The Rhino Resource Center: accessing and utilizing a unique digital database

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Introduction

Rhinos have a long history in European art and literature, having captivated the public for over 500 years. In China and India, this is even longer (Bishop 1933, Bose 2020). This long-term record means that there is a wealth of rhino imagery and publications available for researchers. The Rhino Resource Center (RRC) is a repository of such information. Whilst the power of the RRC's literature database has been documented, we consider that the image gallery has thus far been underappreciated by researchers. To complement a recent publication that made use of the images in the RRC to investigate changing human perceptions of rhinos and morphological changes in rhinos over time, we describe the volume and type of data available on the RRC and the images it contains and how to access these, including thematic information, time and location data, ecological data and morphology. We hope that this paper will facilitate rhino researchers making greater use of this information and we strongly encourage uptake of this resource for future rhino research.
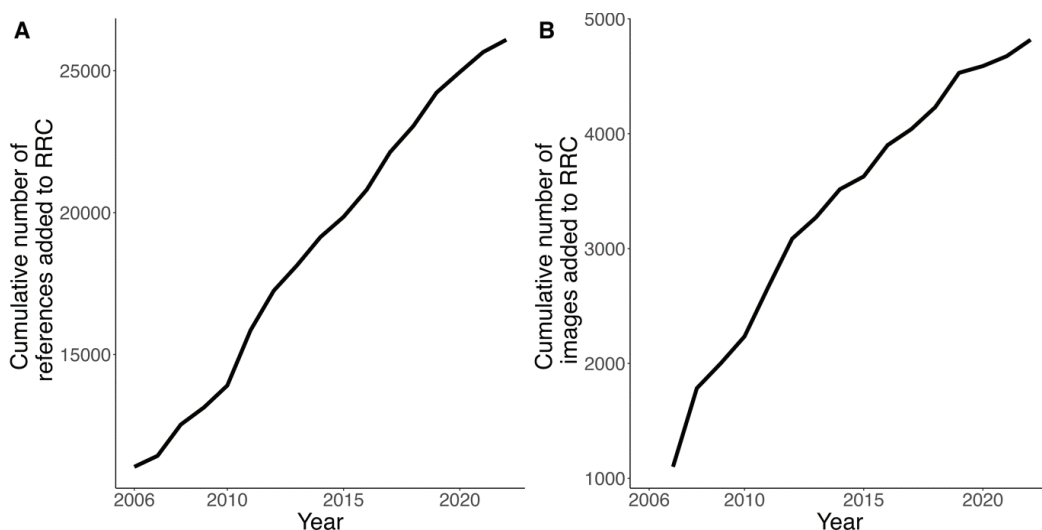
The Rhino Resource Center

The Rhino Resource Center (RRC) (available at rhinoresourcecenter.com) was registered on the 1 August 2003, following the International Elephant and Rhino Research Symposium in 2001, where it was proposed that a single repository for rhino information (Rookmaaker 2003) was necessary. The potential value of the RRC to rhino researchers has been documented previously (Rookmaaker 2010) and continues to grow, with 26,092 references in the literature database at the time of writing this paper, and over 5,000 images in the associated image database (titled the RRC Image Gallery) (Rookmaaker 2022), representing the world's largest collection of information on rhinos and, as far as we are aware, the largest repository of data on any given single group of mammals (Fig. 1).

Previous publications promoting the RRC have focused on the utility of the literature database (e.g. Rookmaaker 2003; 2010), which covers every rhino species, and includes information on publication type, date and locality. The literature database is user-friendly with a search facility and contains PDFs of over 26,000 references, so that authors have access to full texts, as well as titles. In a recent paper (Wilson et al. 2022) we have—for the first time—documented the usefulness of the RRC Image Gallery. The aim of that study was to demonstrate the potential advantage of image repositories in conservation research (in particular the changing relationship between people and rhinos, and the use of photographs for assessing changes in species morphology over time) and to provide recommendations for those interested in starting comparable databases that focus on other taxa. We intend this natural history note as a companion to Wilson et al. 2022 detailing the types of data that are available within the RRC and providing guidance on how to use this database specifically.

The RRC Image Gallery is searchable (like the literature collection) but can also be browsed, either in full or by locality, subject or taxon. Each image, when clicked, is displayed in the same format (Fig. 2). Each image is given a distinct title, searchable in the gallery, and information is given on the author, year of production, origin of the image, location, subject and species. This information is added by the editors of

Above left (A). Figure 1. Growth of the Rhino Resource Center since it was first established. A. Cumulative number of references in the literature collection
Above right (B). Cumulative number of images in the Image Gallery. Values taken from the electronic newsletter of the Rhino Resource Center, published every quarter since 2005 and available in the Rhino Resource Center literature database. Although the RRC was founded in 2003, the number of references and images was not included in the newsletter until 2006.

the RRC who upload each image. Images include both artwork and photographs featuring a rhino/s (depending on whether or not a camera has been used to produce them) and are sourced from the literature database, collected by the editors separately or provided by those with an interest in rhinos. Each image is then checked by the editors to reduce the chance of repeats within the gallery. The associated literature database means that further context (e.g. location, date, purpose of image) for many images is available.

Range of data in the RRC Image Gallery

Every image in the RRC Image Gallery is ascribed a date of production. Where dates are unknown, editors provide a best estimate given the context. These dates allow for trends in rhino images to be examined over time, with the RRC showing a near exponential increase in the number of images with each year (Fig. 3). Locality data to a country level are not always recorded for each image, where location is unknown or identifiable only to a regional level (39% of images for artwork), but for photographs, each image usually has an

associated country designation (95.2%) (Fig. 4, Fig. 5). Mapping the distribution of photographs shows that there is a high number from the USA, these are typically of captive rhinos.

One stated goal of the RRC Image Gallery is to act as a virtual studbook, featuring photographs of every rhino ever kept in captivity (Rookmaaker 2007), so the high number of photographs of captive rhinos helps build towards this goal. The location information associated with each image also describes the captivity status of each rhino. Captive and wild rhinos can show differences in morphology (Groves 1982) so differentiating between these conditions is critical for assessment of morphological trends over time. Finally, the associated data includes the species of rhino pictured. The five different rhino species have had different relationships with humans over time (Wilson et al. 2022; Wilson 2019) and separate treatment of these species allows for improved investigation of species-specific conservation trends.

Both photographs and artwork on the RRC are representations of the way that the authors (and society more widely) viewed rhinos at the time that each image was produced. While photographs provide a 'true' image of a rhino, artwork can subjectively portray rhinos according to the desires of the artist (Clarke 1986), therefore providing insight into society's
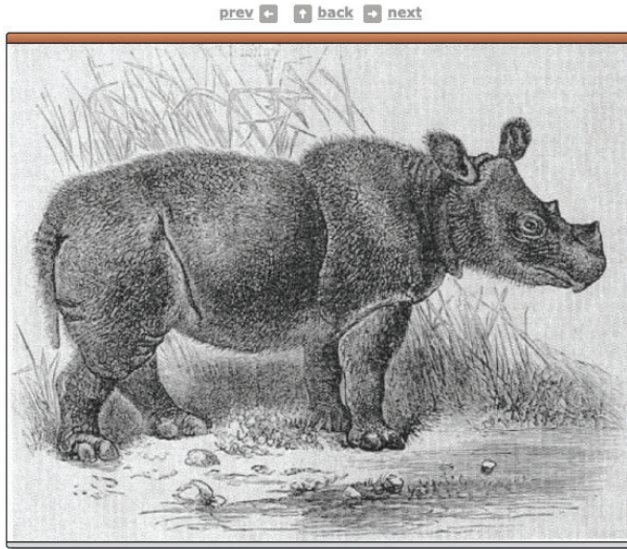
Image Details:

London 1872

Author: Sclater, P.L.

Year: 1872

Description: Sumatran rhinoceros female 'Begum' shown in London Zoo from 15 Feb 1872 to 31 August 1900. It was the type of Rhinoceros lasiotis. Here pictured soon after arrival. From P.L. Sclater, The new rhinoceros. Nature 6, October 24: 518.

Location: Captive - Europe

Subject: Captivity

Species: Sumatran Rhino

File Size: 1.302 kb

Dimensions: 1565x1231 px

High-res: ⓘ To view the high resolution image please register and contact the moderator

Figure 2. Example image from the Rhino Resource Center showing the data associated with each image in the gallery. Image shows the female Sumatran rhino (named "Begum") in London Zoo and is taken from PL Sclater, 1872, The new rhinoceros. *Nature: 6 October 24: 518*.
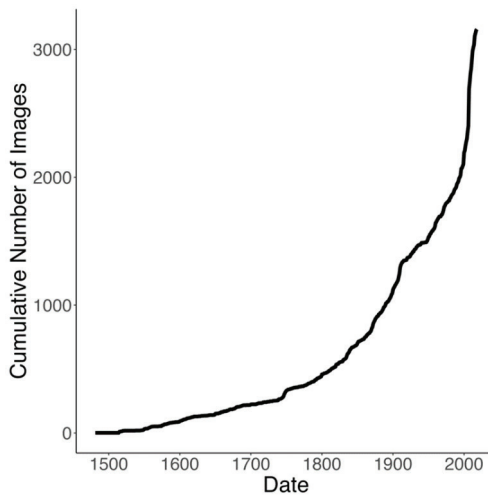

Figure 3. Cumulative number of images from each year between 1481–2019 available on the Rhino Resource Center Image Gallery as of 19 March 2019.
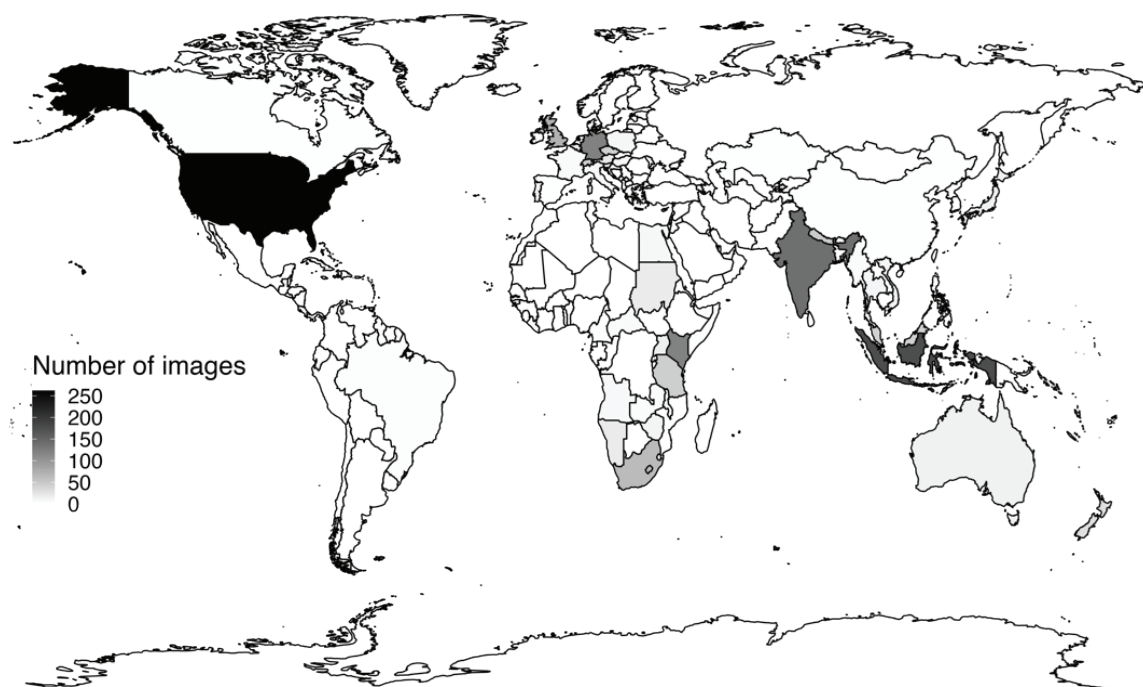
Figure 4. Number of photographs available on the Rhino Resource Center Image Gallery per country as of 19 March 2019.

perception of rhinos at the time. When adding an image to the RRC, editors assign one of 23 subjects to the image, depending on the context in which it is placed (General, Distribution, Taxonomy, Morphology, Anatomy, Physiology, Reproduction, Genetics, Ecology, Behaviour, Diseases, Management, Conservation, Captivity, Translocation, Value, Trade, History, Culture, Organizations, Museums, Bibliography, Text as original), providing important background information to facilitate image interpretation. This requires information on the source of the image, also available in the literature collection.

Potential future uses of the RRC for research

The differing nature of artwork and photographs, paired with published research on the RRC, means that these three types of information could be applied in unique ways to answer research questions and gain a deeper understanding of changes through time. In our paper (Wilson et al. 2022), we showed that photographs from the RRC Image Gallery could be used to assess how morphology changes between species and how horn morphology has changed over time.

Given that high demand for horns has been a major driver of rhino population declines (Di Minin et al. 2015; Gao et al. 2016; Cheung et al. 2018; Shepherd et al. 2018), we believe that investigations into changing horn morphology could be vital for rhino conservation. Other morphological features could be similarly analysed using the RRC as a large and long-term dataset. Soft tissue characters have been used for taxonomic distinction in rhinos (C. Groves and Grubb 2011). For example, the 'drooping hairs' on the ears of Begum, a female Sumatran rhino living in London Zoo (Rookmaaker and Edwards 2022. In press) were used as evidence of the existence of a distinct species, the hairy-eared rhino, ('*Rhinoceros lasiotis*') by Sclater in 1872 (Sclater 1872b; 1872c; 1872a; 1872d; 1873;1876), but later analysis revealed that Begum's ear tufts had disappeared (Thomas, 1901). The species is now considered a northern subspecies of the Sumatran rhino, *Dicerorhinus sumatrensis lasiotis*, mainly differentiated by its larger size (Groves,1967; Rookmaaker 1984). Given the high number of images available on the RRC, including highly threatened taxa and even subspecies which are now presumed extinct (including *D.s.lasiotis*), the RRC has the potential to act as a valuable tool in providing data on disputed morphological characters for taxonomic study (Fig. 6).
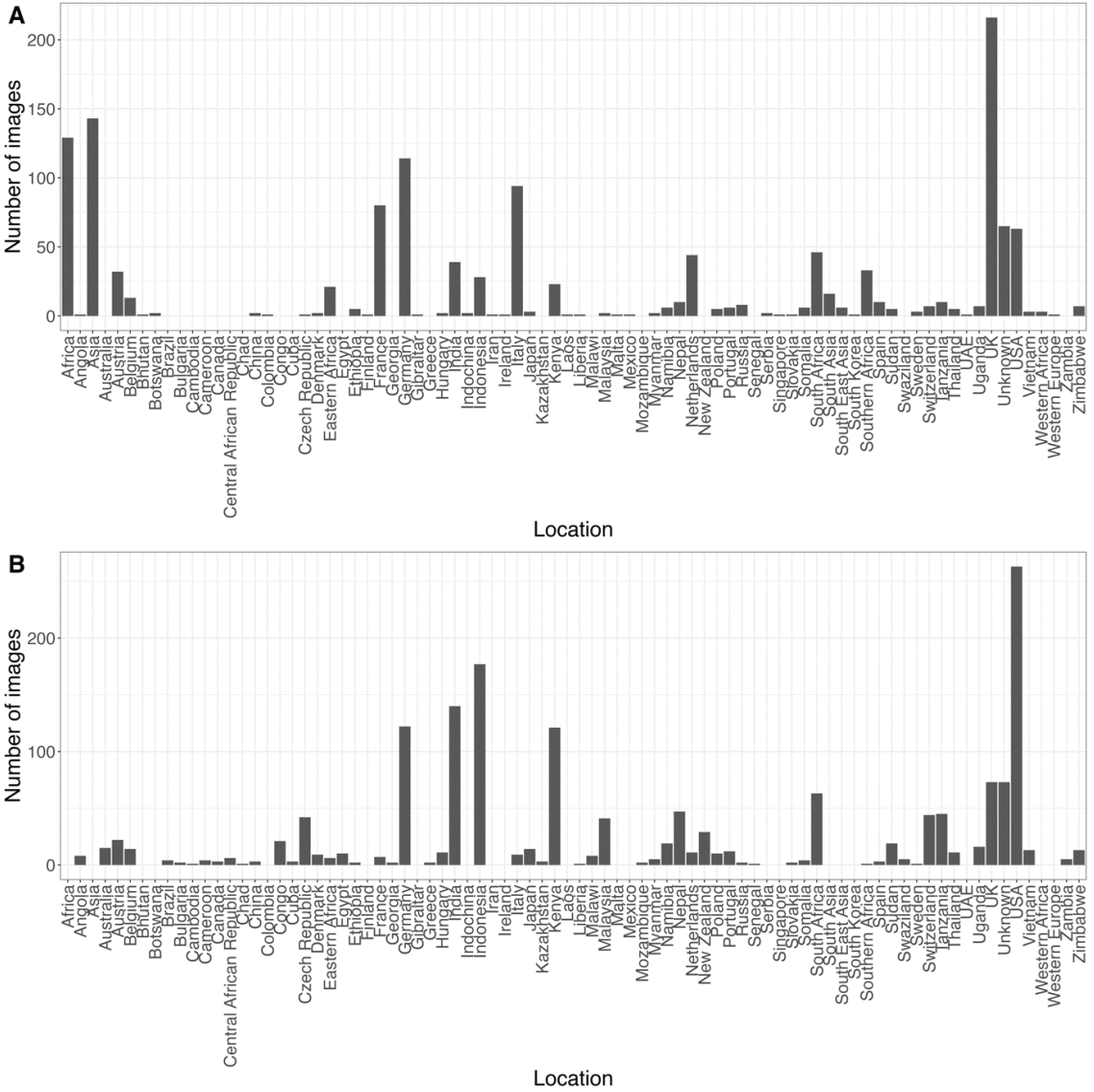
Figure 5. Bar plot showing the number of images available on the Rhino Resource Center Image Gallery for each location (either region or country) as of 19 March 2019. A. Number of pieces of artwork by region and B. Number of photographs by region.

Similar morphometric approaches could also be applied to non-photograph images on the RRC to investigate any potential changes in human perceptions of how rhinos look, with implications for how they have been perceived over time. For example, a recent study on artwork featuring dodos showed that there has been an increase through time in depictions of the dodo with a cartoonishly large anterior part of the beak since 1865, reflecting its perception as an ungainly taxon (van der Geer et al. 2022).

It is not just in examining the 'focal rhino' where images in the RRC may be useful. For example, photographs of captive rhinos could provide data on enclosure design, allowing assessment of how rhinos have been kept in captivity over time. Background vegetation in images of wild rhinos could provide information on habitat choice. Finally, images of wild rhinos could also provide information on group sizes, which are variable across the RRC image database (Fig. 7). Such habitat and group information could also be relevant to conservation. For example, while rhinos are generally considered asocial, interactions between conspecifics in both black and white rhinos have been found to improve chances of survival (Shrader and Owen-Smith 2002; Linklater et al. 2012). Consequently, any changes in group size from RRC images could be important for understanding changing selective pressures on species over time.

Another promising application of the data contained in the RRC is to specifically bring together information from images and publications, to gain a deeper understanding of rhinos. For example, data on how rhinos are written about in publications could be linked with information on how they are portrayed in images for a given time or location, to gain a broader understanding of human perceptions of rhinos, as well
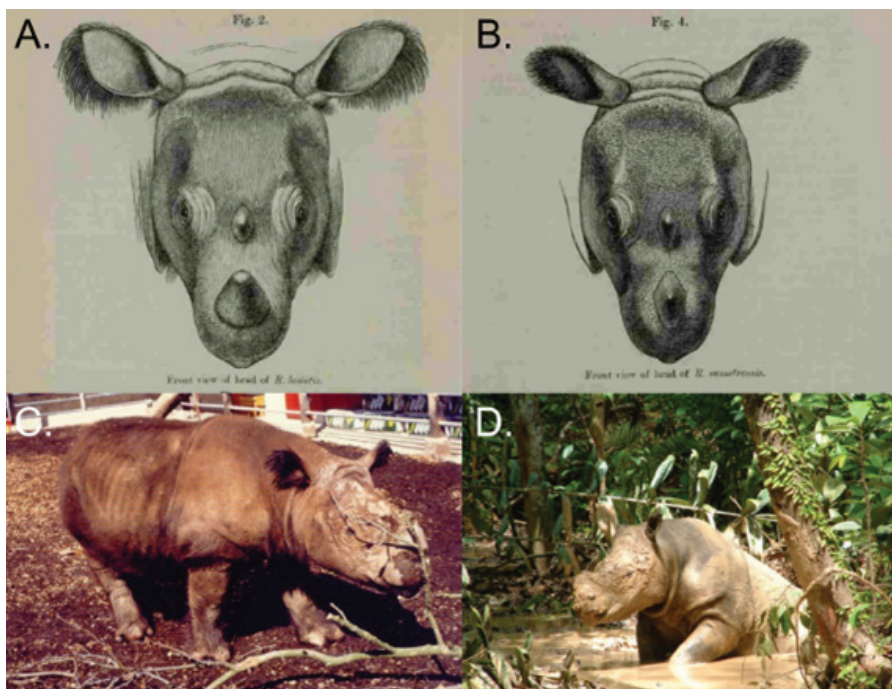
Above left (A). Figure 6. Presence and absence of 'long drooping ear hairs' in Sumatran rhinos (*Dicerorhinus sumatrensis*). Ear morphology used by Sclater to define '*Rhinoceros lasiotis*' (now *D.s. lasiotis*) (from Sclater 1872).
Above right (B). Ear morphology without drooping ear hairs which Sclater used as an example of the condition in '*Rhinoceros sumatrensis*' (now *D.s. sumatrensis*)((from Sclater 1872).
Below left (C). Male Sumatran rhino (*D.s. sumatrensis*), named Torgamba at Port Lympne, 1986, showing long drooping ear hairs (image by Kees Rookmaaker 5 April 1986).
Below right (D). Male Sumatran rhino (*D.s. sumatrensis*), named Torgamba at a reserve in Way Kambas National Park with no visible long drooping ear hairs (image by Nico van Strien 2003). All images available to view on the Rhino Resource Center.

Figure 7. Black rhino (*Diceros bicornis*) group size through time, estimated using the number of conspecifics in the background of artwork featuring wild black rhinos.

as validating any single approach. Similarly, literature in publications on hunting pressure or levels of poaching could be linked to number or proportion of hunting pictures over time, to assess whether images provide information on hunting pressure.

Conclusions

The RRC is an information repository that is currently unique in its ability to contribute to rhino research. The utility of the literature collection has been documented previously and remains invaluable, but we argue that the information content contained within the RRC Image Gallery has so far been underappreciated. Here we have outlined some of the potential for data analysis contained within each image and suggested approaches that could be applied by future researchers from a variety of disciplines. A wide variety of questions could be answered using this image database (in combination with more traditional approaches), and we strongly suggest that researchers with an interest in rhinos consider engaging with it.

Acknowledgements

References

Bishop CW. 1933. Rhinoceros and wild ox in ancient China. *The China Journal* 18: 322–330.

Bose S. 2020. *Mega Mammals in Ancient India*. Oxford, UK: Oxford University Press.

Cheung H, Mazerolle L, Possingham HP, Biggs D. 2018. Medicinal use and legalized trade of rhinoceros horn from the perspective of traditional chinese medicine practitioners in Hong Kong. *Tropical Conservation Science* 11: 1–8. https://doi.org/10.1177/1940082918787428

Clarke TH. 1986. *The rhinoceros from Dürer to Stubbs 1515–1799*. London: Sotheby's Publications.

Di Minin E, Laitila J, Montesino-Pouzols F, Leader-Williams N, Slotow R, Goodman PS, Moilanen A. 2015. Identification of policies for a sustainable legal trade in rhinoceros horn based

on population projection and socioeconomic models. *Conservation Biology* 29 (2): 545–555. doi.org/10.1111/cobi.12412

Gao Y, Stoner KJ, Lee ATL, Clark SG. 2016. Rhino horn trade in China: an analysis of the art and antiques market. *Biological Conservation* 201: 343–347. doi.org/10.1016/j.biocon.2016.08.001

Groves CP. 1967. On the rhinoceroses of South-East Asia. *Säugetierkundliche Mitteilungen* 13 (3): 221–237.

Groves CP. 1982. The skulls of Asian rhinoceroses: wild and captive. *Zoo Biology* 1 (3): 251–261. doi.org/10.1002/zoo.1430010309

Groves C and Grubb P. 2011. *Ungulate taxonomy*. Baltimore, Md: Johns Hopkins University Press.

Linklater WL, Gedir JV, Law PR, Swaisgood RR, Adcock K, Preez P, Knight MH, Kerley GIH. 2012. Translocations as experiments in the ecological resilience of an asocial mega-herbivore. *PLoS One* 7 (1) (e30664): 1–6. doi.org/10.1371/journal.pone.0030664

Rookmaaker LC. 1984. The taxonomic history of the recent forms of Sumatran rhinoceros (*Dicerorhinus sumatrensis*). *Journal of the Malaysian Branch of the Royal Asiatic Society* 57 (1): 12–25.

Rookmaaker LC. 2003. Rhino Resource Center. *Pachyderm* 34: 101–102.

Rookmaaker LC. 2007. Rhino Resource Center Newsletter 9 (November): 1–6.

Rookmaaker LC. 2010. The Rhino Resource Center. *Pachyderm* 47 (1): 100–101.

Rookmaaker LC. 2022. Rhino Resource Center Newsletter 67 (March): 1–22.

Sclater PL. 1872a. A New Asiatic Rhinoceros. Popular Science Review 11, 432.

Sclater PL. 1872b. Notes on *Propithecus bicolor* and *Rhinoceros lasiotis*. Magazine of Natural History 4 (10): 298–299.

Sclater PL. 1872c. On *Rhinoceros lasiotis*. Athenaeum (24 August 1872): 243.

Sclater PL. 1872d. The new rhinoceros. *Nature* 6: 518–519.

Sclater PL. 1873. On a new rhinoceros, with remarks on the recent species of this genus and their distribution. *Report of the British Association for the Advancement of Science* 42 (3): 140.

Sclater PL. 1876. On the rhinoceroses now or lately living in the Society's menagerie. *Transactions of the Zoological Society of London* 9: 645–660.

Shepherd CR, Gray TNE, Nijman V. 2018. Rhinoceros horns in trade on the Myanmar–China border. Oryx 52 (2): 393–395. doi.org/10.1017/S003060531600168X

Shrader AM and Owen-Smith N. 2002. The role of companionship in the dispersal of white rhinoceroses (*Ceratotherium simum*). *Behavioral Ecology and Sociobiology* 52 (3): 255–261. doi.org/10.1007/s00265-002-0506-y

Thomas O. 1901. Notes on the type specimen of *Rhinoceros lasiotis Sclater*; with remarks on the generic position of the living species of rhinoceros. *Proceedings of the Zoological Society of London* 1901: 154–158.

van der Geer AAE, Claessens LPAM, Rijsdijk KF, Lyras GA. 2022. The changing face of the dodo (Aves: Columbidae:Raphus cucullatus): iconography of the Walghvogel of Mauritius. *Historical Biology* 34 (4): 648–657. doi.org/10.1080/08912963.2021.1940996

Wilson OE. 2019. What's the point? Use of image repositories in rhino research. Undergraduate thesis. University of Cambridge, pp. 1–24. Available at: http://www.rhinoresourcecenter.com/pdf_files/165/1656492378.pdf

Wilson OE, Pashkevich MD, Rookmaaker LC, Turner EC. 2022. Online image repositories offer an accessible and information-rich data source for long-term studies of large vertebrates. *People and Nature* 00: 1–15. https://doi.org/10.1002/pan3.10406