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Review Article

Three Decades of Sunda Pangolin (*Manis javanica*) Conservation Research: Mapping Indonesia's Role in the Global Engagement Trends

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Abstract
Limited scientific attention to the Sunda pangolin (*Manis javanica*) persists despite being among the most trafficked mammals globally and a key species distributed across Indonesia. This study examines Indonesia's contribution to global Sunda pangolin research and identifies priority directions to strengthen evidence-based conservation. A combined bibliometric–content analysis approach was applied to 4,474 publications recorded between 1993–2023, from which 130 articles met the topic-specific criteria, and 37 were directly related to Sunda pangolin conservation in Indonesia. Results show that Indonesia contributed only 37 documents (0.83%) to the global pangolin research landscape, with 12 thematic categories dominated by trade and crime studies, while ecological and policy-oriented research remained critically underrepresented. Research on Sunda pangolins was also largely driven by international authors from non-habitat countries, indicating a lack of local leadership and collaboration gaps. These findings highlight a strategic need to increase locally led and multidisciplinary research, expand Indonesia's role as a key habitat country, and establish collaborative research agendas that align ecological knowledge, conservation policy, and wildlife crime mitigation.

Keywords: biblioshiny, conservation governance, Indonesian biodiversity, *Manis javanica*, pangolin, R Studio, sustainable management, wildlife conservation

1. INTRODUCTION

The Sunda or Malayan pangolin (*Manis javanica* Desmarest, 1822) is one of the eight species worldwide and is currently facing severe extinction risk due to persistent overexploitation and illegal trade across its range [1]-[4]. Although this species is morphologically characterized by protective keratinous scales and specialized myrmecophagous feeding adaptations [5]-[8], such biological descriptions alone could not explain the alarming decline that has taken place throughout Southeast Asia. The escalating global demand—shifting from subsistence and traditional medicine [7][9]-[13] to delicacy markets and luxury consumption [12][14]-[16], has intensified poaching pressure within natural habitats. Even with CITES Appendix I protection and IUCN's Critically Endangered status, illegal trade continues [15], with major seizures reported over the past decade, including 120 tons between 2010–2015 [17], and this illegal trade persists, with 23.5 tons traded in 2021.

The ongoing threat to pangolin populations, including the Sunda pangolin in the wild, posed by illegal wildlife trade necessitates the implementation of urgent conservation measures. As one of the primary range states for the Sunda Pangolin, Indonesia plays a pivotal role in this conservation effort. The 2018–2028 Strategic Document for Pangolin Conservation emphasizes the importance of implementing conservation actions within natural distribution areas [18]. However, despite the species' ecological significance and Indonesia's recurring association with global trafficking routes, available scientific information remains fragmented. Studies on Sunda pangolins often rely on trade-based inferences, scarcity reports from hunters and local communities, and opportunistic observations rather than systematic ecological data [7][19][20]. This gap in knowledge poses challenges for developing evidence-based conservation strategies and weakens Indonesia's position in global conservation discourse.

Given these limitations, a comprehensive synthesis of existing scientific work is urgently needed. Bibliometric analysis provides a structured

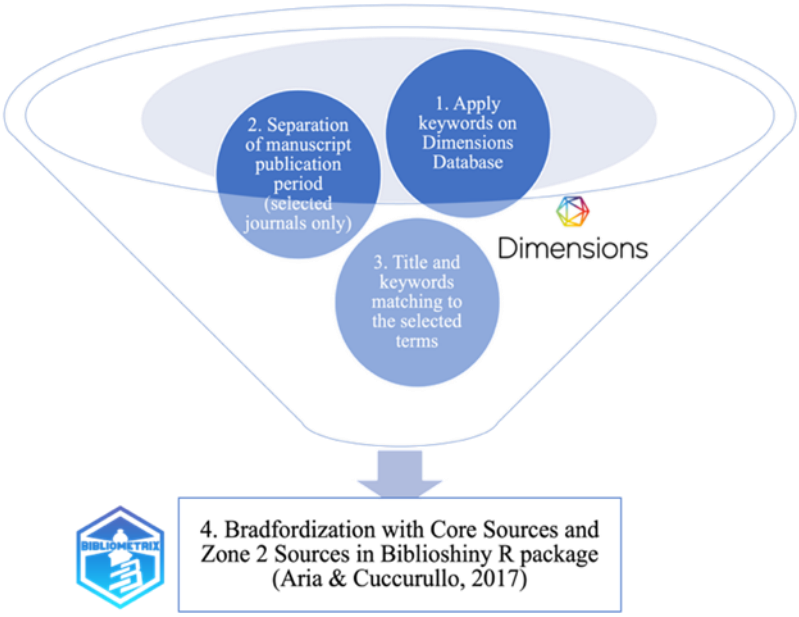

Figure 1. The corpus selection process by filtering data to answer research questions on Sunda pangolin conservation.

approach to examine long-term publication trends, collaboration networks, authorship contributions, and thematic developments. When combined with qualitative content analysis, it can reveal how research has addressed ecological, socio-economic, and governance dimensions of Sunda pangolin conservation—an analytical depth that cannot be achieved by threat descriptions alone [21][22]. Such an approach is essential to understanding Indonesia's scientific engagement relative to non-range countries, identifying research fragmentation, and guiding future, more coordinated conservation efforts. Therefore, this study aims to evaluate Indonesia's contribution to Sunda pangolin research within three decades amidst global scientific engagement. Specifically, it addresses the following research questions: (1) how has pangolin-related research developed globally over the past thirty years, and how is Sunda pangolin research positioned within that trajectory?, (2) what is the scale, thematic focus, and collaborative structure of Indonesia's scientific contribution?, and (3) which knowledge gaps and research priorities should guide future multidisciplinary efforts to conserve this species?

2. MATERIALS AND METHODS

A comprehensive review that combines bibliometric and content analyses is used to answer these research questions. The bibliometric analysis tracks the evolution of scientific research, assesses researcher contributions, and identifies gaps and future research avenues [23]. Content analysis help identify the research gaps and evaluate the effectiveness of existing conservation policies and programmes, based on the approaches used, species studied, and geographic coverage [24]. To ensure the reliability of the content analysis, we developed a detailed and clear coding protocol. Furthermore, validity was enhanced by double coding a subset of articles by an independent researcher to calculate intercoder agreement, ensuring that the categories used accurately reflected the research content.

2.1. Literature Screening and Article Selection Procedures

This research process implemented procedures from extraction and screening to final data analysis, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We followed four main steps in the corpus selection process, which are visualized in Figure 1.

2.1.1. Database, Keywords, and Inclusion Criteria

Pangolin research spans multiple countries and languages. In Indonesia, research results are often

published in Indonesian in national journals, which can significantly limit access to major international databases. To avoid biased analysis and perspectives due to being limited to English-language literature, the Dimensions platform was chosen because of its ability to access articles in both English and Indonesian. This capability offers a credible and more comprehensive alternative to WoS and Scopus, ensuring a more accurate representation of domestic research contributions [25]. Dimensions also covers a wide range of journals and provides an extensive data infrastructure that facilitates the exploration of research relationships [26]-[28].

An extensive Boolean search was conducted on the Dimensions website (app.dimensions.ai) using pangolin-related terms to capture relevant documents that might appear irregularly due to variations in indexing across databases. Although keywords indicate the main idea, they do not fully describe the reviewed papers [29]. Therefore, the keywords used in this pangolin review only focus on the context of pangolins originating from ASEAN countries, including Indonesia. The keywords were evaluated for their effectiveness in retrieving sufficient documents. Some journals present abstracts in English, even if other sections are in local languages. Dimension reads titles and abstracts, ensuring these keywords adequately represent the species. The keywords used were “pangolin”, "*Manis javanica*", "Sunda pangolin", "Malayan pangolin", and "Malay pangolin". The search yielded 4,474 documents dating back to 1859. The next step is to filter the entire corpus to ensure the data matches the expected target. This step applied two filters.

2.1.2. Corpus Screening and Selection Process

The next step is to filter the entire corpus found to ensure it aligns with the research objectives. This filtering process applies two main filters. The first filter was applied directly to the Dimensions search results, sorting documents by publication type and year. The publication period of the selected documents was 30 years, from 1993 to 2023, capturing the modern era of conservation research following the 1992 Rio Convention and the increased attention from CITES. The publication type selected was journals only, not articles published in book or proceedings form. The first screening resulted in 3004 journal articles. Each article's journal was then checked for keyword matches, and only those with the most representative keywords were selected. We performed abstract skimming to identify documents with relevant content, even when titles did not

Table 1. Summary of publication data extracted from Dimensions (1993-2023).

Description	Results	
	Before Bradfordisation	After Bradfordisation
Time span	1993:2023	1993:2023
Source	122	58
Document	195	130
Annual growth rate % (%)	9.86	11.8
Average document age	5.36	5.21
Average citations per document	40.81	49.3
Reference	0	0
Keyword plus (ID)	331	241
Author keywords (DE)	331	241
Number of authors	974	704
Single-author document author	8	4
Documents with a single author	9	5
Co-author per document	7.81	7.98
International co-authorship %	28.35	33.08

match keywords. We also assessed the relevance of documents containing the keyword "pangolin" alone, particularly when the study context is related to ASEAN countries. This search and screening process yielded 195 original research articles.

A second screening stage was conducted on 195 articles to improve the quality of data sources. We used Bradfordisation [30], applying Bradford's Law of Scattering, to identify and select only core sources (zone 1)—journals with the highest concentration of relevant articles—and zone 2 sources (journals with a moderate concentration). This step ensures that the analysis focuses on the most impactful and specialized journals in the field [31][32]. This second screening stage yielded 130 entries ready for bibliometric analysis. Detailed data before and after Bradfordisation screening are presented in Table 1.

2.2 Bibliometric Analysis

The entire database of 130 systematically sorted journals was run in Biblioshiny, a tool within the R package Bibliometrix [33], aiding literature analysis, index calculation, network analysis, and knowledge map creation [34]. For analysis, we used terms or keywords in the abstract (AB-TM), combined with author keywords (DE) and keywords plus (ID). This combination provides more contextual content than the title alone [35][36]. The thematic and evolutionary maps were conducted using the Edge Betweenness algorithm to understand the evolution of the subject and the dominant themes in the field of study [33]. The cutting years used were 2017 and 2021 to reflect changes in conservation status and the impact of the pandemic. Data were visualised using the R package from Biblioshiny and the Orange Data Mining 3.36.1 tool.

2.3. Content Analysis

Before starting the content analysis for a comprehensive review focusing on Indonesia, 130 documents were screened using the keyword 'Indonesia' to ensure relevance. This screening process resulted in 37 papers suitable for content analysis. The content analysis was conducted through systematic manual coding. We used a pre-established coding scheme to categorize the research into key domains. To ensure the reliability

Table 2. Summary of the methodological process and number of documents at each selection stage.

Methodological Stage	Procedure/Tool	Final Outcome	Number of Documents
Stage 1: Extraction	Initial keyword search on dimensions	Raw documents (1859–2023)	4,474
Stage 2: Initial filtering	Filter: Journal type & period (1993–2023)	Selected journal titles	3,004
Stage 3: Corpus selection	Screening titles & abstracts; ASEAN Pangolin Relevance	Original research articles	195
Stage 4: Secondary filtering	Bradfordization (core & zone 2 sources)	Documents for bibliometric analysis	130
Stage 5: Geographic analysis	Keyword screening: "Indonesia"	Documents for content analysis	37

(consistency) of the coding process, a clear coding protocol was developed, and inter-coder reliability was checked on a subset of documents before full coding was undertaken. The overall data filtering process, from extraction to selecting the final articles used in this study, is summarized in Table 2.

2.4. Methodological Limitations

It is important to note that this study has several limitations. Reliance on Dimensions metadata (including titles and abstracts) may inadvertently exclude articles that are relevant but have very poor metadata. Furthermore, although Dimensions mitigates most language bias by including Indonesian-language articles, the platform's coverage may still not include all gray literature or publications from very small domestic journals.

3. RESULTS AND DISCUSSIONS

3.1. Global Publications Trends

From 1993 to 2023, a total of 31 countries involving 974 authors contributed to pangolin-related scientific publications, although only several exhibited a consistent focus on the Sunda pangolin (Figure 2). These include China, Malaysia, Thailand, Singapore, Indonesia, the United States, and Japan, along with the United Kingdom, Australia, and Bangladesh. Publication activity began increasing after 2004, following a brief absence of Sunda pangolin–related scientific output from 2002 to 2004. Prior to 2016, Malaysia produced more publications on Sunda pangolins than China; however, from 2017 onwards, China and Thailand experienced a rapid surge that surpassed that of all other countries. Indonesia demonstrates a more stable but slower growth trajectory, briefly exceeding the United States in 2018 and ranking fifth in 2023. This suggests steady engagement but limited acceleration when compared with high-output countries exhibiting exponential growth.

3.1.1. Thematic Breadth Across Countries

While Figure 2 illustrates temporal differences in publication output, Figure 3 complements this by showing the thematic breadth addressed by each country. China not only leads in total publications but also exhibits the most diverse thematic coverage. Malaysia, Thailand, Singapore, and the United States also contribute across a wide range of topics. Indonesia appears among multi-theme countries, although its contributions are more narrowly concentrated in illegal trade, seizures, and rescue-centre case studies. This narrower thematic scope indicates reduced engagement in scientific domains that have expanded globally, such as molecular biology, breeding technologies, and zoonotic pathways.

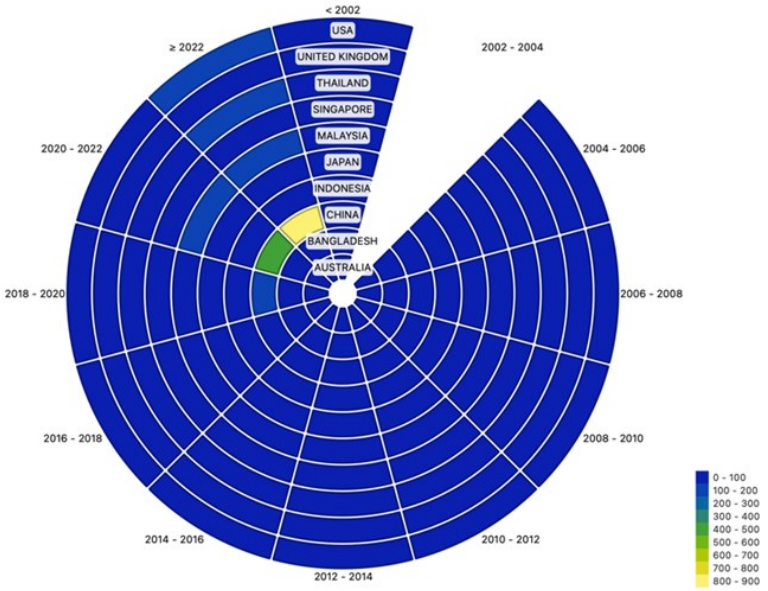

Figure 2. Articles contribution by country over time on Sunda Pangolin research in general.

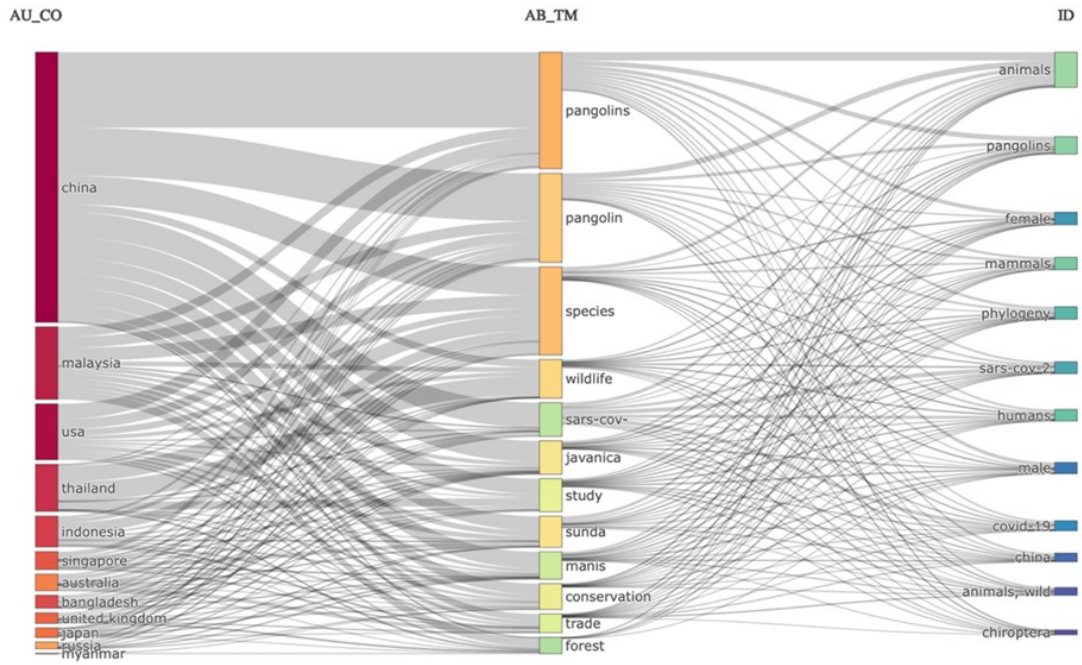

Figure 3. Three-fields plot research topics focusing on Sunda pangolins from 15 recorded countries.

3.1.2. Global Research Themes and Their Strength

Globally, Sunda pangolin research is dominated by ecological conservation (n = 511), followed by illegal trade (n = 373) and breeding (n = 326). During the COVID-19 pandemic, the topic of pangolins as potential intermediary hosts of SARS-CoV-2 emerged as a new Motor Theme. Figure 4 classifies the literature into four quadrants—motor themes, niche themes, basic themes, and emerging/declining themes—reflecting differences in centrality and density. Niche themes include specialized subjects such as molecular analysis and husbandry techniques, while motor themes encompass topics that are both well-developed and influential in shaping the broader field. Although Figure 4 does not categorize themes by country, comparison with the Indonesian subset indicates that Indonesia's publications fall primarily within trade-related and rescue-center themes, with no representation in global motor themes such as molecular diagnostics, zoonotic investigations, or captive-breeding technologies. This underscores a thematic gap between Indonesia's contributions and the global research directions currently driving the field.

3.1.3. Thematic Evolution Across Time

The thematic evolution analysis shows that global Sunda pangolin research maintained relatively stable core themes across periods, although specialization increased after 2018. Themes such as "illegal trade," "Southeast Asia," "captive breeding," and "camera traps" became more prominent, reflecting the diversification of methods and analytical focus. Between 2020 and 2023, general themes re-emerged, suggesting a broadening but less focused direction in the literature. Indonesia shows limited movement across these thematic shifts and remains concentrated on enforcement-related issues throughout all periods. This indicates that Indonesia has not yet aligned with the global trend toward increasingly specialized or multidisciplinary research domains that have emerged since 2018.

3.1.4. Synthesis and Implications for Range-state Participation

The global patterns presented in Figures 2–5 show that although Sunda pangolin publications have increased steadily, contributions from range states—particularly Indonesia—remain comparatively limited. This aligns with broader structural constraints faced by conservation practitioners, including limited institutional incentives for publishing, restricted access to international literature, and a strong emphasis on operational fieldwork rather than scientific dissemination. Many recurring issues related to

pangolin trade, rescue, and enforcement have also been well established in previous studies, which may reduce perceived novelty and further diminish motivation to generate new research outputs.

The dominance of China in Sunda pangolin research, even though this country is not a habitat for the Sunda pangolin, can be understood in the context of its socio-economic and cultural factors. As a major importer and primary destination for illegal pangolin trade, China has a strong scientific interest in understanding pangolin biology, trade dynamics, and disease risks. This is reflected in the breadth of Chinese contributions, including intensive captive-breeding research and comparative genomics involving *Manis pentadactyla* and *Manis javanica* [37][38]. Historical use of pangolins in Traditional Chinese Medicine [16][39][40], despite the subsequent removal of pangolin scales from official pharmacopeia [41], has also supported sustained scientific attention. These patterns suggest substantial financial and institutional investment, enabling Chinese researchers to contribute to Motor Themes and technically advanced research clusters evident in Figures 3 and 4.

In addition to China, high-income non-range countries such as the United States and Australia also appear prominently in the global literature, largely through strong research infrastructure, advanced analytical capacity, and international co-authorship networks. Their participation contributes to methodological innovations in areas such as molecular ecology, disease diagnostics, and wildlife forensics, further widening the thematic distance between global research developments and the narrower, enforcement-oriented focus observed in Indonesia. Overall, these findings highlight a structural gap between global research trajectories—characterized by multidisciplinary growth and increasing specialization—and Indonesia's more limited thematic engagement as a key range state. This gap underscores the importance of examining Indonesia's specific contribution in greater detail. Section 3.2 therefore explores Indonesia's publication scale, thematic focus, and collaboration patterns to clarify its role within the global research landscape and identify critical opportunities for strengthening national

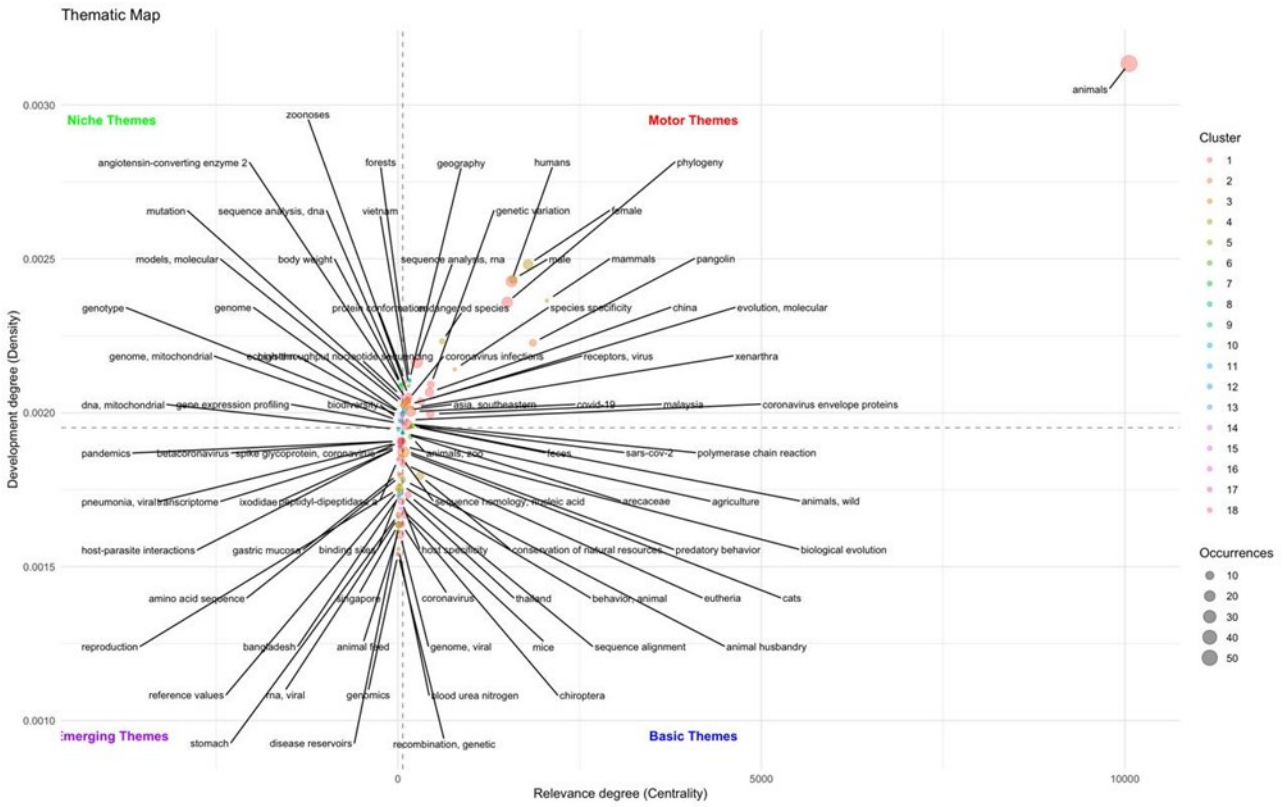

Figure 4. Distribution of developing research themes about pangolin in general and their power in encouraging the birth of related relevant themes or topics.

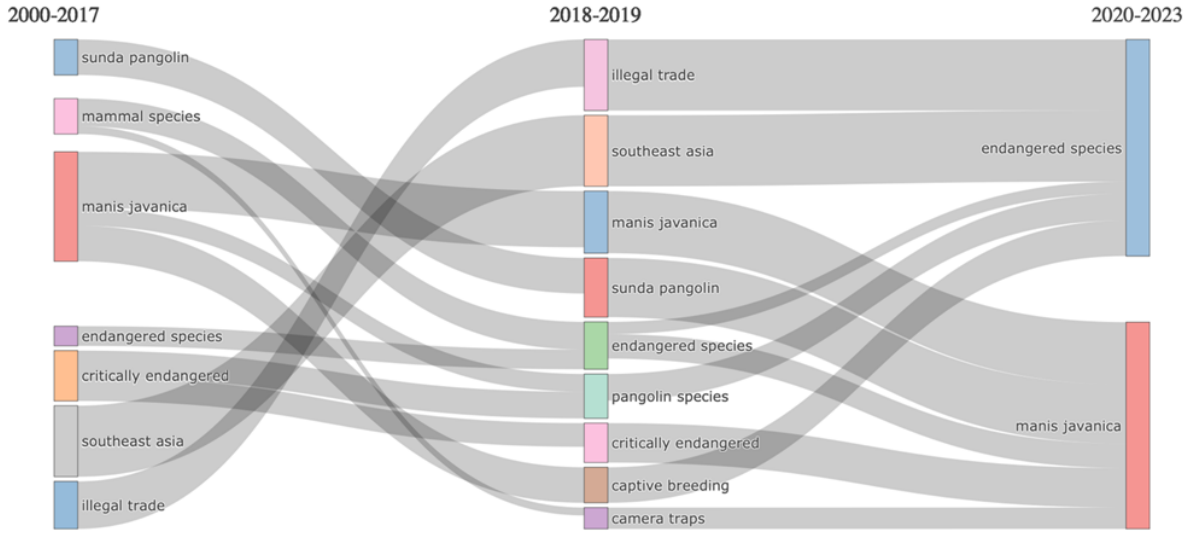

Figure 5. Thematic evolution of the research topic.

participation in Sunda pangolin conservation research.

3.2. Indonesian Scientific Contribution and Collaboration in Sunda Pangolin Research

A content analysis of the 37 Indonesia-related articles—from the refined corpus of 130 publications—revealed that although the number of Indonesian publications is still relatively limited, the thematic diversity is relatively broad and reflects multi-dimensional efforts to understand *Manis javanica*. As shown in Table 3, Indonesian researchers work across twelve key themes, including: taxonomic and morphological studies, habitat characteristics, nest structure, geographic distribution and landscape utilisation, conservation and trade status, behavior in nature and captivity, captive feeding; *in-situ* and *ex-situ* conservation strategies, genetic and molecular approaches, and exploration of local knowledge and traditional practices.

One important finding from Indonesia is the emergence of several molecular studies showing that pangolins confiscated in one location can come from different populations in Java, Borneo, and Sumatra [69]–[73]. These results highlight the high complexity of pangolin supply chains in the illegal trade and underscore the urgency of genetic mapping to support conservation forensics. Habitat-related findings also show that Sunda pangolins occupy highly fragmented environments, ranging from primary and secondary forests to shrubs and various forms of monocultures and mixed gardens [50]–[56].

On the policy side, Indonesia has formally protected pangolins under Law No. 5 of 1990 and Regulation of the Minister of Environment and Forestry No. P.20/Menlhk/Setjen/Kum.1/6/2018, which was previously regulated in Government Regulation No. 7 of 1999. Indonesia's national policy also states that this species has been removed from the "Kuota Tangkap" list issued [9][57]–[60]. However, there is no specific technical framework available to support the effective management of pangolin populations at the site level. However, a specific technical framework to support effective population management at the site level is still absent, contrasting with countries such as Malaysia, China, and Nigeria that have adopted more specific legal instruments for pangolin conservation [3][15][77][78]. Biblioshiny's edge betweenness collaboration network (Figure 6) shows that 43 countries collaborate in Sunda pangolin research. Indonesia appears among the nine countries with the highest collaboration intensity, clustered with China, the United States, Australia, Singapore, Malaysia, the United Kingdom, Zimbabwe, and South Africa.

Proximity centrality indicates that these nine countries serve as core connectors in the global research network. Indonesia's presence on the same "red line" cluster as China indicates a relatively strong networking position despite limited publication output. However, the overall rate of

multi-country publications (MCP) remains low globally (33.08%, Table 1). Figure 7 shows that China frequently publishes in single-country mode, while Australia and Indonesia exhibit proportionally higher collaboration intensity, suggesting openness to cross-national cooperation. Despite this, the potential for deeper Indonesian collaboration—particularly in methodology transfer, genetic labs, data sharing, and long-term ecological monitoring—remains underutilised.

3.3. Knowledge Gaps and Future Research Directions

The management of endangered wildlife species such as the Sunda pangolin is inherently complex and requires contextual, adaptive, and locally responsive strategies [79]. In this context, scientific collaboration is not only a means to share data but also a tool to create collective learning across countries and disciplines [80][81]. In this study, bibliometric patterns show that Indonesia's contribution to global Sunda pangolin knowledge

Table 3. Grouping of key issues regarding the Sunda pangolin studied and published by Indonesian researchers to support their conservation.

No.	Key issues	Author and time of publication
1.	Taxonomy, morphology and anatomy	Nisa' et al. 2010 [42]; Akmal et al. 2014 [43]; Nisa et al. 2015 [44]; and Setiadi et al. 2017 [45]
2.	Morphometrics and meristics	Takandjandji & Sawitri 2016 [5]; Akmal et al. 2014 [43]; and Novriyanti & Takandjandji 2022 [46]
3.	Common habitat characteristics	Manshur et al. 2015 [47]; and Kuswanda & Setyawati 2016 [48]
4.	Nest characteristics	Withaningsih et al. 2018 [49]
5.	Natural distribution (geographic range; landscape utilisation) including other animal diversity	Withaningsih et al. 2021 [50]; Radinal et al. 2019 [51]; Anasari et al. 2021 [52]; Weiskopf et al. 2019 [53]; Allen et al. 2020 [54]; Husodo et al. 2019 [55]; Husodo et al. 2019 [56];
6.	Conservation and trade status	Semiadi et al. 2009 [9]; Sopyan 2008 [57]; Takandjandji & Sawitri 2016 [58]; Rachmad et al. 2021 [59]; Andini & Purnaweni 2019 [60]
7.	Daily behaviour and activities (in nature)	Manshur et al. 2015 [47]
8.	Daily behaviour and activities (in captivity)	Khairunnisa & Yuono 2022 [61]; Masy'ud et al. 2011 [62]; Sawitri et al. 2012 [63]
9.	Captive feeding and consumption	Rianti & Takandjandji 2019 [64]; Rianti et al. 2017 [65]
10.	Exitu and insitu conservation strategies	Kuswanda & Onrizal 2018 [66]; Novriyanti et al. 2016 [67]; Novriyanti et al. 2016 [68]
11.	Genetic diversity and molecular approaches	Sawitri & Takandjandji 2011 [69]; Sawitri et al. 2014 [70]; Zein 2020 [71]; Wirdateti & Semiadi 2017 [72]; Wirdateti et al. 2022 [73]
12.	Local wisdom, indigenous knowledge and traditional utilisation	Novriyanti et al. 2016 [67]; Masy'ud et al. 2020 [74]; Novriyanti et al. 2014 [75]; Mardiastuti et al. 2021 [76]

remains small—only 37 relevant articles—and is concentrated within descriptive, enforcement-related, and site-specific themes. These limitations reflect broader structural barriers affecting scientific productivity, including unequal distribution of scientific and technological capacity [82][83], dependency on dominant scientific powerhouses [84], and fragmented institutional capacity in conservation governance [85].

Based on the analysis, several knowledge gaps become evident in the Indonesian context. First, there remains limited data on the distribution, population, and behavior of Sunda pangolins in natural habitats. Most studies are short-term and spatially restricted. Second, long-term and standardised ecological research is lacking, constraining the ability to compare population dynamics across regions and years. Third, molecular and genetic studies are still insufficient, even though existing studies [69]–[73] indicate that confiscated pangolins originate from genetically distinct populations scattered across Java, Borneo, and Sumatra. Fourth, although several studies recognise the importance of local and indigenous knowledge [67][74]–[76], such knowledge has not yet been formally integrated into conservation planning frameworks. This aligns with global findings that emphasise the importance of community engagement and value-based conservation [86]-[89]. Fifth, Indonesia lacks a national open-access information system for Sunda pangolin data, hindering evidence-based policy development. Sixth, although Indonesia has established strong legal protection under Law No. 5/1990, PP No. 7/1999, and MoEF Regulation P.20/2018, there is still no technical population management framework. This contrasts with countries such as Malaysia—which implements incentive/disincentive approaches—and China, where pangolins are assigned the highest national protection status [3][77]. Nigeria has also strengthened enforcement since 2017 [15][78].

Conservation is not only a matter of science or policy, but also about the relationship between humans and nature. In many countries, local and indigenous peoples consider pangolins to be a species of high cultural value. Therefore, pangolin protection must start at the local level. At the same time, data and information must be openly accessible to strengthen the agenda-setting process in conservation policy [90][91]. Thus, Indonesia has a great opportunity to strengthen its role not only as a habitat country, but also as a knowledge producer, policy leader, and driver of pangolin conservation collaboration at the regional and global levels. To address these challenges, the study recommends several strategic research and policy directions, including: Development of ecological research and

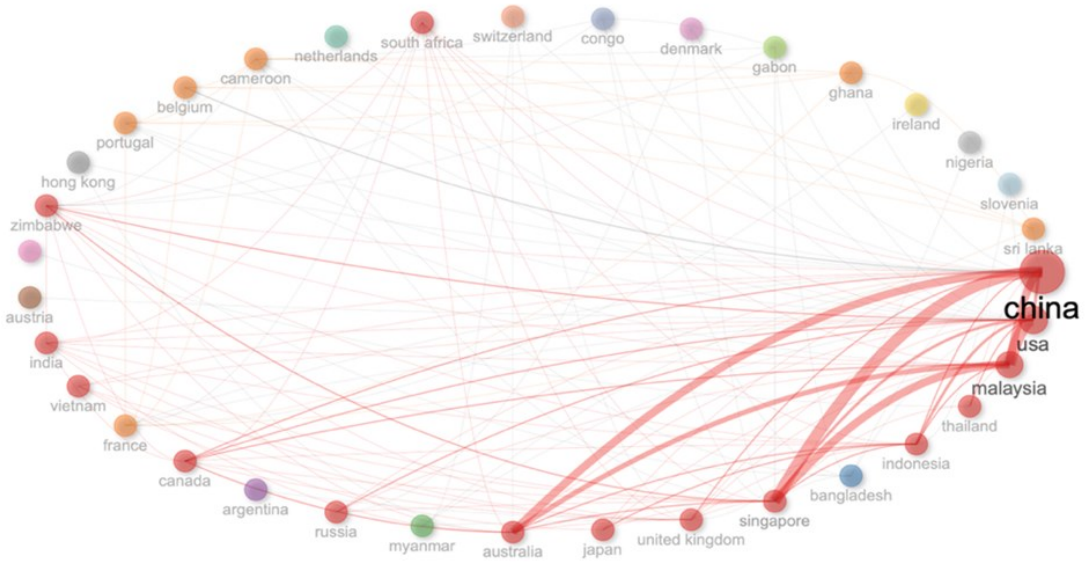

Figure 6. Country collaboration network on *Manis javanica* research topic. The node's size indicates the number of publications, while the line's thickness indicates the strength of the relationship or collaboration between countries.

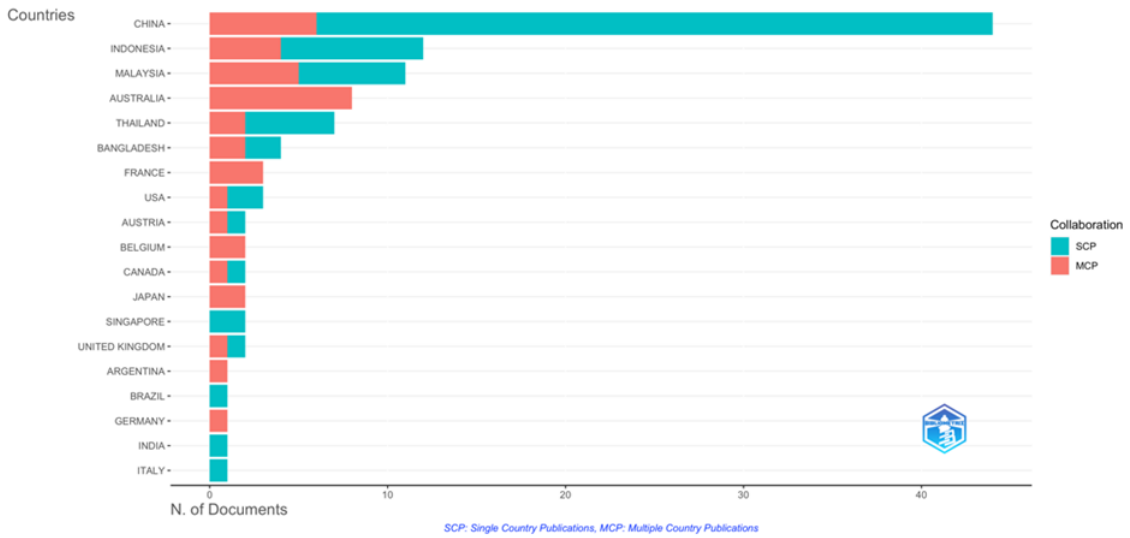

Figure 7. Number of co-authorships. Collaboration types are categorised by Single Country Publications (SCP) and Multiple Country Publications (MCP).

location-based distribution to strengthen basic conservation data; Genetic and molecular studies to support ex-situ conservation, population recovery, and mapping of illegal trade routes; Interdisciplinary research involving social, economic, legal, and cultural sciences to support more holistic policies; Integration of local knowledge and community wisdom into conservation strategies, especially in areas that are the main habitats; construction of an open and integrated national database for Sundanese pangolin; and strengthening international collaboration that is not only technical but also strategic and equitable.

4. CONCLUSIONS

The combined bibliometric and content analysis yields three critical findings for policymakers, Indonesia's scientific contribution is critically low (0.83%); Research is driven largely by international authors, signaling limited local leadership and suboptimal collaboration; and Persistent knowledge gaps remain in ecological genetics and field distribution data. Addressing these shortcomings requires immediate, practical action. We recommend establishing an open national research database, initiating long-term collaborative programs for capacity building, and integrating local ecological knowledge to align research efforts with the National Conservation Strategy and wildlife law enforcement needs.

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Author Contributions

N. N. conceived and designed the experiments, then performed the literature review and analyzed the data; B. M., R. S., and D. B. wrote insights after the data; All authors wrote the paper and made the discussion overall together.

Conflicts of Interest

The authors declare no conflicts of interest. Interpretation of the research results has no influence from any party, either the funding sponsor or the institution, as written in the acknowledgement.

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE MANUSCRIPT PREPARATION

While preparing this work, N. N. integrated at least three types of AI to refine English grammar and edit sentences more effectively: Gemini, ChatGPT, and DeepSeek. The results generated by the AI tools were reviewed by the author members (three other members), and all authors are solely responsible for the publication content.

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