-aye brings bad luck and that killing the animal and exposing the dead body or the tail along a road will take away the bad luck (Table 2). Encountering an Aye-aye inside or close to a village will pose threats to its inhabitants and killing the animal or abandoning the village was reported in 23.8% of the cases. In general, preventive killing of Aye-ayes on sight, particularly close to villages is the major coping strategy towards expected misfortune.

In contrary, our semi-structured interviews (\(n = 83\)) from north-eastern Madagascar revealed a more diversified image: although about 47.0% of all interviewees also hold a negative attitude towards Aye-ayes, 36.1% had a neutral and 18.1% a positive attitude (for detailed attitudes see Table 3). This general perception (negative or neutral/positive) is not influenced by education (\(X^2 = 3.637, df = 2, p = 0.162\)) or the ability to identify the Aye-aye by name (\(X^2 = 4.048, df = 2, p = 0.132\)), but by the fact whether people know this animal from a picture (\(X^2 = 6.648, df = 2, p = 0.036\)) with respondents who could not identify it being more likely to

**TABLE 2** Main problems reported with the Aye-aye and coping strategies extracted from the literature review. Village locations are given in Table S1

| Problem | Coping strategy | Location | Reference |
|---------|-----------------|----------|-----------|
| Brings bad luck | Killing to prevent bad luck, partly exposing body or tail along roads | Ambanja, Bekaraoka, Bora, Ivontaka, Mananara Avaratra, Manasambody hills, Marojejy, Masoala, Sambava | Constable et al. (1985), Albignac (1987), Simons, 1993, Duckworth et al. (1995), Randrianarisoa et al. (1999), König and Zavasoa (2006, 2008), Glaw et al. (2008), Jolly (2015) |
| Harbinger of death | Killing to prevent death | Andasibe, Ankorefo, Menagisy, Sava/Analamajy region | Simons and Meyers (2001) |
| Problematic when seen in village | Killing of Aye-aye or abandonment of village | Analalava, Mantoaka, Marolambo, Sokaramy, Vilandandro | Thalmann et al. (1999), Lehmann and Wright (2000), Simons and Meyers (2001) |
| Kills people and chicken | Killing and exposing dead body along a road | Manongarivo | Goodman and Schütz (2000) |
| Indication of a bad spell | Killing and exposing dead Aye-aye to take away bad spell | Betomendry | König (2005) |

**TABLE 3** Narratives about Aye-ayes from 11 villages around Makira NatP in northeastern Madagascar. The narrative with the highest percentage of repetition among interviewees is listed here. Forest cover refers to the percentage of forested areas with a radius of 5 km around the village derived from Schüßler et al. (2020); \(n\) gives the number of interviews per village with only one key informant interview (3) in village K

| Village | \(n\) | Respondents [%] | Forest cover [%] | Major attitude | Narrative |
|---------|-----|----------------|----------------|---------------|----------|
| A       | 4   | 100            | 34             | Neutral       | 'We do not fear it', 'we see it sometimes going up the roof' |
| B       | 5   | 100            | 45             | Negative      | 'Aye-aye is very aggressive', 'it scares people' |
| C       | 12  | 75             | 35             | Neutral       | 'We do not fear the Aye-aye', 'we rarely see it' |
| D       | 7   | 71             | 38             | Positive      | 'Aye-aye is helpful, it eats larvae from clove trees' |
| E       | 6   | 100            | 15             | Negative      | 'We are scared by the Aye-aye', 'we have never seen it' |
| F       | 10  | 50             | 52             | Positive      | 'It eats larvae from sugar cane' |
| G       | 15  | 93             | 47             | Negative      | 'We fear the Aye-aye', 'Aye-aye is aggressive', 'it destroys a village' |
| H       | 6   | 50             | 50             | Negative      | 'The Aye-aye does scary things to people', 'we feel uncomfortable when we see it' |
| I       | 14  | 56             | 27             | Positive      | 'It is helpful, it eats larvae from clove trees' |
| J       | 4   | 100            | 1              | Negative      | 'There are stories that catastrophic things will happen when the Aye-aye comes', 'it steals chicken' |
| K       | 1   | NA             | NA             | Negative      | 'When it comes to the village, it has to be killed and the dead body should be brought away to the next village' |
have a negative attitude. In addition, women are more likely to be unable to identify the Aye-aye from a picture \( (X^2 = 4.955, df = 1, p = 0.026) \). None of the interviewed migrants \((n = 14)\) could identify it from picture, but all knew it by name. Half of them held a negative attitude, while 35.7% \((5/14)\) and 14.3% \((2/14)\) held a neutral or positive attitude respectively. These percentages are almost similar to those from the entire sample. Across the villages, the proportion of respondents being able to identify the Aye-aye from a picture \((mean = 0.238 \pm 0.188 SD)\) and by name \((mean = 0.534 \pm 0.273 SD)\) was significantly different \((t = 2.824, df = 15.982, p = 0.0122)\). From the overall sample, 79 out of 83 semi-structured interviewees \((95.1\%)\) knew the Aye-aye by name while only 24 \((28.9\%)\) could identify it on a picture.

The CART model (multivariate approach) aimed to distinguish between the three general perceptions based on nine input variables. Six of these were selected in the best model (with a misclassification error \(= 81.8\%\) and multiclass-AUC \(= 94.3\%\)). The first split of the data is determined by whether people reported pest control behaviour of the Aye-aye (‘eating larvae from the clove trees’). If it was reported, all respondents had a positive attitude (Figure 3). The next node depends on its scary perception. If people were not scared by its appearance, respondents had a neutral attitude. In cases in which it was reported that Aye-ayes scare people, the attitude mainly depends on the village. In villages B, D, E, G and J, interviewees held a negative attitude if they knew it by name, and a neutral attitude if not. Whereas in villages A, C, F, H and I, respondents knowing it from pictures had a neutral attitude, while none or lower school education was related to negative attitudes (Figure 3). The divide by village affiliation was subject to further investigations in the following section.

### 3.2 Perceptions in relation to village affiliation

Interestingly, general perceptions translate well into main narratives about the Aye-aye that are mostly consistent within single villages, but highly variable among villages (Table 3). The mean aerial distance between the villages was 31.7 km \((SD = 18.8 km)\) and all villages are connected with each other by footpaths. In four of 11 villages, all respondents hold the same attitude and told the same story: In village A for example, none of the respondents feared the Aye-aye, and it was repeatedly reported that they see it climbing up the roof of houses from time to time and that people are curious about this behaviour and ‘go out to see it’. In contrast, in village B, all respondents told that the Aye-aye is ‘very aggressive’ and that ‘it scares people’ (Table 3). However, one respondent added that it is aggressive ‘when you try to catch it’ and another one told that ‘it is a big problem, because people think it could eat them’. The latter person could not identify the Aye-aye from a picture but knew it by name. This is in accordance with all answers collected in villages E and J, where people were consistently scared by the Aye-aye, but none of them could identify it from picture. In village G, 93% of the interviewees reported that ‘when an Aye-aye comes to the village, you have to leave and build a new village’ in prevention of negative things to happen. The major narrative was that ‘the Aye-aye destroys a village’. Interestingly, only a few kilometres away, we found one of these newly build-up villages and also the abandoned former village. Some respondents from village G added to their statements that people of this neighbouring village had to leave because of Aye-aye encounters. In addition, several people from village D told that ‘when an Aye-aye comes to a village, catastrophic things will happen’. A key informant from this village added that ‘people know stories about the Aye-aye, that when it comes to a village, bad or catastrophic things happen afterwards’ and that ‘it is not good when it comes to a village’. According to one key informant, ‘catastrophic’ means death of a community member or more generally negative things that can happen during everyday life (e.g. illness, crop failure). Influences of participant’s age on general perceptions within village communities could not be further evaluated due to small sample sizes.

In three villages \((D, F and I)\), the majority of the respondents held a positive attitude towards the Aye-aye (Table 3). This is in all cases linked to the observation that it does pest control on a major cash crop, the clove tree. ‘It eats larvae from the flowers’ so that people do not need to remove larvae manually which could reduce the harvest of cloves (key informant 2, village I). In two further villages, the main attitude of the respondents was neutral, which can be explained by the fact that people are not scared by this animal but are rather curious about its behaviour when coming to a village (Figure 2: Table 3). A repeatedly reported behaviour is that the Aye-aye climbs up the roof of houses (village A, Table 3).

![FIGURE 3](image-url) Classification tree based on six out of nine input variables and general attitude (negative, neutral, positive) as output. Variable importance was Aye-aye does pest control (26%), Aye-aye scares people (25%), village affiliation (18%), Aye-aye known by name (11%), highest school education (8%), Aye-aye known from picture (5%). The bottom row is related to general perceptions with values reporting the proportion of respondents (order: negative, neutral and positive perception) and percentages of how many respondents can be found at the respective end of the classification tree \((n = 61)\). Misclassification error \(= 81.8\%\); multiclass-AUC \(= 94.3\%)
A major difference between the villages is the percentage of forested areas within a radius of 5 km (Table 3). This has, though, no influence on the percentage of people being able to identify the Aye-aye from a picture (Pearson correlation: $r = -0.095, t = -0.271, df = 8, p = 0.793$) or by name (Pearson correlation: $r = 0.447, t = 1.415, df = 8, p = 0.195$).

### 3.3 Further perceptions and observations

Despite the above given main narratives and general perceptions, less frequently given answers also hold interesting insights. For example, crop feeding (e.g. on litchi or cacao) was reported by three respondents belonging to three different villages and a further three interviewees from different villages told that the Aye-aye ‘steals chicken/ducks’ or eggs. One respondent told us that the Aye-aye does seed dispersal and that it ‘helps to plant clove trees’.

Four interviewees from three places stated that they would kill an Aye-aye (three of these reported eating an Aye-aye) and 12 respondents from seven different villages could tell that Aye-ayes are ‘very aggressive when you try to catch’ them. In contrast, eight respondents from six villages reported that the Aye-aye is under *fady* (= local taboo) and forbidden to be killed. Two of these could specify that this *fady* comes from [their] ancestors’ while the others did not go into further detail.

### 4 DISCUSSION

#### 4.1 General perceptions on Aye-ayes

The scientific literature concerning local perceptions of Aye-ayes *Daubentonia madagascariensis* is remarkably concordant: In the vast majority of cases: the Aye-aye is reported to be a bad omen, a harbinger of death or dangerous by itself (e.g. Goodman & Schütz, 2000; Simons & Meyers, 2001). Thirteen out of 17 articles about attitudes towards Aye-ayes are published in newsletters of the IUCN/SSC Primate Specialist Group with the latest article being published in 2008 (König & Zavasoa, 2008). Reports like these are invaluable for illustrating rare behaviours, special incidents or interesting insights from the field (Ramsay & Teichroeb, 2019), but are likely to overemphasize the significance of a certain kind of observation (Parker et al., 2019). In this case, these are the ‘horror stories’ about Aye-ayes being sighted or entering villages and being killed as a preventive measure to avert something evil (Table 2). The sampling was not random and lacked outgroups, which makes it almost impossible to judge whether these stories are a consensus across the whole of Madagascar, just striking incidences worth reporting or another example of the so-called man-bites-dog criterion of newsworthiness, for example, the bias towards reporting the unusual and violent (Lawrence & Mueller, 2003; Parker et al., 2019). It is highly probable that if people did not report about problems with Aye-ayes or did not kill them, these statements remained undocumented. To our knowledge, our study is the first to illustrate a more diversified image of local perceptions resulting from a randomized sampling design within a limited spatial and cultural space.

Interestingly, in the 11 villages surveyed around Makira NatP more than half of the respondents (53.0%, $n = 83$; 5/11 villages) reported a neutral or even positive attitude towards the Aye-aye. We found that these attitudes translated well into major narratives that were highly consistent within but differed substantially among villages. This can be illustrated by two cases: villages F and G are only about 10 km apart from each other (aerial distance) and connected by a footpath. In village F, half of the people held a positive attitude towards the Aye-aye due to its pest control behaviour (other half gave mixed answers, 30% neutral and 20% negative) while in village G, almost all respondents had a negative perception reporting that the Aye-aye ‘destroys a village’. When an Aye-aye comes to a village several times, people there have to abandon the village and build a new one. One of these abandoned villages was in between village F and G and people attributed the abandonment to re-occurring Aye-aye encounters in the village. In a second case, villages C and E are separated by 13 km of aerial distance and also directly connected with a footpath. In village E, all interviewees were ‘scared by the Aye-aye’ although nobody has ever seen one, while in village C, most people held a neutral attitude of being ‘not scared by the Aye-aye’ while half of the respondents already reported about sightings of this animal in the forest. A key informant from village K, told that in prevention of anticipated evil, a sighted Aye-aye has to be killed and the carcass should be brought away from the village—a frequently reported coping strategy in the literature (Table 2). What influences these strikingly different perceptions even within a limited spatial setting? This question will be further explored in Section 4.3.

In general, women and migrants were less likely to identify the Aye-aye from a picture, suggesting that they may have never seen one. In rural areas of Madagascar, the prevalence of traditional gender roles of women cooking, doing laundry, caring for children and men working on the fields and in the forest is high (Nascimento Moreira et al., 2017; R.D. Randimbiharinirina and D. Schüßler, own obs.). It is not surprising that men are more likely to encounter Aye-ayes during their everyday life and work compared to women. Several men, for example, reported that they encountered Aye-ayes even during the day (e.g. during tree cutting or when finding their sleeping sites). The difference between migrants and non-migrants can be explained by the fact that migration in northeastern Madagascar is mainly driven by short distance movements of people coming from already deforested areas migrating towards the forest frontier regions (Jones et al., 2018; Schüßler et al., 2020). Aye-ayes are forest-dwelling primates that are unlikely to occur in non-forest landscapes (Ancrenz et al., 1994; Andríasimasimanana, 1994) making it probable that migrants from deforested regions have never seen Aye-ayes but knew stories about them. In accordance with that, more respondents (from the entire sample, $n = 83$) knew the Aye-aye by name than were able to identify it from picture. This species is characterized by very low population densities (Mittermeier et al., 2010; Perry et al., 2012) and their cryptic and nocturnal lifestyle (Feistner
People from the Makira region observed a variety of behaviours when encountering Aye-ayes inside or outside their villages while several respondents told that they did not understand what the Aye-aye was doing. In this following section we aim to shed light on these observations by explaining them in an ecological way. Since 1953, Madagascar has lost about 44% of its primary forest cover (Vieilledent et al., 2018) mainly fuelled by agricultural expansion and shifting cultivation (Andriamasimanana, 1994; Llopis et al., 2019; Schüßler et al., 2020; Vieilledent et al., 2018). Forest loss and therefore the decline in preferred habitats increases the percentage of secondary vegetation and fallow land (called ‘savoka’) in which available food may not satisfy the Aye-ayes’ nutritional requirement (Andriamasimanana, 1994). This forces Aye-ayes to forage in plantations, feeding on human crops like litchi, sugar cane and coconuts (Ancrenaz et al., 1994; Andriamasimanana, 1994; Randimbiharinirina et al., 2018; Sterling, 1993). Home gardens or a high abundance of fruit trees inside of villages are common in Madagascar, and it is realistic that Aye-ayes enter villages in search for these easily accessible resources in villages. Few respondents told about Aye-ayes ‘stealing chicken’ or eggs. While the former cannot be explained by its dietary preferences (e.g. Randimbiharinirina et al., 2018) and is therefore unlikely from an ecological perspective, the latter was also reported from its natural environment (Sefczek et al., 2018) and from captivity (Winn, 1989). We conclude that Aye-ayes may also be attracted by another abundant food resource in villages, that is, eggs, and that while ‘stealing’ them, chicken may be noisy and panicked so that observers could interpret this as a stealing behaviour targeting chicken. The term ‘stealing’ can be often found in cases of crop feeding concerning primates, because observed behaviours are commonly measured against human moral ideas (Hill & Webber, 2010).

In contrast, other reports cannot be explained ecologically. Aye-ayes are mainly insectivorous, supplementing their diet with fruit, seeds and eggs (e.g. Andriamasimanana, 1994; Randimbiharinirina et al., 2018; Sefczek et al., 2018; Sterling, 1993) but are unlikely to attack small livestock or even people. When not disturbed during foraging they can be observed even from close distances (approx. 2 m; pers. obs. RDR BMR). However and also in accordance with own experiences (RDR, BMR) and our interviewees, Aye-ayes appear to be very aggressive when disturbed like during the catching process. Although rather a protective behaviour, it can be easily interpreted as actively attacking people. Most challenging are reports of Aye-ayes destroying a village. We see the best explanation in its behaviour of climbing up roofs to search for insects. Climbing up by an animal of about 2.5 kg and the search for insects in itself may damage houses build from wooden planks and leaves. If these observations are then passed on verbally—the usual mode of news transmission in rural Madagascar (e.g. Kaufmann, 2014)—it may be exaggerated from simple damage to the destruction of a house. If this is the case, this story could even be adapted to that re-occurring Aye-ayes destroy an entire village in this manner. Although damage to the house by an Aye-aye might be a bad thing, it cannot be considered as catastrophic. These ‘catastrophic things’ are often referred to as death of a community member, illness or crop failure. Simons and Meyers (2001) gave a convincing explanation: mortality rates in rural villages of Madagascar are high (i.e. high child mortality, widespread occurrence of infectious diseases). After seeing an Aye-aye in the vicinity of a village, people appear to be waiting for something bad to happen to give meaning to these unusual encounters.
4.3 Development of narratives

We have detailed in the previous sections how general perceptions on Aye-ayes differ among and are mostly consistent within villages and how these perceptions translate well into major narratives. Furthermore, we have found convincing evidence that some behaviours observed by our participants can be explained in an ecological way. How do these narratives develop then?

The human ability to detect statistical contingencies (i.e. the relationship between cause and effect) is seen as an adaptive behavioural trait (Fiedler et al., 2013). Psychological research has shown, though, that humans are also prone to detect illusory correlations, that is, to link a cause to an effect or to link a trait to a group even when in reality there is no such correlation (Hamilton & Gifford, 1976). These ‘pseudocontingencies’ can be a useful heuristic and proxy to detect existing relationships with few or missing data available and much less mental effort needed (Fiedler et al., 2013). This basic concept derived from cognitive psychology offers a valuable explanation why a cause (‘seeing an Aye-aye’) is linked to an effect (‘catastrophic things will happen’; ‘Aye-aye destroys the village’) that certainly has no conditionality. Due to low population densities and its nocturnal and solitary behaviour, coming across an Aye-aye is most likely very rare. Its peculiarities, overall blackness and completely different appearance compared to other lemurs may elevate these rather uncommon events to exceptional encounters. Seeking explanations for that or ‘waiting’ for something (bad) to happen (see Simons & Meyers, 2001) may be indeed convincing to explain these strong pseudocontingencies. Weaving these kinds of narratives is furthermore a common strategy to handle uncertainty, illness and detrimental environmental change in Madagascar (Golden & Comaroff, 2015; Sodikoff, 2019) and elsewhere (Dhee et al., 2019; Richards, 2000; West, 2001). In the Moramanga district of Madagascar, for example, the spread of rabies is attributed to a mystical feral dog (‘kelibetatra’) that lives in the rainforest. Due to ongoing deforestation, this dog now leaves its habitat under the cover of darkness, roams cultivated lands and attacks pet dogs and cats in villages, infecting them with rabies (Sodikoff, 2016). It is remarkable that these beliefs from Madagascar closely resemble those of distant cultures, like those associated with bad luck from ‘Western’ folklore such as the proverbial black cat crossing a person’s path or the black dog which’s appearance at night is a portent of death. This points in the direction of some common perception by humans of black and nocturnal animals. The colour black itself is regarded as bad and associated with impurity, evil and death across a wide array of cultures (Adams & Osgood, 1973; Sherman & Clore, 2009). There is ‘black cat bias’, attributing higher aggressiveness to black cats, the higher a person scored on superstition, and evidence that black cats are less likely to be adopted from an animal shelter (Jones & Hart, 2019; Kogan, 2013). In Southwest Asia, bats are associated with bad luck due to their nocturnal existence and strange, hybrid nature, seen as neither bird nor mammal, presaging by their cries the death of clan members in some cultures (Frembgen, 2006). Mental images of a certain exceptionally looking or behaving species can become embodied in cultural memories and lead to stereotypes as seen in the perception of the grey wolf in Europe (Jürgens & Hackett, 2017). Such cultural memories could explain the attitudes held by people who never had the chance to see an Aye-aye like migrants and villagers in non-forested areas (i.e. village E).

Our data further showed that attitudes towards Aye-ayes were strikingly similar within villages, but differed between villages, even in close vicinity. For the Mikea people of southwestern Madagascar, Tucker (2007) found that their coping strategy with unpredictability and inter-annual variability in rainfall and livelihood activities relied heavily on shared ethno-theory and social learning in judging variation over time. This leads to rather homogenous rules within communities with some variability due to individuals striving to perform better by adhering to a different set of rules. Jones et al. (2008) also reported that the set of taboos varied across villages in southeastern Madagascar, and Brinkmann et al. (2018) concluded that belief systems can vary due to even small-scale differing origins. In rural regions like Makira, characterized with marginal infrastructure, limited access to education or information systems (e.g. radio), it is standing to reason that local community members also use social learning to cope with their environment, leading to shared narratives and communal beliefs.

There was a striking difference between the effects allegedly caused by Aye-ayes as attributed to it by individuals or groups with a positive or negative attitude towards this lemur. Whereas positive attributions refer to specific and observable behaviours (‘it eats larvae from clove trees’; ‘eats larvae from sugar cane’) in line with the known biology of this still enigmatic species, the negativistic descriptions including statements of fear and discomfort or moralistic values like beliefs about bad omens and myths were unspecific, vague and generic, and way out of reach for a rather small animal (‘people are scared by Aye-aye because they think it could eat them’; ‘it is a big problem’; ‘it destroys a village’). It has to be noted that in many cases, narratives are important reservoirs for communal knowledge (Fernández-Llamaraza & Cabeza, 2017) and aim at explaining real or perceived problems with certain species (e.g. leopards, lions, crocodiles; Dhee et al., 2019; Richards, 2000; West, 2001), environmental variability (Tucker, 2007) or diseases (Sodikoff, 2016, 2019). In contrast, Aye-ayes do not represent a physical threat to people or livestock, but reactions induced by fear often result in the preventive killing of specimens or even the abandonment of entire villages.

4.4 Implications for Aye-aye conservation

The Endangered Aye-aye is a species of conservation concern due to habitat loss and the prosecution by local communities (Randimbiharinarina et al., 2019). Although reports on negative attitudes towards Aye-ayes are fairly consistent in the literature, our localized study revealed a much more diversified image— while negative perceptions were attributed to vague and unspecified stories, positive attitudes were connected to observable and beneficial behaviours illustrating a utilitarian value of the Aye-aye (Jacobs et al., 2019). Similar to that, neutral attitudes were represented by...
naturalistic values, experiences when encountering an Aye-aye in the forest or curiosity about certain observed behaviours. These perceptions could offer a promising approach in Aye-aye conservation by explicitly communicating these beneficial behaviours (Bruskotter & Wilson, 2013; McLennan & Hill, 2012). Almost every household in the region is engaged in clove cultivation (Table 1) and the ecosystem service of pest control on this major cash crop (and on sugar cane) was reported independently from three villages. Perceived ecosystem services provided by certain species are known to have a positive impact on conservation in a variety of settings (e.g. vultures (Campbell, 2009), chimpanzees (McLennan & Hill, 2012)), sometimes even magical ones like spotted hyenas eating evil spirits at night (Baynes-Rock, 2013). Building up on this local knowledge by co-creating and using locally adapted education interventions (Brias-Guinart et al., 2020; Richter et al., 2015; Schüßler et al., 2019) could act as a key concept for a regional conservation strategy that first addresses villages with overall positive attitudes and then distributes their knowledge and experiences across a wider area. Based on our initial data, the Makira region could become a stronghold for Aye-aye conservation based on the support of local communities.

5 | CONCLUSION AND THE BROADER CONTEXT

Long-established knowledge in conservation science requires re-evaluation from time to time (Chua et al., 2020). In the case of Aye-ayes in Madagascar, widely agreed on perceptions were challenged by new investigations resulting from changing the resolution of the study and by applying a more standardized survey strategy. We illustrated a more diversified set of perceptions on Aye-ayes than expected from the literature, highlighting the prevalence of publication bias (Parker et al., 2019) and the custom to extrapolate findings across a diverse cultural space that not necessarily allows for this generalization (Browne-Nuñez & Jonker, 2008; Chua et al., 2020). Conservationists and practitioners are often trapped in a binary thinking about local attitudes towards wildlife, ranging from well to badly perceived species, positive or negative attitudes. In contrast, our study in line with others (e.g. Campbell-Smith et al. 2010; McLennan & Hill, 2012; Ulicsni et al., 2020) illustrated that local perceptions, attitudes and interspecies relations are much more complex and can cover a variety of facets and different shades, including not only utilitarian or negativistic values typically attributed by subsistence farmers but also naturalistic interests expressed by human curiosity about certain observations. Broader perception of beneficial behaviours could furthermore give a strong signal towards species conservation, not only specific to our case study (e.g. McLennan & Hill, 2012). In conclusion, we call for more ground research to break up long held narratives, revisit long-standing attitudes and explore the potentially underappreciated diversity of local perceptions and their value for species conservation—far beyond the Aye-aye-related context.

ACKNOWLEDGEMENTS
This study was conducted under the research permit No. 119/19/MEDD/SG/DGDF/DGRNE, kindly issued by the Directeur du Système des Aires Protégées, Antanarivo and the regional authorities from the Direction Régional de l’Environnement et du Développement durable (DRED) in Maroantsetra. Funding was provided by the Zempelion Foundation of the ‘Deutsches Stiftungszentrum’ under grant no. T0214/32083/2018/sm and Houston Zoo, TX, USA. The authors are particularly thankful for the valuable help of Mr. Jao Roland Randriantiana during the interviews, the help of Mr. Yves Rostant Andriamalala during the whole fieldwork period and their local guides and cooks without whom this study would not have been possible. Extensive discussions with Eleanor Dobbs further helped to improve the manuscript. They also thank André Binotto (https://www.flickr.com/photos/bohnengarten) for providing pictures of an Aye-aye in its natural environment. They also thank the Wildlife Conservation Society Madagascar for providing infrastructure and guidance around Makira Natural Park. The valuable comments of three reviewers and the associate editor of People and Nature helped to improve the manuscript and to broaden the scope of their findings. Open Access funding enabled and organized by Projekt DEAL. [Correction added on 6th March 2021 after first online publication: Funding information added].

CONFLICT OF INTEREST
The authors declare no conflict of interests.

AUTHORS’ CONTRIBUTIONS
T.R. and D.S. conceived the ideas and designed the methodology; R.D.R. and D.S. collected the data and led the writing of the manuscript; D.S. analysed the data. All the authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT
Table S1 and the raw interview data are available at https://doi.org/10.25625/USVVHJ (Schüßler, 2021).

ORCID
Dominik Schüßler https://orcid.org/0000-0001-5885-7988

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SUPPORTING INFORMATION

Additional supporting information may be found in the Supporting Information section.