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An endemic-rich island through the eyes of children: Wildlife identification and conservation preferences in São Tomé (Gulf of Guinea)

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Abstract

Species that the public knows and is willing to protect often do not align with international conservation priorities. Assessing perceptions on wildlife is thus essential to guide conservation initiatives, especially in island developing states where native and introduced species often have contrasting values for biodiversity. We used a game to assess the ability of third class students in São Tomé Island (São Tomé and Príncipe, central Africa) to identify wildlife and their conservation preferences. Students correctly identified 28% of the animals shown. Children who were poorer, male or from rural schools were more likely to correctly identify species. Urban children were less successful identifying species endemic to São Tomé and Príncipe than rural children. Conservation preferences were not associated with species identification and instead were justified by subjective species-specific traits, such as attractiveness or profitability. Despite the low identification rates for endemic (10% correct identifications) and threatened birds (2%), children were keen on preserving endemic species, indicating that these might become effective flagships for the unique biodiversity of the island. These results illustrate the need to consider separately the attributes that affect knowledge and willingness to protect, and how both can be used to guide conservation strategies.

KEYWORDS
biodiversity conservation, Central Africa, developing country, environmental awareness, São Tomé and Príncipe, threatened species

1 | INTRODUCTION

Assessing what drives perceptions of and decisions about biodiversity is the key for understanding how humans use natural resources, protect certain species while over-exploiting others, and support policies or allocate research investments (Frew et al., 2017; Lindemann-Matthies et al., 2014). Understanding and integrating human dimensions are thus critical to improve policies and guide conservation action (Bennett et al., 2017). For example, to promote public support for the conservation of specific species, it is important to assess what are the public's existing perceptions on the target species. High values might be typically placed on charismatic species for reasons that are external to their extinction risk or ecosystem importance (Shapiro et al., 2016), limiting conservation initiatives that target less charismatic species and depend on public support (Veríssimo et al., 2017).

Childhood is a key period to forge connections with the surrounding environment (Ballouard et al., 2011). Attitudes and behaviors toward the environment start developing at an early age but these start consolidating during adulthood, making the promotion of positive attitudes more difficult to achieve (Otto et al., 2019). Children are, therefore, a frequent target audience of environmental education activities, particularly given the links to changes in the attitude and behavior of parents (Damerell et al., 2013). A better understanding of how to enhance the learning experiences of children and what drives their perceptions of the environment is essential to improve human–wildlife connections (Hooykaas et al., 2019), raise environmental awareness, and promote public support for conservation (Lindemann-Matthies, 2005). To achieve this, it is important to consider what species children are already interested in and evaluate how their wildlife knowledge and preferences can align with conservation priorities (Liles et al., 2021).

The way children perceive and connect with biodiversity is influenced by a complex suite of social and environmental factors (Bermudez et al., 2015). For example, age and gender can influence knowledge and attitudes toward species (Hooykaas et al., 2019; Prokop & Randler, 2018); socioeconomic context might affect access to biodiversity literature (Bermudez et al., 2015); exposure to natural environments and activities such as hunting, trapping, and fishing can potentially influence children's understanding of the environment (Lekies & Brensinger, 2017; Rice & Torquati, 2013); and the degree of urbanization might influence familiarity with the natural world (Hinds & Sparks, 2008); Franquesa-Soler & Serio-Silva, 2017). Furthermore, teachers often guide and shape first impressions about biodiversity (Wolff & Skarstein, 2020). Knowledge might also vary according to species traits, such as taxonomic group (Huxham et al., 2006), or whether it is native or introduced (Genovart et al., 2013). In addition, the link between ecological knowledge of species and connection to nature is often based on untested assumptions, and it is context dependent (Mikołajczak et al., 2021; White et al., 2018). Understanding the links between knowledge and attitudes toward species, such as wildlife conservation preferences and their drivers, is crucial to implement effective actions (Prokop & Tunnicliffe, 2008; Shapiro et al., 2016).

Children tend to prefer large animals that resemble the morphology and behavior of humans (Lindemann-Matthies, 2005), with a prevalence for mammal and birds, and frequently dislike dull-colored invertebrates, bats, and snakes (Frew et al., 2017). The interest of children in specific species is an opportunity for educators to propose learning experiences and promote pro-environmental attitudes aiming to produce behavioral shifts toward biodiversity conservation (Barthel et al., 2018; White et al., 2018). However, there is a possibility that species children find interesting do not represent conservation priorities (Ballouard et al., 2011). In fact, the interests of children are often skewed toward species that are abundant in the local surroundings or that are attractive (for instance, large animals with forward-facing eyes) often resulting in favoring appealing species that are not native or threatened, such as exotic charismatic mammals (Ballouard et al., 2011; Bermudez et al., 2015; Smith et al., 2012). In the Balearic Islands, for example, children identified non-native species better than native ones (Genovart et al., 2013).

Children might be prone to develop positive conservation attitudes toward species that they already know and appreciate (Zhang et al., 2014). This becomes a critical issue in oceanic islands where endemics, which are often highly susceptible to anthropogenic threats, might go unnoticed compared to exotic attractive species (Fordham & Brook, 2010), and especially in small island developing states, where the extinction risks are greater compared to continental developed locations (UN-OHRLLS, 2017). However, most studies on knowledge and stated preferences of children about local wildlife have focused on developed nations (e.g., Ballouard et al., 2011; Huxham et al., 2006; Patrick & Tunnicliffe, 2011).

We explored children's wildlife identification ability and conservation preferences in the endemic-rich oceanic island of São Tomé (São Tomé and Príncipe, Central Africa). Specifically, we (a) assessed factors influencing the ability of children to identify animal species and (b) explored potential links between species identification and wildlife conservation preferences. We hypothesized that the ability of children to identify species could be explained through attributes related to student, school, and species (Patrick & Tunnicliffe, 2011; Soga et al., 2016). Namely, we hypothesized that species identification would be higher for non-endemic than for endemic species (e.g., Genovart et al., 2013), and that species that were non-endemic, correctly identified, esthetically appealing, and economically important would be preferred for conservation (Ballouard et al., 2011; Frew et al., 2017; Lindemann-Matthies, 2005; Roque de Pinho et al., 2014). Finally, we aimed to provide recommendations on how to influence willingness to protect biodiversity, for example, through enhanced design of conservation education programs.

2 | METHODS

2.1 | Study area

This study was carried out in São Tomé, an 854 km^2 volcanic island in the Gulf of Guinea, 255 km west of the African continent (Figure 1), and part of the Democratic Republic of São Tomé and Príncipe (STP). The country is part of the "Guinean Forests of West Africa" biodiversity hotspot (Mittermeier et al., 2011) and São Tomé hosts a high proportion of single-island endemic species in many animal groups, such as amphibians (100%, IUCN, 2021), reptiles (64%, Ceríaco et al., 2021), terrestrial mollusks (44%, Holyoak et al., 2020), and birds (30%, Jones & Tye, 2006). São Tomé presents a strong gradient of anthropogenic environmental degradation, from the densely populated northeastern coast and to the mountainous center,

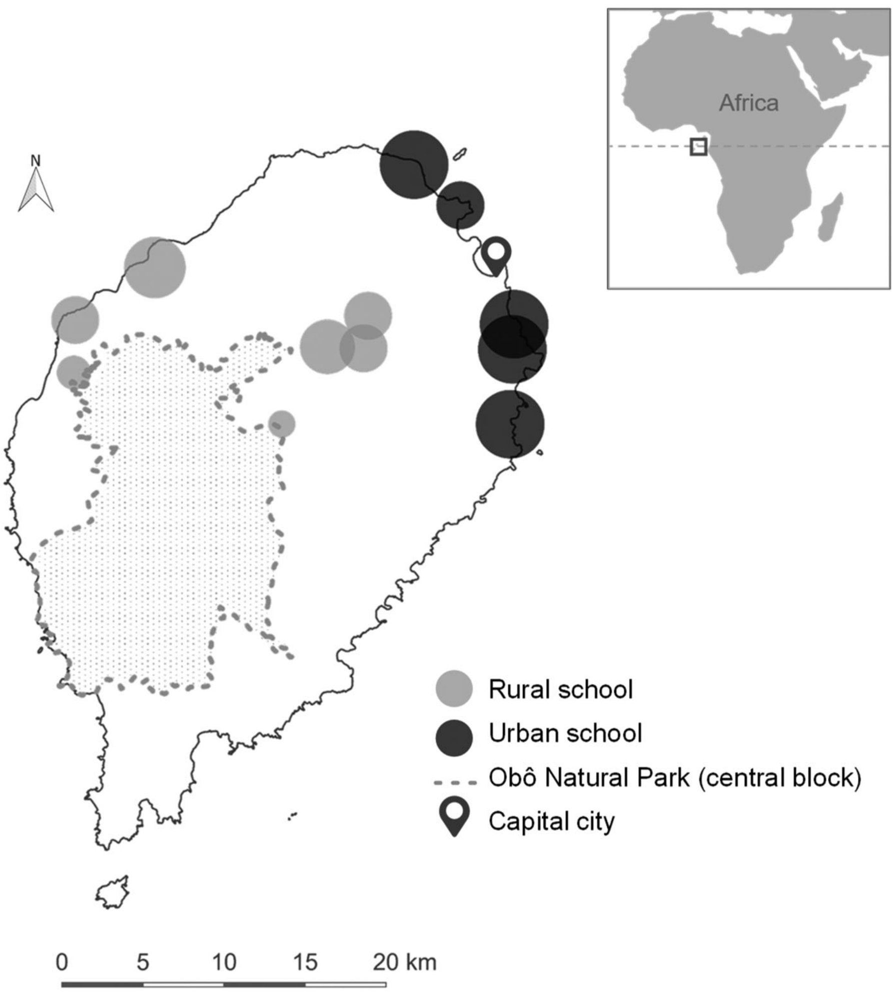

FIGURE 1 Location of schools surveyed in São Tomé Island. Point colour distinguishes rural (grey) and urban (black) schools, while size is proportional to the number of students interviewed, ranging from 13 to 41 students. The São Tomé Obô Natural Park is represented by the grey dotted area. The inset on the upright shows the location of São Tomé Island

mostly covered by native forest (Salgueiro & Carvalho, 2007). Anthropogenic land-use expansion and intensification are key drivers of biodiversity change in the island, leading to habitat loss for most endemic species and to the spread of non-native species (Soares et al., 2020). These threats are intensified by overharvesting of several species, including threatened birds, such as the São Tomé green pigeon *Treron sanctithomae* (Carvalho, Palmeirim, et al., 2015), and land mollusks, such as the Obô giant snail *Archachatina bicarinata* (Panisi et al., 2020). In 2006, the São Tomé Obô Natural Park (ONP) was created mostly to protect the main forest block in the mountainous center of the island, where the endemic-rich fauna and flora still thrive (DGA, 2006). Nevertheless, enforcement is weak and many anthropogenic activities, such as logging and hunting, persist inside the ONP (Lima et al., 2017), with negative consequences for biodiversity. Several environmental education campaigns have targeted schools and communities in recent decades to highlight the urgent need to protect threatened species. However, these campaigns were not planned based on children's baseline biodiversity knowledge and preferences (Ayres et al., 2022), limiting our ability to design effective activities and monitor their impacts.

STP is a lower-middle income developing state, where about one-third of the population lives on less than $1.9 per day (The World Bank, 2021), and many rely directly on local natural resources for subsistence (Carvalho, Rego, et al., 2015). The human population is concentrated around the capital city, São Tomé, where approximately 60% of the c. 201,000 inhabitants of the country live (INESTP, 2012, 2020). The literacy rate is high (90%; INESTP, 2020) and most 5–11 years old children attend school (78% in 2012; UNICEF, 2016).

2.2 | Sampling design

Twelve schools took part in our study. Aiming to assess the effect of the proximity to natural environments, we selected the five schools that were closest and five that were furthest away from the ONP from a list of 81 public first cycle schools (first to fourth grade, typically 6–10 years old) that had at least 25 children in each class. In addition, the two schools closest to the ONP were also included despite having fewer students, to represent small rural schools. The seven schools closer to the ONP were in rural areas, while the other five sampled schools were in urban areas (INESTP, 2012; Figure 1, Table S1).

We selected one class in each school under the advice of school directors, who chose based on the teachers' availability to be part of the study. Because we wanted to determine what factors might be related to baseline biodiversity knowledge and preferences, we used third grade classes only, the highest level of education before biodiversity is taught as part of the curriculum. Also, it corresponds mostly to 8- and 9-year-old children, who already possess cognitive abilities to form interests and concerns related to environmental issues (Frew et al., 2017; Hooykaas et al., 2019). Not all students in the third grade classes surveyed were 8 or 9 years old; however, all students in the selected classes were invited to participate in our study, and potential age-derived effects were subsequently accounted for.

2.3 | Survey design and administration

In April and May 2019, we carried out a survey to assess wildlife knowledge and conservation preferences of children. Species identification is commonly used as a proxy for biodiversity knowledge (e.g., Hooykaas et al., 2019). Instead of using standard survey techniques, such as questionnaires, we used a card game with images of animal species that occur in São Tomé Island. This approach was preferred since it does not rely on the ability to read and write and should be more appealing to children (Collado & Staats, 2016; Franquesa-Soler & Serio-Silva, 2017). A balanced designed survey based on preselected animal species was used to assess potential differences between species more reliably. The 18 animal species were represented by photographs on cards (similarly to Carvell et al., 1998; Balmford et al., 2002; Huxham et al., 2006), including a combination of common and threatened species (similarly to Genovart et al., 2013) and of endemic and non-endemic, probably introduced, species (Table 1, Figure 2). The 18 species belonged to several taxa representative of local biodiversity (Jones, 1994) and were organized in three sets of six species (Table 1). To ensure that each set had similar difficulty, we assigned the same number of species in each level of difficulty. This was allocated based on the percentage of correct identification obtained in a preliminary survey in 10 schools (Figure S1), and on the expertise of authors, local guides and literature information on species distribution and visibility (Table S2).

The survey was delivered as an extracurricular activity by two researchers and one local guide, with the help of teachers and local technicians. First, we assessed the familiarity of each teacher with local biodiversity (-Table S3). Then, each child was invited to play a 5–10 min game. To avoid survey fatigue, we used the three

TABLE 1 Description of species selected to build the three sets of cards and their attributes

Set	Scientific name	English name	Local name	Endemism	Status	Difficulty level	Taxonomic group
A	*Schistometopum thomense*	São Tomé caecilian	Cobra-bobô	E	LC	Low	Amphibian
	Treron sanctithomae	São Tomé green pigeon	Céssia	E	EN	Medium	Bird
	Archachatina bicarinata	Obô giant snail	Búzio-d'Obô	E	VU	High	Gastropod
	Archachatina marginata	West African giant land snail	Búzio-do-mato	N	NE	Low	Gastropod
	Estrilda astrild	Common waxbill	Bico-lacre	N	LC	Medium	Bird
	Mustela nivalis	Least weasel	Kauirí	N	LC	High	Mammal
B	*Zosterops lugubris*	Black-capped speirops	Olho-grosso	E	LC	Low	Bird
	Atopocochlis exaratus	-	Búzio-veneno	E	NE	Medium	Gastropod
	Dreptes thomensis	Giant sunbird	Selelê-magotchi	E	VU	High	Bird
	Rattus rattus	Black rat	Rato	N	LC	Low	Mammal
	Civettictis civetta	African civet	Lagaia	N	LC	Medium	Mammal
	Coturnix delegorguei	Harlequin quail	Codorniz	N	LC	High	Bird
C	*Anabathmis newtoni*	Newton's sunbird	Selelê	E	LC	Low	Bird
	Philothamnus thomensis	São Tomé wood snake	Suá-suá	E	NE	Medium	Reptile
	Bostrychia bocagei	São Tomé Ibis	Galinhola	E	CR	High	Bird
	Cercopithecus mona	Mona monkey	Macaco	N	NT	Low	Mammal
	Sus scrofa	Feral pig	Porco-do-mato	N	LC	Medium	Mammal
	Vidua macroura	Pin-tailed whydah	Viuvinha	N	LC	High	Bird

Note: The species (Figure 2) are classified as "E, endemic" or "N, non-endemic" (Carvalho, Rego, et al., 2015; Dutton, 1994; Jones & Tye, 2006; Leventis & Olmos, 2009). Conservation status is reported according to the International Union for Conservation of Nature's Red List of Threatened Species (NE, not evaluated; LC, least concern; NT, near threatened; VU, vulnerable; EN, endangered; CR, critically endangered. IUCN, 2021). Each child only saw cards from one of the sets: A, B, or C.

sets of six cards, and each child was randomly allocated to a single set of cards. Every card in a set was shown individually to each student, who was asked to name the species. The species were always shown in the same order (Table 2), to alternate different levels of difficulty, and endemic and non-endemic species. We checked with local eco-guides and teachers if the student provided a valid unambiguous name for each species to assess whether the identification was correct. Incomplete and vague names were not considered as correct answers. To assess student preferences, the same six cards were shown simultaneously for the student to choose which one they would like to protect and to provide a short open-answer justification.

At the end of the game, each student was asked about their gender, age, economic status (using indicators that can easily be reported by children, such as household ownership of television, electricity, and sanitary services) and the level of exposure to the forest and local biodiversity. Information on nature exposure was recorded by inquiring on activities directly practiced by the student, such as snail harvesting and bird hunting, or by the parents, such as having a job related to forested areas (e.g., logger, palm-wine harvester, farmer), hunting or snail harvesting (Carvalho, Rego, et al., 2015).

2.4 | Data analysis

2.4.1 | Factors influencing species identification

We used generalized linear models (GLMs) and generalized linear mixed models (GLMMs; Bolker et al., 2008; Zuur et al., 2009) to investigate the links between the ability to identify wildlife and factors related to the students and the schools surveyed, and the species used (Table 2). All statistical analyses were done in R 4.0.2 (R Core Team, 2019). For each level, we assessed the contribution of predictors to explain the ability of children to identify species by constructing a 99% confidence set, using the function *dredge* of the *MuMIn* package (Bartoń, 2016). We also computed the sum of Akaike weights for each variable to quantify their relative variable importance (RVI), using the function *sw* from the

FIGURE 2 Photos illustrating the species used in the study and survey delivery. First row, from left to right: São Tomé caecilian *Schistometopum thomense* (photo by Rainer Wendt); São Tomé green pigeon *Treron sanctithomae* (photo by Thibaud Aronson); Obô giant snail *Archachatina bicarinata*; West African giant land snail *Archachatina marginata*; Common waxbill *Estrilda astrild* (Photo by Gale Verhague); Least weasel *Mustela nivalis* (photo by Michel Roesink). Second row, from left to right: Black-capped speirops *Zosterops lugubris* (Photo by Thibaud Aronson); *Atopocochlis exaratus*; Giant sunbird *Dreptes thomensis* (photo by Paul van Giersbergen); Black rat *Rattus rattus* (photo by Rae Narraway); African civet *Civettictis civetta* (photo by Roger Wasley); Harlequin quail *Coturnix delegorguei* (photo by Bernard Dupont). Third row, from left to right: São Tomé sunbird *Anabathmis newtoni* (photo by Paul van Giersbergen); São Tomé wood snake *Philothamnus thomensis* (photo by Sónia Ferreira); São Tomé Ibis *Bostrychia bocagei* (photo by Nik Borrow); Mona monkey *Cercopithecus mona* (photo by Pete Rodgers); Feral pig *Sus scrofa* (photo by Pete Rodgers); Pin-tailed whydah *Vidua macroura* (photo by Bernard Dupont). On the fourth row, aspects of the survey delivery. Photos were taken by Vasco Pissarra, unless stated otherwise

same package. This approach allows comparing the weight of all models in which each variable is present, based on AIC model selection, using all possible models by recombining explanatory variables. We tested multicollinearity using variance inflation factors (VIFs < 1.77), checked that explanatory variables were not correlated ($\rho < 0.7$) and calculated the pseudo-R^2 to assess the amount of variance explained by each model obtaining a measure of their goodness-of-fit. For GLMMs, we used the function *r.squaredGLMM* of the *MuMIn* package to calculate the marginal R^2, which is a measure of the variance explained by the models' fixed terms ($R^2_{\text{GLMM(m)}}$), and conditional R^2 ($R^2_{\text{GLMM(c)}}$), which is a measure of the variance explained by the combined fixed and random terms (Nakagawa & Schielzeth, 2013). For GLMs, we calculated the McFadden pseudo-R^2 using the function *PseudoR2* of the *DescTools* package.

Student level

The variation of knowledge at student level was assessed using correct species identification as the response variable in a binomial GLMM, built using the *lme4* package *glmer* function (Bates et al., 2014). Gender, age, economic status, and exposure to nature were the explanatory variables (Table 2). The first two were obtained directly from the surveys, while the others were derived from principal components analysis (PCA), computed using the *princomp* function from the *factoextra* R package (Kassambara & Mundt, 2017). PCAs were built using indicators of economic status and exposure to

TABLE 2 Description of the variables used to (a) model species identification, at student, school and species level and (b) explore links to wildlife conservation preferences. The expected direction of the effect is included for each explanatory variable

(a) Species identification			
Response variables			
Variable	Type	Description	
Correct species identification	Binary	1 if the species is correctly identified by the student and 0 otherwise.	
Schools BLUPs	Continuous	Predictors extracted for each school from the fitted mixed student model.	
Species BLUPs	Continuous	Predictors extracted for each species from the fitted mixed student model.	
Explanatory variables			
Variable	Type	Description	Expected effect
Student level			
Student ID	Nominal	An individual identifier for each student	Individual predispositions and learning abilities may influence student knowledge (Neitzel et al., 2019).
Gender	Binary	0 if the student is female and 1 if male	Boys have a better knowledge of wildlife (Campos et al., 2012; Huxham et al., 2006).
Age	Discrete	Age of the student	Older students have a better knowledge about biodiversity (Hooykaas et al., 2019).
Economic status	Continuous	The first principal component of a PCA constructed on household ownership of television, electricity, and bathroom	Children from wealthier households are more knowledgeable about nature (Bermudez et al., 2015).
Exposure to nature	Continuous	The first principal component of a PCA constructed on information on the level of exposure to forest and local biodiversity	Children and their parent's experiences in natural environments might enhance knowledge of wildlife (Remmele & Lindemann-Matthies, 2018) or not (Hooykaas et al., 2019).
School level			
School ID	Nominal	The 12 schools selected for the survey (Figure 1)	School characteristics may influence student knowledge (Patrick & Tunnicliffe, 2011).
School location	Binary	0 for rural area and 1 for urban area (Eyzaguirre, 1986)	School location affects knowledge of biodiversity, but the direction is context dependent (e.g., Campos et al., 2012; Franquesa-Soler & Serio-Silva, 2017).
Teacher biodiversity knowledge	Discrete	Teacher biodiversity test results (Table S3)	Teacher knowledge is transmitted to students (Wolff & Skarstein, 2020).
Species level			
Species ID	Nominal	The 18 species selected for the survey (Table 1 and Figure 2)	Species-specific traits influence student ability to identify them.
Set of cards	Nominal	The three sets of cards used in the card game (Table 1)	No effect expected, since the sets were standardized.
Species order	Ordinal	Cards were showed always in the same order (Table 1)	Students can get progressively better or poorer at identification as the game progresses
Species difficulty level	Ordinal	Easy, medium, or difficult to identify (Table S2)	We expect that the ability to identify decreases with difficulty.
Endemism	Binary	0 if endemic to STP and 1 if non-endemic	Children identify non-endemic species better (e.g., Ballouard et al., 2011; Genovart et al., 2013), both in urban and rural schools (Campos et al., 2012; Schuttler et al., 2019).

(Continues)

TABLE 2 (Continued)

Species taxonomic group	Nominal	1 if mollusk, 2 if amphibian or reptile, 3 if bird and 4 if mammal	Higher scores for mammals and birds than for herps and invertebrates (Campos et al., 2012; Yli-Panula & Matikainen, 2014). Birds are less recognized than mammals (Hooykaas et al., 2019)
(b) Wildlife conservation preferences			
Wildlife conservation preference	Nominal	Species that the student chooses to protect from the six animals in the allocated card set	Preference for non-endemic animals (Ballouard et al., 2011) that resemble human morphology and behavior (Lindemann-Matthies, 2005). Preferences vary between genders (Prokop & Randler, 2018).
Preference reason	Nominal	Student justification for species preferences, categorized in nine classes (Table S5)	Children prefer species due to aesthetic and curious characteristics (Lindemann-Matthies, 2005), and possibly due to edibility and watchability (Frew et al., 2017).

nature (Table 2); the first principal component from both PCAs explained, respectively, 66.9% and 36.1% of variation in the total data, and they were used as proxies of each explanatory variable. Species order and species identity were included as a nested random effect to control for differences among species, since we were primarily interested in factors relative to the ability of students to identify species, and differences related to the fixed order used to show the cards. A second nested random effects structure was added to account for school and student identity, since each student belonged to a single school and identified multiple species. The variation explained by the sets of cards was accounted within the species identity random effect. The GLMM with this random effect structure also had the lowest Akaike's information criterion (AICc) value and was considered the best (Table S4).

School level

To analyze unexplained deviance from the mean correct identifications at school level, we extracted the best linear unbiased predictors (BLUPs) of the School identity random effect from the student model (Jones et al., 2016) using the *lme4* package *ranef* function (Pinheiro & Bates, 2000). Positive values indicated that the school had higher than expected levels of correct species identification estimated from the fixed effects. We fitted linear models by using the predictors obtained for each of the schools as a response variable with school location (rural/urban) and teacher knowledge (Table S3) as explanatory variables. Since two teachers refused to participate, only 10 schools were included in these models.

Species level

To explore variation at species level, we extracted the BLUPs for the species identity random effect from the student model. We fitted linear models using the predictors obtained for each of the 18 species as the response variable, and whether the species was endemic or non-endemic and taxonomic group (gastropod, amphibian/reptile, bird, mammal) of each species as explanatory variables. Post hoc Tukey tests were used to test differences between categories. We also used two-proportions z-tests to assess differences in the proportion of endemic and non-endemic species correctly identified between rural and urban school.

2.4.2 | Species identification and conservation preferences

To assess links between species knowledge and wildlife preferences, we evaluated the correlation between identification scores (percentage of correct identifications for each species) and wildlife conservation preferences (percentage of selection as species preferred for being protected). To explore conservation preferences, we analyzed cross-species variation in preference score and developed a series of univariate analyses to assess preferences variations across gender, school location and whether the species was endemic or non-endemic. We used chi-square tests to determine whether wildlife conservation preferences varied according to gender or school location by comparing the prevalence of species preferences among each of these groups separately. We assessed differences in preferences for endemic and non-endemic species, and

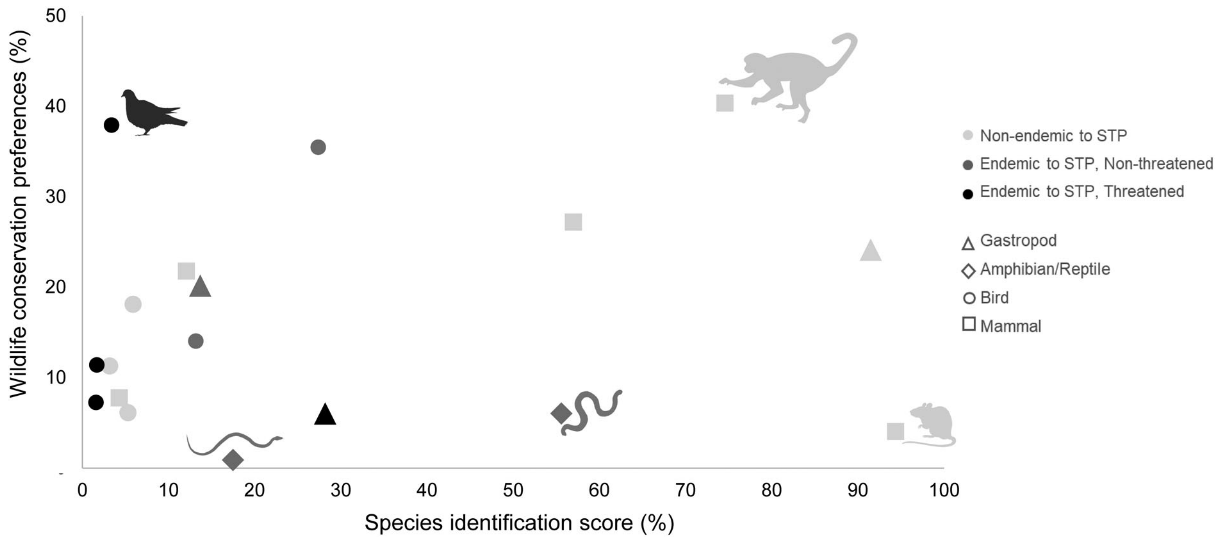

FIGURE 3 Wildlife conservation preferences (species selection rates for protection) and identification scores (Table S6)

whether the prevalence of preferences for these two groups varied across urban and rural schools, using two-proportions z-tests. Finally, we explored students' reasoning behind self-reported preferences by categorizing them by attributes (Frew et al., 2017; Shapiro et al., 2016) and analyzing their frequency of use.

3 | RESULTS

All students agreed to participate in the study, resulting in 361 students being interviewed in the 12 schools. We discarded six student surveys that had missing data. The median number of participants for class was 29, ranging from 13 to 41. Student age ranged from 5 to 13 years old, although most students were aged eight (47%) or nine (44%). Gender was marginally skewed toward girls (53%). The sets of cards were used a similar number of times (33% Set A; 35% Set B; 32% Set C). Teachers were able to identify between 46% and 90% of the species, with a median score of 60%.

3.1 | Species identification

Students correctly identified 28% of wildlife species on the cards ($N = 603$ correct answers), 68% of which corresponded to non-endemic species. Correct species identifications varied from 2% for the endemic Giant sunbird *Dreptes thomensis* to 94% for the introduced Black rat *Rattus rattus* (Figure 3). The most correctly identified species were all introduced, namely the Black rat, the invasive West African giant land snail *Archachatina marginata* (91%), which was claimed to be harvested by 75% of the students, the Mona monkey *Cercopithecus mona* (75%), and the Feral pig *Sus scrofa* (57%). These were followed by six endemic species that obtained relatively high scores as well, including the São Tomé caecilian *Schistometopum thomense* (53%), the Obô giant snail (28%), and the Black-capped speirops *Zosterops lugubris* (27%). Among the least correctly identified species, were the endemic threatened birds: the Giant sunbird, the São Tomé Ibis *Bostrychia bocagei* (2%) and the São Tomé green pigeon (3%), and non-endemic species, such as the Least weasel *Mustela nivalis* (4%) and the Harlequin quail *Coturnix delegorguei* (3%).

3.2 | Factors influencing species identification

Correct answer rates were significantly different among different sets, with Set A associated with significantly better scores than Set B ($\chi^2 = 6.58$, $df = 2$, $p < .05$; Tukey's Test, 95% family-wise confidence level, $p < .03$). As expected, species identification varied according to difficulty level: 60% correct identifications for the easy level, 18% for the medium level, and 7% for the difficult level. At the student level, the combined effect of fixed and random terms in the fitted model explained a greater data variation ($R^2_{\text{GLMM(c)}} = .584$) compared to the variance explained solely by the fixed terms and their interactions ($R^2_{\text{GLMM(m)}} = .011$). The resulting models with the highest AICc weight (i.e., most parsimonious) at the school level had good fits (McFadden pseudo-$R^2 = .437$, where values that lies between .2 and .4 represents an excellent fit), while the models at the species level had lower predictive values (McFadden pseudo-$R^2 = .100$).

3.2.1 | Student level

Gender was the most important variable to explain variation in the ability of students to identify species (RVI = 1), with boys performing better than girls (31% vs. 26% correct answers). The economic status of students was also an important predictor, with students with lower economic status performing better (RVI = 0.63; Table S7, Figure S2), while age (older students perform better, RVI = 0.42) and exposure to nature (students with higher exposure to nature perform better, RVI = 0.33) were less important predictors.

3.2.2 | School level

School location was the most important variable to explain variation in student ability to identify species (RVI = 0.91), as students attending rural schools performed better than those in urban schools (34% vs. 23% correct answers, Figure S3). Teacher knowledge was a weak predictor (RVI = 0.11).

3.2.3 | Species level

This model showed low predictive value, and species taxa (RVI = 0.10, and Tukey's test, 95% family-wise confidence level) and whether the species was endemic or non-endemic are not important factors to explain children's ability to identify species (RVI = 0.18). However, we found that the proportion of endemic and non-endemic species correctly identified in rural and urban schools was significantly different ($\chi^2 = 17.83$, $df = 1$, $p < .001$), as students in rural schools were better at identifying endemic species than those in urban schools (26% vs. 10% correct identifications).

3.3 | Species identification and conservation preferences

Wildlife conservation preferences, obtained from the rates of selection for protection, varied from 40% for the non-endemic Mona monkey to 0.9% for the endemic São Tomé

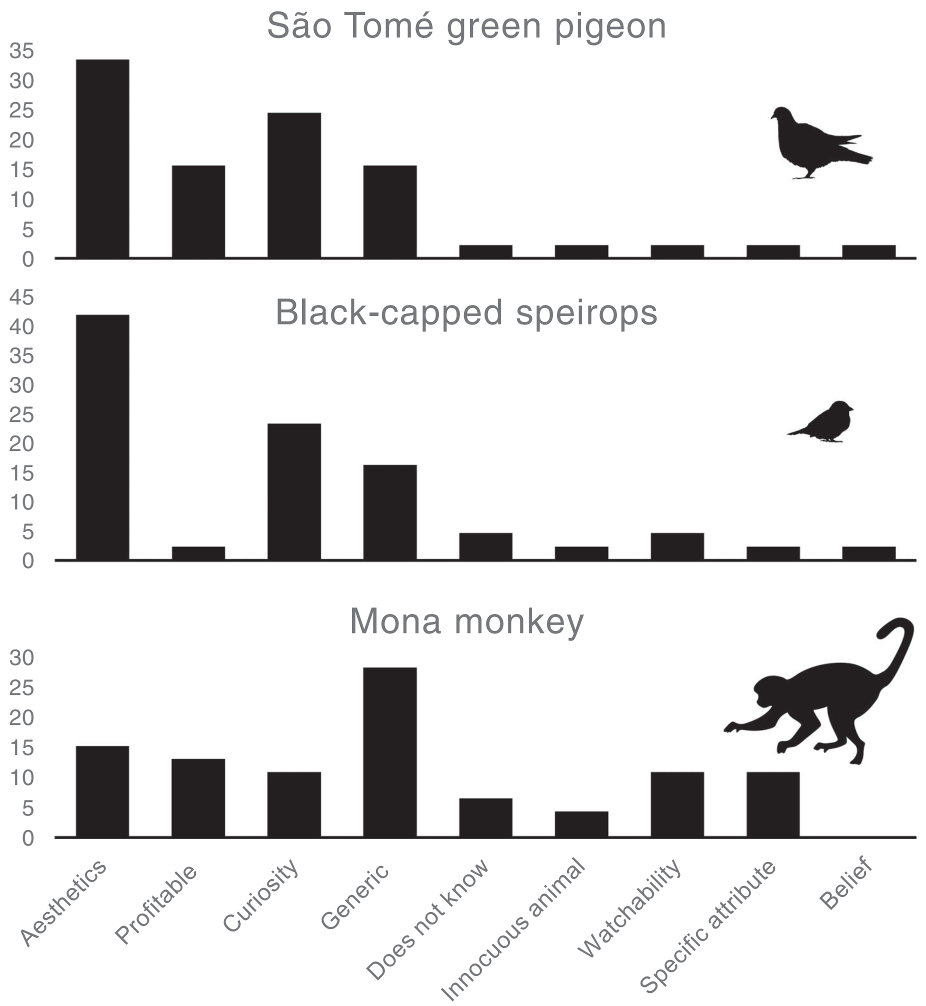

FIGURE 4 Frequency of justifications provided for the protection of the three top species that were selected to protect: São Tomé green pigeon *Treron sanctithomae*, Black-capped speirops *Zosterops lugubris* and Mona monkey *Cercopithecus mona*. Justifications are ordered according to their overall frequency of use (Table S5)

wood snake *Philothamnus thomensis*. Other species often selected for protection included the endemic and threatened São Tomé green pigeon (38%) and the endemic Black-capped speirops (35%). The most identified species, the Black rat, was the least selected among the non-endemic species (4%). Similarly, the most identified endemic, the São Tomé caecilian, was the second least selected endemic species (6%; Figure 3, Table S6).

We found no significant correlation between species identification and conservation preference. We did not find significant differences in wildlife conservation preferences depending on student gender, on whether the school was rural or, on whether the species was endemic or non-endemic, or on the proportion of endemic and non-endemic species preferred in rural and urban schools.

The most common reasons to protect selected species were related to esthetic (e.g., colors or shapes; 23.1% frequency of answer), utility (e.g., the species can be eaten or sold; 18.6%), curiosity (e.g., the student is curious to see the species, breed it or take care of it and, ultimately, protect it; 18.1%), or generic reasons (e.g., the students say it is their favorite animal; 18%, Table S5, Figure 4).

4 | DISCUSSION

4.1 | Factors influencing species identification

In São Tomé Island, boys, lower economic status, and rurality were linked to a higher ability to identify species. A greater knowledge of wildlife by boys was not surprising, as it is well documented elsewhere (Almeida et al., 2018; Bermudez et al., 2015; Campos et al., 2012; Huxham et al., 2006). This can be related to sociocultural practices that encourage boys to develop more outdoor activities, such as hunting or fishing, allowing them to gain a better knowledge of species (Bermudez et al., 2015. Children from less wealthy households, especially in rural areas (UNICEF, 2016), might be better at identifying wildlife because they are more likely to contribute to the household and to be dependent on local natural resources, which might enhance interactions with the environment and increase local ecological knowledge (Pilgrim et al., 2008). Students attending rural schools were better at identifying species than those attending schools in urban areas, suggesting that, as expected, the level of urbanization and access to natural areas play an important role (Hinds & Sparks, 2008), even in such a small island. Unsurprisingly, teacher knowledge was a weak predictor of wildlife identification, as lessons about local biodiversity were reserved for higher grades. Future studies should assess the importance of teacher knowledge for classes in higher grades. Although age and exposure to nature were weak predictors of species identification in our study, we acknowledge limitations in exploring these potential effects, given our focus on a limited age range and indirect proxies used to assess exposure to nature.

We found that children in urban schools have more difficulty in identifying endemic species than those in rural schools. Urban children might be less familiar with forest endemics because in São Tomé native species tend to occur in forested land uses, whereas introduced species tend to be restricted to areas with higher human disturbance (Soares et al., 2020). Children in São Tomé seem to be better at identifying species that are more relevant to humans, such as species that occur near inhabited areas or that can be eaten or sold, like the invasive West African giant snail, which is largely harvested by the children that participated to this study. Endemic threatened birds are all among the least identified species (10% identifications of endemic birds were correct, 2% of endemic threatened). These threatened endemic birds are hunted as well, but their consumption is lower than that of more correctly identified non-endemic introduced species that are also hunted, which might be one of the causes behind poor identification scores (Carvalho, Palmeirim, et al., 2015).

4.2 | Species identification and conservation preferences

We found that the ability of children to identify species was not related to wildlife conservation preferences. These preferences were mainly justified by subjective species-specific factors. This fits in with the known affinity of children for charismatic or beautiful animal species, especially those phylogenetically or behaviourally closer to humans, such as large mammals, and other large species with forward-facing eyes, which are, therefore, commonly used by international NGOs as flagships (Bermudez et al., 2015; Huxham et al., 2006; Lindemann-Matthies, 2005; Roque de Pinho et al., 2014; Smith et al., 2012).

In fact, as expected, the most preferred species was the introduced Mona monkey. Surprisingly also the endemic São Tomé green pigeon and Black-capped speirops, despite their much lower identification scores. The most common reasons to protect species were esthetic, profitability, curiosity and generic reasons. The preference for these endemic birds might be linked to specific esthetic features, such as relatively large eyes and short neck, which are particularly attractive to humans for resembling juvenile birds (Lišková & Frynta, 2013).

These appealing morphological features seemed enough to overcome a low familiarity with the species. On the other hand, the fear or aversion observed for certain animals, such as rats and snakes, might also be inherently human, as we are innately conditioned to fear species that might be dangerous (Prokop & Randler, 2018). This fear can be socially reinforced by myths (Prokop & Tunnicliffe, 2008), as it seems the case for the harmless São Tomé caecilian. This species is an amphibian, but it is locally treated as a snake due to its appearance and it is locally believed to be dangerous. These social constructs likely contributed to making this species one of the least preferred, and conservation initiatives on the island have tried to demystify this species among schoolchildren, by designating it as a biodiversity mascot during environmental awareness campaigns (Drewes, 2012). Finally, we found that apart from esthetic attractiveness, the most common reason for species protection was that the species can be eaten or sold. Children from low socioeconomic backgrounds may have a more utilitarian interest for wildlife, since it is known that a shift toward esthetic or intrinsic biodiversity values might occur when more material needs have been met (Frew et al., 2017); however, we were unable to validate this trend based on our data.

4.3 | Recommendations and conservation implications

Future environmental activities in São Tomé should align children's conservation wildlife preferences with conservation priorities and target environmental education efforts for audiences that have been shown to be less knowledgeable about biodiversity. Although we did not find a correlation between species knowledge and preferences, learning about local biodiversity will prevent the loss of environmental knowledge between generations, and help children to set conservation priorities by knowing how to recognize threatened species or distinguish endemic from introduced species (Soga & Gaston, 2018).

Furthermore, low levels of eco-literature can influence children's fear and aversion for living beings. This can be reduced by increasing children's knowledge of nature through environmental experiences (Soga et al., 2020). Namely, initiatives in STP can promote educator-mediated experiences that engage urban schools in practical environmental activities (Barthel et al., 2018; White et al., 2018), such as birdwatching, BioBlitz or performing environmental education activities at interpretation centers. The willingness of children to protect some endemic birds, despite the low identification rates, could be used as effective means to make them aware of the value of the unique biodiversity of the island. Low willingness to protect endemic reptiles and amphibians due to innate and culturally mediated reasons must be addressed as well by continuing to showcase these taxa in environmental education campaigns (Prokop & Randler, 2018). Finally, gender differences in biodiversity knowledge need to be addressed, for example, by promoting more outdoor activities for girls.

Past and current initiatives have already started to address these issues, for example, by disseminating information on the importance of critically endangered birds, promoting birdwatching initiatives with schools, or offering the possibility to learn about local flora and the conservation of terrestrial mollusks during field trips (Ayres et al., 2022). These environmental experiences will likely help children to increase their affinity with nature and to develop a greater support for biodiversity protection (Soga et al., 2016).

Future studies should evaluate more in detail the species-specific preferences among the target audience and assess how the exposure to additional sources of information, for example, provided by the media, might influence wildlife knowledge and preferences in São Tomé Island.

Conservation strategies should further explore how to promote willingness to protect. In this regard, our methodological approach using games was appealing to students, easy to replicate, and can be adapted to distinct situations, namely by including information on threatened species and main threats, with the aim to increase environmental awareness and ecoliteracy (Callahan et al., 2019).

Oceanic islands hold high proportions of endemic species that are also more vulnerable to extinction than continental counterparts (Gillespie, 2007). However, public perceptions of endemics do not always match those of conservationists (Bremner & Park, 2007). Non-native widespread species with particularly attractive traits can divert expected conservation outcomes. For example, the absence of charismatic native mammals on oceanic islands may lead to preference for introduced mammals (Shapiro et al., 2017). In STP, this is the case of the Mona monkey which, despite being identified as a threat to endemic avifauna (Dutton, 1994; Guedes et al., 2021), is appreciated by the public and used as a food source, so that conservation initiatives might have difficulty in addressing actions that limit its spread. Islanders often have positive views of introduced species, particularly when they serve specific cultural or economic roles, which can halt collaboration with conservation initiatives (Novoa et al., 2018). The invasive West African giant land snail, for example, has rapidly begun to play an important role in the diet and economy of local populations since its introduction in STP in the 20th century (Panisi et al., 2022). Although its spread appears to be linked to the decline of the threatened Obô giant snail, and environmental awareness campaigns have extensively addressed this concern (Ayres et al., 2022; Panisi et al., 2020), any initiative promoting its eradication would likely find public resistance (Pereira, 2021).

It is fundamental to consider the factors and species attributes that explain species identification and preferences when planning, for example, conservation campaigns for the protection on threatened endemic species. Flagship species campaigns often use marketing techniques, choosing colorful flagships and promoting national pride, to generate public support aiming for behavioral changes, representing important fundraising tools for conservation (Butler, 2000; Smith et al., 2012). In this regard, children's perspectives and preferences are important as they may influence adults, leveraging pro-environmental behaviors and conservation support (Frew et al., 2017). Assessing children's wildlife knowledge and preferences can guide decisions regarding the identification of the best flagship species to stimulate conservation awareness (Frew et al., 2017), and how to promote threatened species that have high ecological value but low esthetic attractiveness, detectability, or economic value (Veríssimo et al., 2017). Finally, environmental education programs with schoolchildren promote greater affinity with nature and help build pro-environmental behaviors toward species that align with international conservation priorities, with the general aim of raising generations that are environmentally conscious. This is especially critical in endemic-rich developing countries that, like STP, are facing strong anthropogenic threats, and where esthetic and economic values might overturn conservation or ecological values in driving the willingness to support biodiversity conservation.

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CONFLICT OF INTEREST

The authors have no competing interests.

AUTHOR CONTRIBUTIONS

Martina Panisi, Ana Nuno, Ricardo Faustino de Lima, and Jorge Marques Palmeirim conceived and designed the study. Martina Panisi led the study and collected the data with Vasco Pissarra and Gabriel Oquiongo. All authors contributed to interpretation. Martina Panisi wrote the manuscript, Ana Nuno, Ricardo Faustino de Lima, and Jorge Marques Palmeirim edited it, and all authors reviewed it.

DATA AVAILABILITY STATEMENT

Data are accessible on figshare doi: https://doi.org/10.6084/m9.figshare.18762953.

ETHICS STATEMENT

This research was approved by the University of Exeter Ethics Committee (Ref: eCORN001732 v3.3), by the director of each school sampled, and by the teachers of each class involved. The Ministry of Education, Culture and Science, and the Direction of Forests and Biodiversity of STP were also informed about the objectives and methods of the study. All participants gave their informed consent to participate, and data were anonymized.

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SUPPORTING INFORMATION

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