Research trends and outlook for Indonesia's most threatened land vertebrates

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Abstract Indonesia is home to a high number of Critically Endangered land vertebrates. Examining the research on these species is important to improve biodiversity-related policy and management and to provide insight into knowledge gaps. We conducted a comprehensive review of 2,188 publications published during 2000–2021 that studied the Critically Endangered vertebrate species of Indonesia, to understand variations in the level of research on each species and the proportion of research carried out within Indonesia and by Indonesian researchers. Over this 22-year period, research on Critically Endangered species in Indonesia increased, but > 50% of this research was carried out by researchers based outside Indonesia. Moreover, the quantity of research was uneven across taxonomic classes, indicating an imbalance in research attention. Most publications during the period were on mammals (1,573 publications), followed by reptiles (310), birds (300) and amphibians (5). We identified 17 species for which there were no significant publications, suggesting little attention has been given to these species. We highlight three key issues: limited Indonesian authorship, taxonomic bias towards mammals and birds, and a need to address these challenges in authorship and bias. The low number of publications on many Critically Endangered land vertebrates reflects a lack of research effort, mostly because of limited funds and unequal conservation attention.

Keywords Critically Endangered species, Indonesia, IUCN Red List, land vertebrate, research gap, Southeast Asia, systematic review, threatened species

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Introduction

Species extinction during the Anthropocene is considered one of the most critical current environmental challenges (Dirzo et al., 2014; Kaiho, 2022). With limited resources, there is a need to prioritize conservation efforts, and the IUCN Red List is widely used as the standard for assessing species' extinction risk (Vié et al., 2008). The results of Red List assessments are important to help authorities, managers and scientists focus resources and efforts on mitigating population declines and species losses. Each species categorized as threatened on the IUCN Red List should be a high priority for conservation, especially those categorized as Critically Endangered, which are at high risk of extinction if no captive populations exist (Rodrigues et al., 2006).

Comprising 11 countries, Southeast Asia is recognized for its unique biodiversity and four global biodiversity hotspots: Sundaland, Wallacea, Indochina and the Philippines (Myers et al., 2000). For more than 20 years scientists have warned of the risk facing Southeast Asian biodiversity as a result of forest loss, habitat destruction, overharvesting and the wildlife trade, amongst other threats (Sodhi et al., 2004; Harrison et al., 2016; Hughes, 2017). Species extinctions in the region are inevitable if action is not taken (Duckworth et al., 2012).

Of 17,160 Southeast Asian land vertebrate species assessed on the IUCN Red List, 3,792 occur in Indonesia, 1,939 in Myanmar and 1,935 in Thailand. Indonesia has 78 Critically Endangered land vertebrates, Viet Nam 48 and Malaysia 43. Indonesia has 1,826 threatened bird species (31 Critically Endangered), 786 threatened mammals (26), 755 threatened reptiles (18) and 409 threatened amphibians (three; IUCN, 2022).

The Asian Species Action Partnership, a cross-institutional programme of the IUCN Species Survival Commission, was established to prevent extinctions of land and freshwater vertebrate species in Southeast Asia (Duckworth et al., 2012; Rao et al., 2014). The Partnership works to catalyse and accelerate conservation action to prevent extinctions and promote species recovery of Critically Endangered land and freshwater vertebrate species in Southeast Asia. It provides funding as well as direct support to partner organizations through training

programmes and other mechanisms, to strengthen individual and organizational capacity, enabling partners to lead conservation action for these species (Chao et al., 2022).

As a mega-biodiverse country (Mittermeier et al., 1998), Indonesia has attracted global attention regarding the potential for biodiversity-related research (von Rintelen et al., 2017). Such research has been used for IUCN Red List assessments and to develop priority and future conservation strategies. However, Red List assessment is only one of the many methods for assessing conservation status, prioritizing species and developing conservation strategies (Mace et al., 2006). Not all species are perceived equally, as aesthetic appeal, charisma and publicity levels have all been shown to influence research or protection priorities and can determine the popularity of species (Prokop & Fančovičová, 2013; Adamo et al., 2021). To examine the research efforts focused on these threatened species, here we review the number, type and language of publications on the Critically Endangered land vertebrates of Indonesia published during 2000–2021, as well as the research topics and the location of the research and first authors of these publications. Our analysis will help to narrow gaps in research on and knowledge of the most threatened species in Indonesia, and serve as a guide for Indonesian and international researchers, and funding donors. We also recommend areas for further research and attention.

Methods

Following Xiao & Watson (2019), we formulated inclusion criteria for a systematic review process. We compiled published papers indexed by Google Scholar and/or Scopus using the Publish or Perish application (Harzing, 2010), which includes peer-reviewed scientific papers, grey literature and other sources of information for conservation research (Haddaway & Bayliss, 2015). We searched the titles of all publications for the scientific and common names of each of the 78 Critically Endangered land vertebrate species. We did not consider changes in species names or species separations during the data processing phase. We collected reports written in English or Bahasa Indonesia published during 2000–2021, based on Putera et al. (2022), who noted a significant increase in research activity in Indonesia from 2000 onward. We cleaned the data to ensure the completeness of publication metadata and to eliminate duplicates.

We found 4,073 records, of which 2,188 met the inclusion criteria for analysis in our systematic review. We categorized publication language as 'English' or 'Bahasa Indonesia' and publication type as 'scientific article', 'thesis', 'report', 'seminar proceeding' or 'book chapter'. We omitted most non-scientific books and other publications (multimedia, posters and magazines). For analysis of research topic, we categorized publications into 'ecology', 'behaviour', 'veterinary science', 'biochemistry and molecular biology', 'anatomy, morphology and physiology', 'biodiversity and conservation', 'reproductive and developmental biology' and 'people and nature'. To analyse the research outputs of Indonesian researchers, we compared the quantity of research conducted by Indonesian researchers to that of foreign researchers (based on the first author). To analyse the geographical distribution of the publications, we noted whether the research was carried out within or outside Indonesia. Research conducted outside Indonesia could include ex situ and laboratory studies.

Results

Based on our analysis of the 2,188 publications, we observed an increase in the number of publications across the four taxonomic classes during 2000–2021 (Fig. 1a). This increase in research corresponds with a notable rise in the number of species categorized as Critically Endangered, particularly from 2008 onwards (Fig. 1b). Over the years studied, there has been a general increase in the number of publications per year for birds, reptiles and mammals, with the most notable rise occurring in mammals. In contrast, research on amphibians remained relatively stagnant, with few or no publications during most of the study period (Fig. 1a). This pattern suggests that mammals have received proportionally more research attention over time compared to other taxonomic groups.

The most common publication type was scientific articles (67.5%), followed by academic theses (23.6%), reports (4.8%), seminar proceedings (3.8%) and book chapters (0.3%; Fig. 2). The majority (69.1%) of publications were in English, with 30.9% in Bahasa Indonesia, and English dominated all publication types except for theses. Analysis of research topics revealed that ecology (27.4%), behaviour (20.7%) and veterinary science (14.6%) were the most frequent subjects of study (Fig. 3).

With respect to the nationality of researchers and the geographical locations of the research (Fig. 4a-c), foreign researchers comprised c. 58.1% of all authorship across the 2,188 studies reviewed. This was calculated based on the total number of first and co-authors recorded in the dataset. The high percentage of foreign authorship is probably because some species occur in multiple countries (e.g. the Malay crestless fireback *Lophura erythrophthalma* and the Siamese crocodile *Crocodylus siamensis*), and some species have garnered international attention. This was particularly evident in the case of the Bornean and Sumatran orangutans *Pongo pygmaeus* and *Pongo abelii*. Forty-three per cent of studies were conducted outside Indonesia, primarily on species with extensive geographical distributions in Borneo.

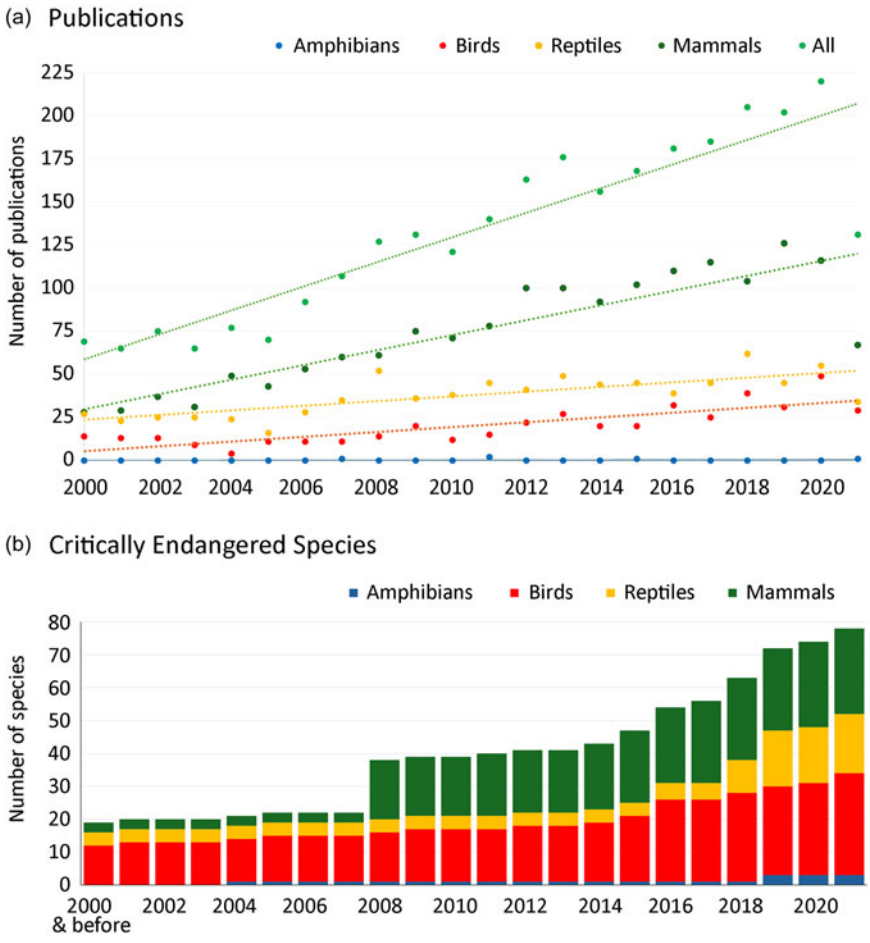

FIG. 1 (a) Number of research publications on Indonesian Critically Endangered species across four taxonomic groups (amphibians, birds, reptiles, mammals) from 2000 to 2021. The trend lines represent linear regression fits for each group. (b) Number of species categorized as Critically Endangered on the IUCN Red List in each year. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

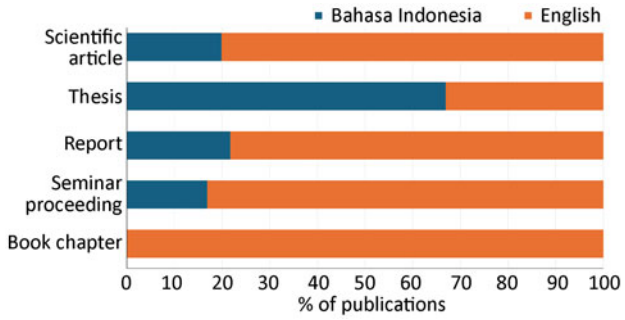

FIG. 2 Types of publications focused on Critically Endangered species of Indonesia during 2000–2021, and the percentage of publications in Bahasa Indonesia and English.

With respect to publication titles, 61 species (78%) had publications focused on them specifically (i.e the species name was stated in the title; Table 1). However, the remaining 17 species had no major publications associated with them. Instead, publications featuring these 17 species were only found through searching for relevant keywords within the text, indicating these species have received limited research attention. This included seven bird species (the Malay crestless fireback, Siau scops owl *Otus siaoensis*, blue-fronted lorikeet *Charmosyna toxopei*, Sangihe dwarf kingfisher *Ceyx sangirensis*, Sangihe whistler *Coracornis sanghirensis*, black-chinned monarch *Symposiachrus boanensis* and Sangihe golden bulbul *Hypsipetes platenae*), four mammal species (the black-spotted cuscus *Spilocuscus rufoniger*, golden-mantled tree-kangaroo *Dendrolagus pulcherrimus*, Emma's giant rat *Uromys emmae* and Wondiwoi tree-kangaroo *Dendrolagus mayri*) and six reptile species (*Calamaria longirostris*, *Eremiascincus antoniorum*, the Jampea Island pipe snake *Cylindrophis isolepis*, *Cnemaspis minang*, the Apreocular reed snake *Calamaria apraeocularis* and *Dibamus manadotuaensis*).

Most publications studied mammal species (1,573), followed by reptiles (310) and birds (300), with only five studies on amphibians (Table 1). A research imbalance in Indonesia persists, with some species being the focus of only one publication: five bird species (the Javan blue-banded kingfisher *Alcedo euryzona*, Rück's blue flycatcher *Cyornis ruckii*, the rufous-fronted laughingthrush *Garrulax rufifrons*, Nias hill myna *Gracula robusta* and Sangihe white-eye *Zosterops nehrkorni*), four mammal species (the Pagai Island macaque *Macaca pagensis*, East Sumatran banded langur *Presbytis percura*, Attenborough's long-

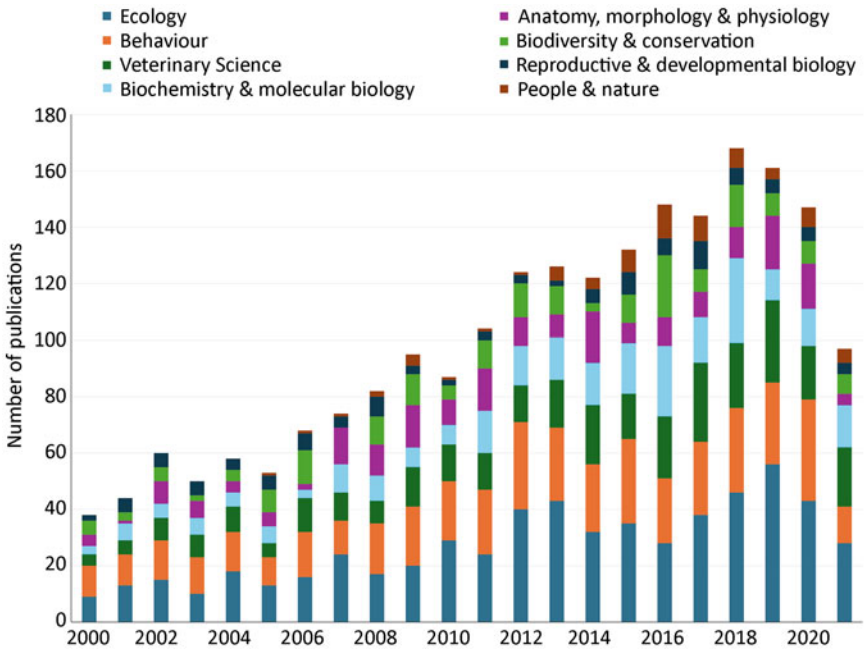

FIG. 3 Number of publications on Critically Endangered species of Indonesia during 2000–2021 by research topic. (Readers of the printed journal are referred to the online article for a colour version of this figure.)

beaked echidna *Zaglossus attenboroughi* and blue-eyed spotted cuscus *Spilocuscus wilsoni*), two reptile species (*Cyrtodactylus celatus* and *Cyrtodactylus gordongekkoi*) and two amphibian species (*Occidozyga tompotika* and *Philautus jacobsoni*). For mammals, birds and amphibians > 50% of research was conducted in Indonesia, compared to only 19.3% of reptile research (of 310 publications, 157 are focused on *C. siamensis*, a species also occurring outside Indonesia). The first authors of mammal and reptile publications were mainly foreign (56.0 and 87.4% respectively), whereas research on birds and amphibians was predominantly carried out by Indonesian researchers (61 and 100%, respectively; Table 1).

We identified the species with the highest number of publications from each taxonomic class (Table 1). These were the Bali myna *Leucopsar rothschildi* (22.7%), the maleo *Macrocephalon maleo* (19.7%) and the yellow-crested cockatoo *Cacatua sulphurea* (18.3%) for birds, the Bornean orangutan (36.5%), Sumatran orangutan (19%) and Sunda pangolin *Manis javanica* (9.5%) for mammals, the Siamese crocodile (53.5%), southern river terrapin *Batagur affinis* (8.7%) and Asian forest tortoise *Manouria emys* (8.4%) for reptiles and one amphibian species, the bleeding toad *Leptophryne cruentata* (60%). We observed that, for each taxonomic class, one species not only had the highest number of publications but also had most of the research activities conducted within Indonesia. These species were the Bali myna, Bornean orangutan, Sulawesi forest turtle *Leucocephalon yuwonoi* and bleeding toad. The species with the most research conducted outside Indonesia were the spoon-billed sandpiper *Calidris pygmaea,* Bornean orangutan and Siamese crocodile.

The majority of bird research was on the Bali myna, maleo and yellow-crested cockatoo, all of which are endemic to Indonesia. Most of the research on these species was conducted in Indonesia and carried out predominantly by Indonesian researchers. There is an uneven focus on one reptile species, the Siamese crocodile, for which research was mostly conducted outside Indonesia. Omitting this species from our data, we found that reptiles and amphibians are understudied in Indonesia. Of the reptiles endemic to Indonesia, the species with the most publications was the Sulawesi forest turtle *L. yuwonoi* (Fig. 4c). There are few publications on Critically Endangered amphibians, with three studies on *Leptophryne cruentata* and just one each on the frogs *O. tompotika* and *P. jacobsoni*. The research on these three endemic amphibians was mostly conducted by Indonesian researchers in Indonesia.

As the group with the highest number of publications, mammals have evidently attracted significant research interest from both Indonesian and foreign researchers. Primates were the most extensively studied mammalian order, accounting for 74.0% (1,164 publications) of the publications on mammals (Fig. 5a). Other orders with high numbers of studies include Perissodactyla (12.8%, 202 publications; 121 publications on the Sumatran rhinoceros *Dicerorhinus sumatrensis* and 81 on the Javan rhinoceros *Rhinoceros sondaicus*) and Pholidota (9.5%, 149 publications; all on the Sunda pangolin). In contrast, considerably less research attention has been given to the orders Artiodactyla, Rodentia, Chiroptera, Monotremata and Diprotodontia, collectively comprising 3.7% of total publications, with monotremes and diprotodonts having the lowest publication

TABLE 1 Details of publications on Critically Endangered species of amphibians, birds, mammals and reptiles in Indonesia, and of the researchers carrying out the studies, during 2000–2021.

Finding	Amphibians	Birds	Mammals	Reptiles	Total
Number of Critically Endangered species	3	31	26	18	78
Number of species whose names appear in at least one publication title	3	24	22	12	61
Number of species with name not in any publication title	0	7	4	6	17
Total number of publications	5	300	1,573	310	2,188
Number of species with only one publication	2	5	4	2	13
Publications with research conducted in Indonesia (%)	100	72.7	61.4	19.3	57.0
Publications with Indonesian first author & research conducted by Indonesian researchers (%)	100	61.0	44.0	12.6	42.0
Species with the highest number of publications (% of total publications for each class)	*Leptophryne cruentata*[1] (60.0)	*Leucopsar rothschildi*[1] (22.7) *Macrocephalon maleo*[1] (19.7) *Cacatua sulphurea*[1] (18.3)	*Pongo pygmaeus* (36.5) *Pongo abelii*[1] (19.0) *Manis javanica* (9.5)	*Crocodylus siamensis* (53.6) *Batagur affinis* (8.7) *Manouria emys* (8.4)	
Species with the highest number of publications & research conducted in Indonesia	*L. cruentata*[1]	*L. rothschildi*[1]	*P. pygmaeus*	*Leucocephalon yuwonoi*[1]	
Species with the highest number of publications & research conducted outside Indonesia		*Calidris pygmaea*	*P. pygmaeus*	*C. siamensis*	

[1]Endemic to Indonesia.

rates of these. Only one publication, conducted in New Guinea, featured Attenborough's long-beaked echidna. The western long-beaked echidna *Zaglossus bruijnii* had slightly better representation, and the research in three of five of its publications was conducted in Papua, Indonesia. Three publications featured the Talaud bear cuscus *Ailurops melanotis*, deriving from a study conducted in Sulawesi; only one publication featured the blue-eyed spotted cuscus but did not have a specific focus on the species.

Orangutans have received the greatest attention, with studies on the three species (*P. pygmaeus, P. abelii* and the Tapanuli orangutan *Pongo tapanuliensis*) constituting 56.3% (886 publications) of all publications on mammals (Fig. 5b). The Bornean orangutan is the primate with the highest number of publications, accounting for 49.3% (574 publications) of total primate-related publications. Of these, only 24.9% of the authors were Indonesian, indicating that most research on *Pongo pygmaeus* was conducted or led by foreign researchers. *Pongo abelii* also had a high publication count, representing 25.7% (299) of primate publications (Fig. 5b). However, we note this number may include publications on *P. tapanuliensis*, as this species was only recognized as distinct from *P. abelii* in 2017. Nevertheless, it is evident that large primates receive more research attention than other Indonesian mammal species.

Discussion

Attention towards threatened species can be indicated by the quantity of research and publications. Research on Critically Endangered species in Indonesia has shown a consistent upward trend since 2000, as has the number of species categorized as Critically Endangered. This increased focus on these species was also highlighted by Ardiantiono et al.'s review of mammal research in Indonesia (2024). Although the increasing number of studies is encouraging, there are still challenges and research gaps regarding Critically Endangered species in Indonesia. We analysed the present situation to understand any research gaps, identify biases and address challenges.

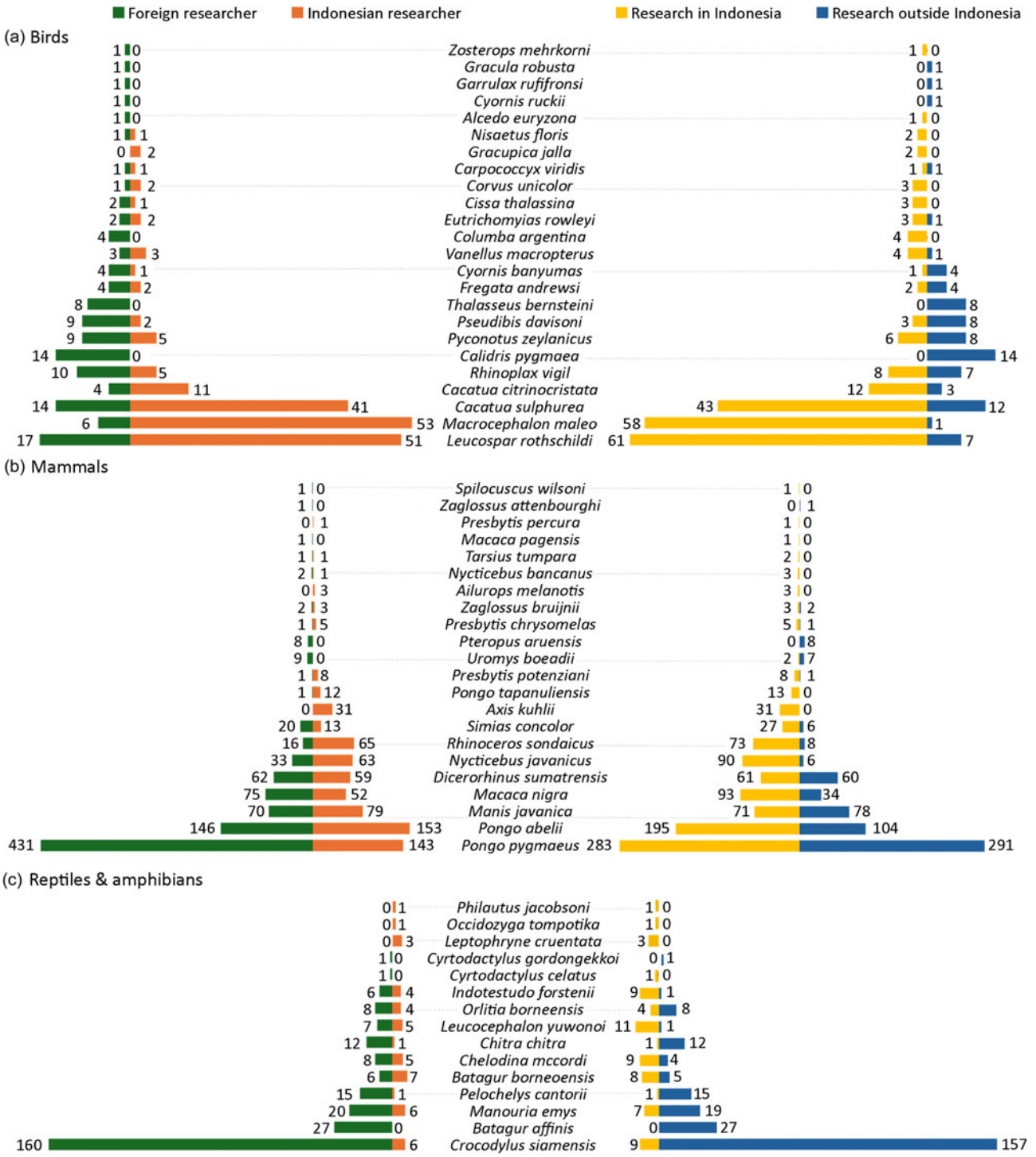

FIG. 4 Number of publications on Critically Endangered species of Indonesia during 2000–2021 categorized by researcher nationality (left) and research location (right) for (a) birds, (b) mammals, and (c) reptiles and amphibians. Species with no publications during 2000–2021 are not shown.

Limited Indonesian authorship

Scientific articles were the main publication type in terms of quantity, but only 42% of this research was carried out by Indonesian researchers. Experts are often defined by their research outputs and authorship, and geographical disparities of experts in wildlife research has been highlighted, with Africa and Asia being the most underrepresented (Maas et al., 2021; Tuyisenge et al., 2023). The greater number of experts from countries outside biodiversity

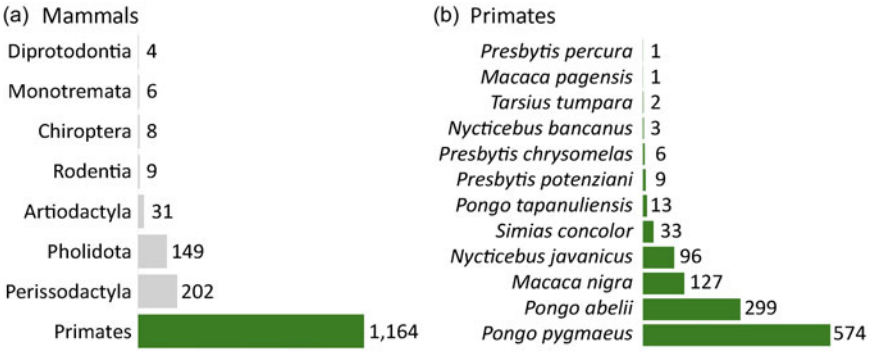

FIG. 5 Number of publications on Critically Endangered (a) mammals and (b) primates of Indonesia during 2000–2021.

hotspots has been labelled 'the biodiversity paradox' (Rodríguez et al., 2022), and there are concerns regarding the low percentage of local authorship in Indonesia (von Rintelen et al., 2017).

The large proportion of publications by foreign researchers highlights the limitations faced by Indonesian researchers in accessing opportunities to publish their findings. Language barriers are a major cause of disparities in biodiversity research (Amano & Sutherland, 2013; Amano et al., 2016; Negret et al., 2022; Nature Human Behaviour, 2023). Local researchers may be missing opportunities to access resources to conduct wildlife research compared to their English-speaking counterparts, both during the development of proposals to international donors and when writing up their research.

Funding for species research is linked to publication outputs by researchers (Heyard & Hottenrott, 2021), and publication outputs from such research can be used to improve conservation action (Sutherland et al., 2004; Salafsky et al., 2019). Insufficient funding poses a formidable barrier for local researchers aiming to publish their work in internationally reputable open access journals, in which publication costs are typically USD 2,000–4,000 (Van Noorden, 2013; Yuen et al., 2019). Although some journals offer waivers to cover these costs, competition and lengthy peer review processes are additional challenges for local researchers seeking to disseminate their work.

For species with the highest numbers of research publications in each taxonomic class (except for reptiles), the number of studies conducted in Indonesia by Indonesian lead researchers is > 50%. Despite concerns regarding so-called helicopter or parachute research by researchers from developed countries (Stefanoudis et al., 2021; De Vos & Schwartz, 2022), research on land vertebrates in Indonesia is increasingly led by local researchers. Most of this research is field-based, an advantage that local researchers have over their international counterparts.

Taxonomic bias

Few Critically Endangered land vertebrates in Indonesia are well studied and c. 20% have not been studied at all. Bias towards vertebrate species is common within biodiversity research (Donaldson et al., 2017) and our results show there are further biases within land vertebrates, consistent with the findings of Ardiantiono et al. (2024).

Our findings highlight a strong bias towards primates, with orangutans being the most researched genus. This high level of interest can be attributed to several factors, including the genus being a great ape (the most closely related group to humans) and its exclusive presence in Indonesia and Malaysia. It has been estimated that USD 1 billion was invested in orangutan conservation during 2000–2019 (Santika et al., 2022), contributing to its prominence in the scientific literature. However, Indonesia and Malaysiaare facing considerable land-use changes, posing further threats to the survival of these great apes (Gaveau et al., 2009; Sherman et al., 2020).

The availability of funding can influence research priorities (Thelwall et al., 2023) and could affect the regions or taxa studied. Funding for biodiversity research may be disproportionately directed towards high-profile or politically significant projects, leading to a biased allocation of resources, as has been observed with orangutan research. The high conservation investment in the three species is unsurprising considering that at least 12 organizations feature 'orangutan' in their names. Furthermore, the active involvement of the Ministry of Environment and Forestry is evident through various initiatives, notably the introduction of the 2019–2029 Orangutan Conservation Strategy and Action Plan (MoEF, 2019).

There is a bias in conservation investment in well-known species (Bellon, 2019; Adamo et al., 2022), with less funding devoted to other, less well-known or less charismatic, species. An incomplete understanding of the ecology of lesser-known and less studied taxa could further increase the risk of research neglect and vulnerability to extinction. The limited research on lesser-known Critically Endangered species is of concern for improving their conservation status. The skew in public support and funding affect how priorities for species conservation are developed (Colléony et al., 2017; Davies et al., 2018; Adamo et al., 2022).

There are limited or no data on conservation investment for most Critically Endangered species in Indonesia. Except

for orangutans, there have been no reports on the effectiveness of funding for biodiversity conservation in Indonesia (Santika et al., 2022). Greater investment is needed to improve the knowledge and conservation status of threatened species (McCarthy et al., 2008), especially for unpopular and lesser-known species. Research on funding trends for biodiversity conservation in Indonesia is needed to narrow the gaps in research, as has been shown for Bhutan, China and the USA (Bakker et al., 2010; Devkota et al., 2023; Yang et al., 2024).

Addressing biases and challenges

Addressing biases in biodiversity research requires a concerted effort from the scientific community, policy-makers and funding agencies both nationally and internationally (Ocampo-Ariza et al., 2023). Encouraging local researchers to fill knowledge gaps, especially by providing access to resources to explore less studied taxa and regions, is crucial for their engagement and for the stewardship of these species. The inclusion of citizen science efforts under local researcher leadership not only enables local researchers to conduct cost-effective research on the distribution of species, including threatened species, but also improves awareness of the general public (Pocock et al., 2018; Callaghan et al., 2020; Fontaine et al., 2022). Although there are concerns regarding the quality control of citizen science data (Crall et al., 2011; Aceves-Bueno et al., 2017), this kind of monitoring (Callaghan et al., 2019) is crucial to gathering data on species distributions and the occurrence of harmful invasive species (Devictor et al., 2010; Johnson et al., 2020). Currently, there are two citizen science programmes for recording land vertebrates in Indonesia, focusing on herpetofauna and birds (Kusrini et al., 2019; Gumilang et al., 2020; Squires et al., 2020; Maharani et al., 2022).

Challenges faced by Indonesian researchers include limited funding and often limited access to scientific literature, global networks and specialized equipment and technology. Insufficient resources hinder the ability to conduct research and participate in biodiversity studies and conservation efforts. Thus, opportunities for local researchers to access funding needs to be increased by establishing targeted funding opportunities. Funding sources should not only be provided by international donors but should also be available from local governments and NGOs (Oktaviani et al., 2018).

Although there have already been several attempts to increase funding for the conservation of lesser known Critically Endangered species, such funding remains limited. For example, the Asian Species Action Partnership has 77 Indonesian partner organizations (excluding international NGOs such as WWF and the Wildlife Conservation Society, or those based outside Indonesia) that work to protect 41 Critically Endangered mammal, bird, reptile and amphibian species. In line with our own findings, orangutans are the most frequently listed focal species of these organizations (29% of the Asian Species Action Partnership in Indonesia list one or more orangutan species as a focus of their work). To bridge some of the gaps faced by local organizations and to catalyse greater action for neglected species, in 2020 the Partnership launched new funding mechanisms with a specific focus on supporting projects by local organizations, projects led by Indonesian researchers affiliated with one of the Indonesian partner organizations, and projects focused on neglected species. To date, the Partnership has funded its partners' work on 16 Critically Endangered land vertebrates in Indonesia (nine bird, three mammal, three reptile and one amphibian species). However, the amounts are small and the funding mostly focuses on conservation action. Although additional funding is available from other organizations (such as the Mohammed bin Zayad Species Conservation Fund, Mandai Nature and Synchronicity Earth), the funding gap relative to the conservation needs of Critically Endangered species remains large.

Funding is also needed for capacity building. An assessment of organizations implementing species conservation in Southeast Asia indicated the need for greater and more diverse training opportunities in the region (Chao et al., 2022). Organizations and institutions should invest in capacity-building programmes that provide local researchers and conservationists with training, mentorship and access to resources.

Building local capacity through training programmes, workshops and conferences in scientific methodologies, data analysis and conservation techniques, amongst other skills, can empower individuals to take an active role in biodiversity research and conservation. Funding and capacity-building initiatives also need to target research in underrepresented regions and amongst researchers from diverse backgrounds. The International Wildlife Symposium series conducted by WWF–Indonesia in collaboration with local universities across Sumatra (including Riau, Andalas, Lampung and Syiah Kuala Universities) is an example of how to empower local students and researchers to conduct research and share their processes and findings whilst at the same time organizing international events. Side events at the conference in Lampung University have led to the establishment of organizations that further promote international networking and collaboration for local researchers: the Society of Conservation Biology Indonesia Chapter and, later, the IUCN Species Survival Commission Indonesia Species Specialist Group.

Improving research by local researchers through collaboration and networking with experienced scientists from outside the country is important. Engaging local researchers in biodiversity studies is crucial for several

reasons. Local researchers possess valuable knowledge about ecosystems, species distributions and traditional practices that can significantly contribute to a comprehensive understanding of biodiversity. Moreover, involving local researchers fosters capacity building and enhances local ownership and therefore long-term sustainability and more effective conservation efforts. Although international researchers in Indonesia are required to work in partnership with local researchers, the latter may feel discouraged if their contributions are not adequately recognized or rewarded within the scientific community, or if they feel there is no knowledge exchange or a lack of equal opportunities and shared responsibilities (Rochmyaningsih, 2019; De Vos & Schwartz, 2022).

Recognition and incentives, such as co-authorship, opportunities to attend conferences and to present findings, can enhance the motivation of local researchers. In addition, co-authorship enables local researchers to increase their academic capacity (Li et al., 2019), improve their data analysis and writing skills and access funding. As language barriers can be significant obstacles to effective collaboration, efforts to facilitate communication and translate scientific knowledge into local languages should be encouraged, to improve engagement (Primack, 2008). Local people can and should be the guardians of biodiversity in their countries, actively participating in and leading research into biodiversity in their local regions. It is our collective responsibility as policymakers, scientific communities, donor agencies and journal editors, amongst others, to make this a reality.

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Conflicts of interest None.

Ethical standards No specific approval was required for this research, and the research abided by the *Oryx* guidelines on ethical standards.

Data availability The data that support the findings of this study are available from the corresponding author, RKT, upon reasonable request.

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