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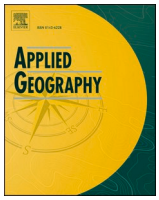

Quantifying illegal rosewood trade, seizures and forestry law enforcement in Indonesia

Vincent Nijman [a,*], Jessica Chavez [a,b], Devon Simons [a], Penthai Siriwat [a], Ratna Ayu Widiaswari [c], Magdalena S. Svensson [a,d]

[a] Oxford Wildlife Trade Research Group, Department of Anthropology and Geography, Oxford Brookes University, Oxford, OX3 0BP, UK
[b] School of Biological and Medical Sciences, Oxford Brookes University, Oxford, OX3 0BP, UK
[c] Faculty of Law, Universitas Warmadewa, Denpasar, Bali, Indonesia
[d] Botanic Gardens Conservation International – Global, Descanso House, 199 Kew Road, Richmond, TW9 3BW, UK

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ABSTRACT

Patterns of illicit trafficking networks can be explained by economic, geographic and environmental factors, and has clear implications for forest management. Rosewood is one of the most valuable taxa in the illegal wildlife trade. We focus on its illegal trade in Indonesia. Here, rosewood is not a protected species, but logging is prohibited in protected areas, logging and transportation of rosewood requires permits, and its international trade is subject to CITES regulations. Using seizure data from 2021 to 2023, we test factors explaining seizure patterns at regency level and conduct a baseline analysis of those arrested and the arresting authorities. Seizures (46, for a total of 4302 logs) occurred throughout southern Indonesia, and seizure activity remained constant over time. Regency size, human population, and purchasing power did not correlate with seizure data, but seizures were positively related to the absolute amount and the percentage of forest present in regencies. A third of logs seized came from state-managed or protected forests. Seizures were carried out by the police (23% in collaboration with other authorities; mean seizure of 85 logs), by forestry officers (45% collaboration; mean 138 logs) and by the army (83% collaboration; mean 245 logs). Violation of forestry and job creation laws, and lack of transport documents were the main reasons for arrests. Number of suspects arrested was unrelated to number of logs seized. Successful prosecution was documented for 21–28% of cases, with an average sentencing of 2 years imprisonment and fines of US$29,000. We show that seizure data can be used to provide a first quantitative assessment of rosewood criminal networks and how this links to forest presence and management. While the end destination for much of Indonesia's rosewood is China, our results support the argument that the rosewood trade network in Indonesia is domestically organized rather than internationally orchestrated, and solutions have to be found within Indonesia's forestry policies and regulations.

1. Introduction

Timber is one of the most traded items of wildlife (Brack, 2003; Dudley et al., 2014) and in terms of monetary value, in 2019, the legal timber trade was valued at ~ US$244 billion year^{-1}, with fisheries coming second at ~ US$151 billion year^{-1} (Nijman, 2021). In addition to the legal trade there is a consistent and persistent trade in illegally acquired timber or trade in timber without the required documentation, especially originating from tropical regions (Brack, 2003). Over the last decade, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has increased its attention on the regulation of international commercial trade in high-value (tropical) hardwood species (Reeve, 2015; Schloenhardt, 2008; Waeber et al., 2023) as to ensure legal and sustainable tropical timber trade.

The term rosewood is used to designate several hundred species of tropical hardwood timber, found across tropical and subtropical America, Africa and Asia. A subgroup of rosewoods known as hongmu (also spelled as hong mu, hóng mù, 红木, meaning red wood) is used to produce high-quality furniture, flooring and handicrafts. Under China's National Hongmu Standard, 29 species are officially designated as hongmu, 15 of which belong to the genus *Dalbergia*. Within China, the Hongmu Standard can be legally enforced concerning any marketing

* Corresponding author.
E-mail address: vnijman@brookes.ac.uk (V. Nijman).

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claims. As such, the Standard is an important economic tool in the manufacturing, investment, and utilisation of rosewood. A preference for hongmu has a long history in China, and as early as the Ming Dynasty (1368–1644) rosewood was a symbol of social standing (Zhu, 2022). With the recent return of Chinese traditional culture and with a rapidly growing wealthy middle-class elite, the global demand for rosewood has increased. This has led to significant declines in rosewood supply, and subsequent increases in legal protection and regulations of some of the most valuable rosewood species within their respective native ranges (Arunkumar et al., 2021; Atikah et al., 2021; Baidoo et al., 2023; Dumenu, 2019; Innes, 2010; Siriwat & Nijman, 2018ab; UNODC, 2020; Zhu, 2022). With a mismatch between supply and demand, rosewood thus has become the most valuable trafficked wildlife commodity globally (Baidoo et al., 2023; Ding & Yin, 2024; Dumenu, 2019; EIA, 2016; Ke & Zhi, 2017; Nijman et al., 2022; Schuurman & Lowry, 2009; Treanor, 2015; Waeber et al., 2023). Between 2005 and 2014, the UN Office for Drugs and Crime calculated that rosewood made up 35% of the monetary value of seized wildlife, i.e., more than the monetary value of elephants ('ivory'), rhinoceros ('horn'), pangolins, big cats, sturgeons ('caviar') and marine and freshwater turtles combined (UNODC, 2016). Aiming to regulate international trade in rosewoods and to curb illegal international trade, in 2016 all ~300 species of *Dalbergia* rosewoods were included in Appendix II of CITES. Appendix II listing became effective on January 4, 2017. With an already high demand for rosewood, trade limitation measures led to highly dynamic shifts in supply and demand for rosewood. The investment demand for rosewood encouraged speculative rosewood trade (Zhu, 2020). This has led to large, consecutive, price bubbles (the sustained rise in the price of an asset above its normal market value because of expectations of future increases in the price of the asset) (Ding & Yin, 2024), putting even more pressure on the remaining stocks of rosewood trees.

One of the 29 hongmu species is Indian rosewood *Dalbergia latifolia*, a species that is found naturally in India, Nepal, Bangladesh (possibly western Myanmar) and parts of western Indonesia (Arunkumar et al., 2021; BGCI, 2024; Lakhey et al., 2020). There has been some uncertainty on whether the species is native to this part of Indonesia, but it has been present in Java at least since the 1700s, and an India-Indonesia distribution of wildlife is not uncommon (Nijman, 2024). In the timber trade, Indian rosewood is also known as East Indian rosewood (especially in North America), sitsal or Bombay blackwood (India), sonokeling (Indonesia) or Indonesia heisuanzhi (Indonesian black rosewood: China). Indian rosewood's overexploitation has led to a decline from which it is yet to recover. Taking its slow growth rate and long rotation cycles into account, it is listed as Vulnerable on the IUCN Red List (Lakhey et al., 2020) and the red list of timber trees (Hills et al. 2022). Nepal has banned the export of Indian rosewood logs and sawn timber, and neither Nepal nor Bangladesh has reported any exports of Indian rosewood to the CITES Secretariat since its inclusion in Appendix II. Under India's Forest Act (1927) the export of Indian rosewood is banned, and in the period 2018 to 2022, relatively small amounts of Indian rosewood veneer and wood products from managed plantations were exported (mean of 3598 $\pm$ 2191 m^3 $year^{-1}$). Annually, Indonesia legally exports 84,334 $\pm$ 3721 m^3 of Indian rosewood (equal to over half a million logs), 97.6% of which is imported into China (Nijman, 2024), making Indonesia the largest exporter of Indian rosewood.

In Indonesia, Indian rosewood is found in the lowlands in natural forests, including protected areas, in home gardens, planted as boundary trees or along roads, and in non-native forests and plantations. In the latter, Indian rosewood grows as monoculture stands or it is mixed with other tree species such as teak *Tectona grandis*, mahogany *Swietenia macrophylla,* and Moluccan albizia *Paraserianthes falcataria* (Yulita, Wardani, et al., 2022). Its harvest is managed largely by the Indonesian State Forestry Company (known as Perhutani) and currently, trees being harvested were planted around 50 years ago. The harvest of Indian rosewood is planned annually via a preapproved management plan, it is licenced and involves replanting trees from seeds from nurseries. However, Indian rosewood is also harvested from communal or privately owned forests or plantations, and this area of harvesting is less planned (Nijman, 2024; Yulita, Setyawati, et al., 2022). Rosewood is used domestically in the creation of handicrafts (Chavez et al., 2024) but most of it is bound for export to China (Nijman, 2024). Exports of raw logs from Indonesia were banned in 2001, but in 2017 an exemption was introduced for logs from managed plantations, thus allowing the export of Indian rosewood logs.

Recently, Nijman (2024) gave the first overview of the illegal trade in rosewood in Indonesia (based on seizure reports from 2014 to 2022) showing that over this period, the number of seizures had increased, possibly linked to the CITES-listing that came into force midway during this timeframe and that there were clear regional differences in the amount of rosewood that had been seized (large seizures in eastern part of the species' range and smaller seizures on Java). Here, we build upon this initial review, expanding the focus to more recent seizures only (2021–2023). Further insight will be detailed by first, reporting on the actors involved in this trade (arresting agencies, suspects, modus operandi), on successful prosecutions, and the legislative process that underpins the seizures and, secondly, by analysing seizures at a small administrative level (regency), establishing what geographic, environmental, and socio-economic factors differ between regencies with and regencies without rosewood seizures. We created a series of null hypothesis to test for these relationships (Table 1).

2. Methods

2.1. Data acquisition

We followed a similar methodological approach as taken by Siriwat and Nijman (2023) in investigating and quantifying the illegal rosewood trade in the Greater Mekong Region in using media sourced seizure reports. While these reports offer an alternative source of data which offers real-time information on trade (Siriwat & Nijman, 2018b), from the outset we acknowledge that media sourced seizure reports addresses the issue of rosewood trade at an intermediate stage of the supply chain; that is, the trees have been logged and often cut, thus providing no information on the logging process, and the seizure prevents us to gain insights further into the trade chain, including its export. In November 2022, February 2023, and March 2024, we collected online reports of seizures of Indian rosewood in Indonesia, using the keywords sonokeling (also written as sono keling) or Dalbergia latifolia in combination with bksda (the abbreviation of the natural resource conservation agency, responsible for forest management), gakkum (the abbreviation of the law enforcement agency under the Ministry of Environment and

Table 1
Null hypotheses on the relationship between geographical, socio-economic and natural variables and the illegal trade in Indian rosewood in Indonesia.

Hypothesis	Variables used for testing	Statistical tests
There is no change in illegal logging over time	Number of logs seized in 2021, 2022 and 2023	One-way ANOVA
Arrests and sentencing are unrelated to the seriousness of the crime	Number of logs seized, number of people arrested; length of prison sentence and amount fined	Pearson's product moment correlation coefficient.
Seizures are independent on mode of transport or of arresting agencies	Seizure size, mode of transport (motorbikes, cars, trucks), arresting agencies (policy, forestry, military)	One-way ANOVA
Geographic, economic and natural factors at regency level do not explain seizures	Regency size, population size, purchasing power, and amount of forest	Pearson's product moment correlation coefficient.
Regencies with seizures are similar to regencies without seizures	Regency size, population size, purchasing power, and amount of forest of matched regencies	t-tests

Forestry), polisi (police) or sita (seizure), for each of the years 2021, 2022, and 2023 separately (Fig. 1).

A similar search conducted in English, and consulting TRAFFIC's Wildlife Trade Portal, did not result in new reports. For most seizures, the number of logs was reported; from photographs that accompanied many of the seizure reports it was clear that this indeed consisted of raw logs (Fig. 2), sometimes with the edges sawn off to square them. We obtained data on all seizures, irrespective of size, provided that logs were indeed confiscated (thus excluding cases where merely rosewood logging had been reported). This includes the date of the seizure itself (not of the reporting of the seizure, although this could be the same), the location in terms of the nearest village or town and regency (kabupaten), and the number of rosewood logs that were confiscated (and, if available, their origin) and, in particular, if there were indications that it was taken from protected areas or the State-managed forest. In the seizure reports, suspects were normally identified by their initials and age only. Vehicle number plates gave information on where these were registered (e.g., DK number plates for Bali and BE number plates for Lampung). Seizures were made by several different agencies, including firstly the police at various levels (national, Polri, provincial Polda, city or regency Polres, and district Polsek), secondly, officers linked to the Ministry of Forestry, including forestry police (Polhut), natural resource conservation agency (BKSDA), national parks or nature reserve (taman nasional and cagar alam) and Perhutani, and thirdly, the military including the Military District Command (Komando Rayon Militer, Koramil, Komando Distrik Militer Kodim, Komando Resor Militer, Korem) and the Indonesia Armed Forces (Tentara Nasional Indonesia, TNI).

We noted what laws were mentioned in the seizure report concerning any arrests that had been made. These are the most pertinent ones: (1) Law No. 41 (1999) on Forestry which regulates the management of forests and includes conservation-oriented policies, (2) Law No. 18 (2013) on the Prevention and Eradication of Forest Destruction, which strengthens law enforcement by providing additional legal certainty and defining penalties for those engaged in forest destruction and (3) Law No. 11 (2020), Law No. 2 (2022) and Law No. 6 (2023) on Job Creation (also known as the Omnibus Law); these three laws advocate administrative sanctions to address destructive forest activities including small-scale activities conducted by people living in or around the forest area where the logging tool place.

In March 2024, 4 months after the last seizure was made in 2023 (on 20 November), we searched the Directory of Decisions of the Supreme Court of the Republic of Indonesia (Mahkamah Agung Republik

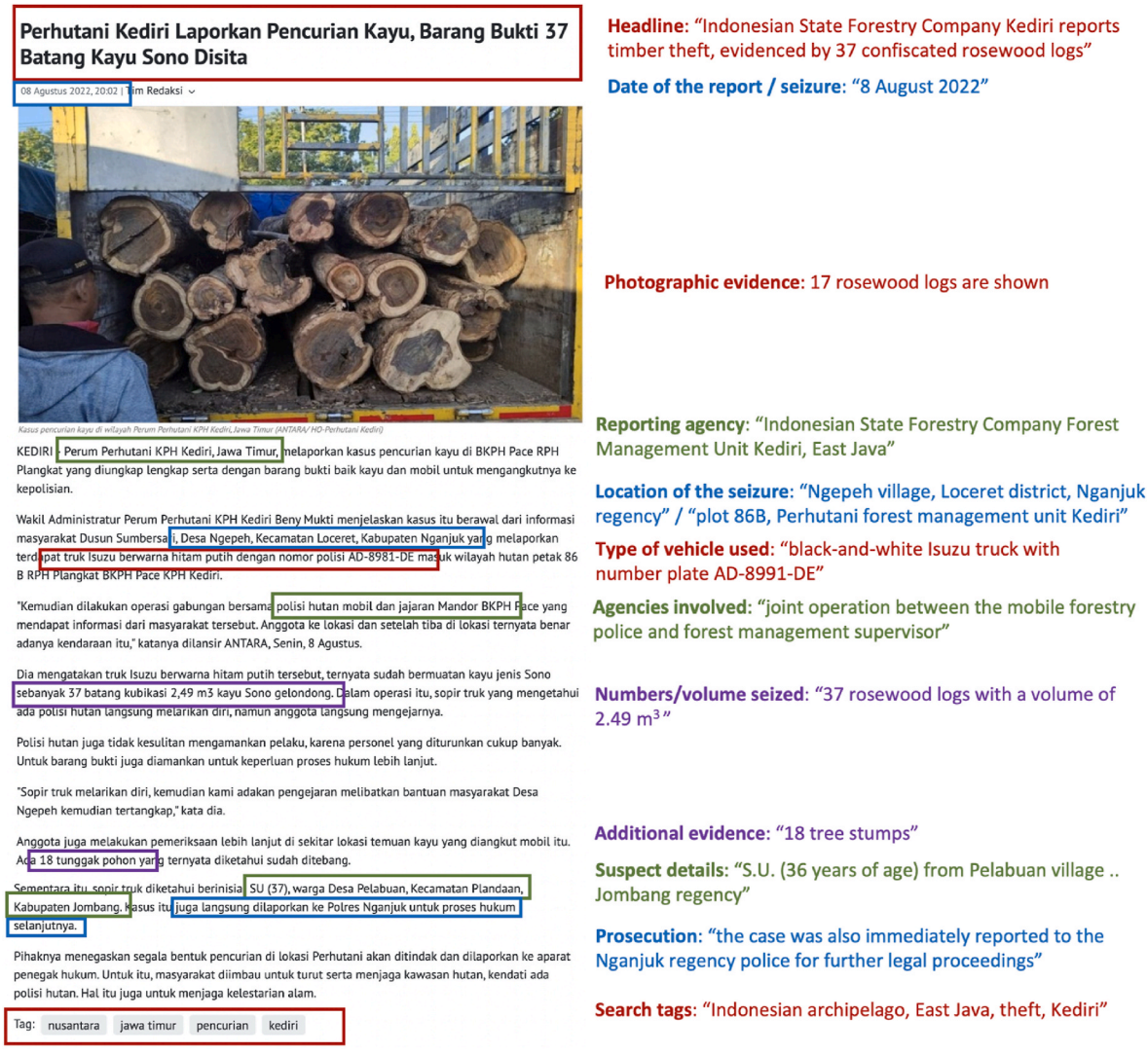

Fig. 1. Example of a screenshot of news showing the boilerplate format of a news article. Each news article usually contains information on the agencies involved, the number of logs seized, geographic location, if it originated from State-managed forest or protected areas, suspect information, laws under which a suspect will be charged, and photographic evidence. Number plates are habitually given and provide information on where the vehicle is registered (AD number plates are from the province of Central Java, whereas the seizure was made in East Java).

Indonesia) for successful prosecutions of offenders involved in the rosewood trade. We restricted this to convictions linked to seizures in 2021–2023 where rosewood was indeed seized. The mean time between the arrest of a suspect and a conviction was about six months, and we expect that most, but certainly not all, court cases following arrests made in 2023 (or earlier) were completed at the time of our search.

For each of the 31 regencies where seizures had been made, we obtained data on human population size (2020), area (in km^2) and total forest cover (in hectares, converted to km^2) from the Indonesian Statistical Agency (BPS, 2024). For each regency, we also obtained the government-recommended monthly minimum wage for 2024 (in Indonesian rupiah). Using an online randomiser, we then picked 32 regencies within the range of Indian rosewood (i.e., from the province of South Sumatra in the west to West Timor in the east) and we obtained the same data as for the regencies where seizures were made.

2.2. Data preparation, conversions and statistical analysis

Each first report of a seizure led to an entry in a database; subsequent media reports, either published the following days or at later stages, for instance when the suspects were brought in front of a judge or when law enforcement agencies released new statistics, allowed for adding additional information. For those seizures that led to successful prosecutions the court documents often provided new, hitherto unreleased contextual information. As a result of this, and because of the temporal and spatial spacing of seizures, each seizure was unique and easily identifiable. Double counting (whereby the same seizure is considered twice) was not deemed a problem.

Values given in the Indonesian rupiah were converted to the US dollar, using a March 2024 conversion rate of 15,880 rupiah to the dollar. We subtracted one year from each suspect's age, as in Indonesia it is custom to give your age as the age you will become that year, which is one year more than what is custom in Western societies. We obtained the age distribution for Indonesia (in 5-year bins) for 2023 from the CIA World Factbook (CIA, 2024). From the regency's human population size, area, and total forest cover, we calculated human population density and percentage of forest cover for each regency. Most of the data was not normally distributed. We used log-transformations and arcsine transformations for the data to approach a normal distribution, and we tested for an equal variance allowing us to use parametric statistics. We used one-way ANOVAs followed by post hoc Tukey's tests for honest difference to test for differences in seizure size between years and between modes of transport; unpaired t-tests to observe any differences between regencies with and without seizures; Pearson's product-moment correlations to test for relationships between the number of logs seized in each regency and regency specific characteristics and seizure size and number of suspects being arrested; chi-square tests to test whether certain age groups were more prone to be arrested (with expected values generated based on country-wide age distribution for men). Throughout we present means ± one standard error of the mean, and we used the Social Science Statistics software accepting significance when $P < 0.050$ in a two-tailed test.

3. Results

3.1. Sex and age of offenders, type of vehicles used, number of arrests if arrests are made

We found 47 seizures of rosewood for a total of 4321 logs, with no difference in the number of logs seized per year (2021: 1521 logs, 89.5 ± 37.9 logs $seizure^{-1}$; 2022: 1310 logs, 68.9 ± 42.4 logs $seizure^{-1}$; 2023: 1480 logs, 147.1 ± 91.3 logs $seizure^{-1}$) (one-way ANOVA $F_{2,43} = 0.719$, $P = 0.493$). When arrests were made, larger seizures did not lead to more arrests (Pearson's product-moment correlation $R = 0.148$, $P = 0.427$); 34 of the 47 seizures led to the arrest of suspects and 70 arrests were made (range 1–6 suspects per seizure). All arrests were men and all of them were Indonesian (i.e., none was singled out as a foreign national). For 60 men the age was given (mean age of 37.3 years, range 16–61 years), with 65% of them being between the ages of 30 and 50 years. Compared to the male population in Indonesia as of 2020, the ages of the men arrested showed a different distribution ($\chi^2 = 13.89$, df = 1, $P = 0.0002$) (Fig. 2). Few young men were arrested based on their number in Indonesia (two arrested, ages 16 and 17), but this did not differ significantly from what was expected ($\chi^2 = 3.82$, df = 1, $P = 0.051$). The largest gap was for men between the ages of 40 and 49 years, with 22 arrests where 13.6 were expected ($\chi^2 = 6.88$, $P = 0.009$).

A range of vehicles were used to transport the illegally logged rosewood; twice modified motorbikes were used, cars three times, pickup trucks ten times and trucks 17 times. The number of logs that were seized differed significantly between motorbikes and cars (12.6 ± 3.7 logs $seizure^{-1}$), pickup trucks (20.7 ± 6.8 logs $seizure^{-1}$) and trucks (166 ± 71.6 logs $seizure^{-1}$) (one-way ANOVA, $F2,28 = 9.24$, $P = 0.0008$). Post-hoc Tukey Honestly Significant Difference tests show that the difference between trucks and motorbikes/cars ($Q = 4.91$, $P = 0.005$) and trucks and pickup trucks ($Q = 4.17$, $P = 0.017$) is significant but not between motorbikes/cars and pickup trucks ($Q = 0.13$, $P = 0.862$).

3.2. Who makes the arrest and what organisations cooperate

Most of the seizures were made by the police, followed by the forestry officers and forestry police, and lastly by the military (Table 2); in terms of collaboration, 23% of the actions involving the police also involved one or more other agencies, for forestry this was 45% and for the military 83%. Seizures involving the police (84.5 ± 37.2 logs $seizure^{-1}$) were smaller than those involving the forestry department (138.1 ± 56.0 logs $seizure^{-1}$) and these were smaller than those where the military was involved (245.8 ± 157.3 logs $seizure^{-1}$), but none of these differences were statistically significant (one way ANOVA: $F_{2,45} = 0.421$, $P = 0.659$).

From the seizure reports and especially from the court documents, it is clear that both the police and especially the forestry police (not being part of the National Police but of the Ministry of Environment and Forestry) took the lead in instigating the seizures and, for a restricted number of cases, passing it on to the prosecutor's agencies. The role of the military appears to be supportive, especially in those cases where large quantities of rosewood were involved, whereas the forestry police

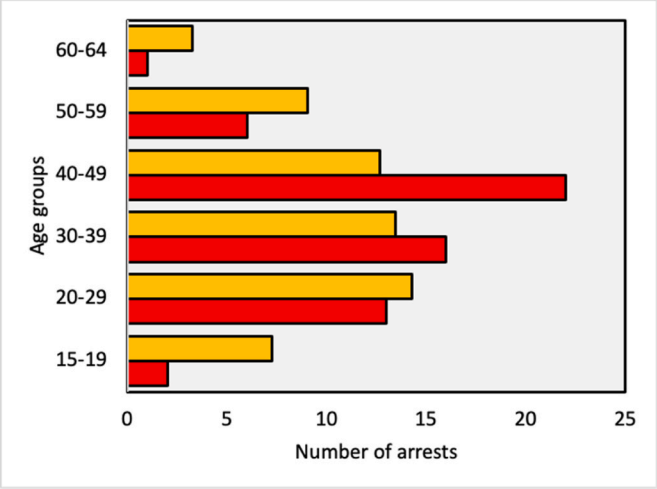

Fig. 2. Age distribution of 60 men arrested in the illegal trade of Indian rosewood *Dalbergia latifolia* (red bars) compared with the age distribution of men in Indonesia (orange); only the difference in the 40–49 years age group is statistically significant. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

were the central actor (Table 2).

3.3. What laws are invoked and where does logging take place

In the seizure reports, Law No. 18 on the Prevention and Eradication of Forest Destruction was referenced 13 times, Law No 11/2 on Job Creation was referenced four times, and three times a lack of either a People's Timber Transport Letter (indicating species, volume, source and destination), a Document of Domestic Transport of Wild Plants and Animals (needed for all CITES-listed species) or both were referenced. In addition, once reference was made to Indonesia's Criminal Code (1915; the new Criminal Code of 2022 will come into effect in 2026) and once to a Decree of the Minister of Forestry (no 447/Kpts-II/2003) concerning the collection of wild animals and plants.

For 12 seizures (involving 865 logs or 20.3% of the total number of logs seized) it was indicated that the rosewood was illegally logged from protected areas: six times from a national park (taman nasional), three times from a protected forest (hutan lindung), once from a strict nature reserve (cagar alam), once from a wildlife reserve (suaka margasatwa) and once from a greater forestry park (taman hutan raya). For another 13 seizures (651 logs or 15.2%) the rosewood was allegedly taken from a State-managed forest (Perhutani).

3.4. Prosecutions and lack of ecological insights by the courts

We found nine cases where there was a successful prosecution of a total of 13 suspects (one deceased at the time of the conviction) because of their involvement in the rosewood trade. One case, involving the seizure of 693 rosewood logs and the arrest of the truck driver, led to an acquittal and a return of the logs to the owner (who himself was not charged or arrested). All these cases were picked up in our earlier search. In all ten cases one or more branches of the forestry department were mentioned in the court documents as being involved in the seizures and arrests, clearly indicating their leading role in successful prosecutions (the military was not mentioned, thus underscoring their role as supporting only during the seizure operation).

The time between arrest and conviction was 6.3 ± 2.2 months, with the longest lasting 13.4 and 19.1 months. All 12 men received a prison sentence, of a duration of 2.0 ± 0.3 years. The lowest prison sentence was seven months whereas the highest was 3.5 years. In addition, all but one (a driver of a truck carrying illegally logged rosewood) had to pay a fine of on average US$29,769 ± 4579 (range US$12,594 to US$62,972). The number of rosewood logs that were confiscated (mean 331 ± 196 logs) was not related to the length of the prison sentence ($R = 0.156$, $P = 0.628$) nor the size of the fine ($R = -0.550$, $P = 0.080$). Of the 47 cases 10 were resolved in the courts, and taking the time between arrest and completion of the court proceedings into account, we can expect that up to three additional cases from 2023 can be resolved. This thus means a prosecution rate of between 21 and 28% in terms of cases, and 20–27% in terms of suspects that according to the seizure reports were arrested.

In the prosecution reports it was mentioned if rosewood had been logged from managed forest or protected areas, but the negative effects this illegal logging has on the ecology or integrity of the forests was never flagged up. Indian rosewood are slow growing trees; the legal harvest of Indian rosewood by in State-managed forests (by Perhutani) targets trees that were planted 50 or more years ago, suggesting the illegal loggers target similar aged trees, but neither the slow growth rate nor the age of the trees was mentioned in the court cases.

Table 2
Seizures by police, forestry and military and their collaborative efforts and the number of logs seized by the different agencies.

	Police	Forestry	Military	Total seizures	Mean log seizure^{-1}
Police	21	5	1	27	84.5 ± 37.2
Forestry		5	4	20	138.1 ± 56.0
Military			1	6	245.8 ± 157.3

3.5. Socio-economic and geographical correlates of seizures

Seizures were made in 31 regencies covering most of the species' geographic range within Indonesia including the island of Sumatra (six regencies), Java (19 regencies), Bali (two regencies), Lombok (two regencies) and Sumbawa (two regencies) (Fig. 3). At the regency level, the number of logs that were confiscated was not correlated with human population size (Pearson's product-moment correlation $R = -0.077$, $P = 0.684$), human population density ($R = -0.037$, $P = 0.844$), regency size ($R = -0.012$, $P = 0.952$), regency's purchasing power ($R = 0.032$, $P = 0.868$), forest area ($R = -0.012$, $P = 0.950$) nor forest cover ($R = 0.052$, $P = 0.773$).

When comparing the 31 regencies where seizures were made with 32 regencies where no seizures were made, there were no statistical differences in terms of human population, population density, or size of the regencies (Table 3).

The purchasing power of people in regencies with seizures (as measured by its minimum wage) was significantly lower than in regencies where no seizures were made. Regencies with seizures had significantly more forest, both in absolute terms and as a percentage of the regency's total area, than regencies where no seizures were made (Table 3).

4. Discussion

4.1. General overview of findings

Gaisberger et al. (2022) conducted an Asia-wide assessment of the vulnerability of 63 socio-economically important tree species to over-exploitation, fire, overgrazing, habitat conversion and climate change and found that Indian rosewood ranked third in terms of these combined threats, necessitating the need for proper protection and management. This is equally true in the mainland part of its distribution range as it is in Indonesia. Arguably one of the greatest limitations in our efforts for assessments of trade sustainability is specific information on species' populations, or indeed accurate data on many of the species involved in either domestic or international trade, as indeed these are largely lacking for Indian rosewood in Indonesia (Atikah et al., 2021; Yulita et al., 2022). The data requirements to assess off-take in 'managed' settings, such as is the case for Indian rosewood in Indonesia, varies from straightforward to complex (Hughes et al., 2023). International trade can only be sustainable if offtakes at the domestic level are sustainable, so some oversight of national harvest levels is necessary (Sutherland, 2001) and incorporating all other threats to the targeted species is indispensable.

There is only limited evidence that the legal hardwood timber trade is sustainable (Houghton & Naughton, 2017; Hughes et al., 2023; Liu et al., 2020) and several initiatives have been launched to promote the sustainable trade of various species (Li & Chen, 2015). This includes domestic and regional legislative bans on certain trades (Brack, 2010; Dumenu, 2019; Maria-Sube & Woodgate, 2019), forest certification systems to track the legality of forest products along the supply chain (Gutierrez Garzon et al., 2020; Lawson & MacFaul, 2010), legality verification (Arts et al., 2021; Li & Chen, 2015) and global initiatives such as the Forest Law Enforcement Governance and Trade (FLEGT) action plan implemented to curb illegally sourced timber in markets by improving existing legislation in source countries whilst pushing consumer countries to heavily scrutinize imports (Cashore & Stone, 2012; Rougieux & Jonsson, 2021). In recent years CITES has become an important tool to regulate and monitor the international trade in selected hardwood species, including all species of *Dalbergia* rosewood.

In terms of the hypotheses we tested, we did not detect any changes over time in terms of the number of logs that were seized, and larger seizures did not lead to more arrests or harsher sentencing. While the

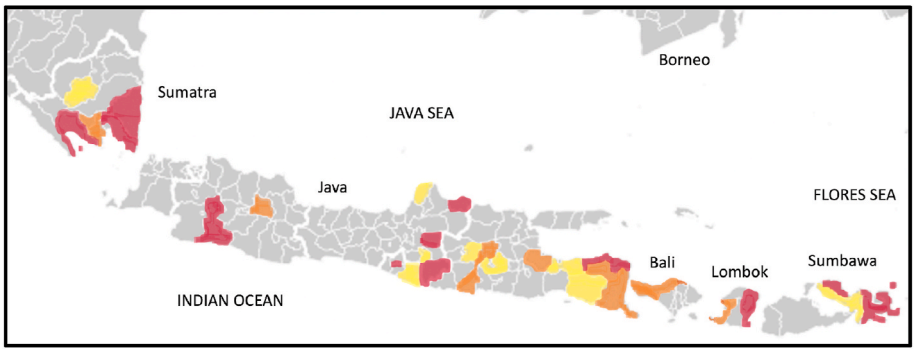

Fig. 3. Seizures of rosewood in Indonesia over the period 2021–2023 by regency. Grey: no seizures; Yellow: seizures of between 3 and 12 logs; Orange: seizures of between 22 and 50 logs; Red: seizures of between 62 and 951 logs. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 3
Differences between regencies where rosewood was seized over the period 2021–2023 (n = 31) and where it was not (n = 32), all within the natural range of rosewood in Indonesia. Presented are means ± sem, and t-tests were performed on log-transformed or arc-sin transformed data.

Indicator	Seizures	No Seizures	t-value	P-value
Human population (million)	1.005 ± 0.104	1.184 ± 0.178	0.289	0.774
Human population density (people km^{-2})	1001 ± 363	939 ± 154	0.227	0.822
Minimum monthly wage (US$ month^{-1})	159.0 ± 3.9	198.4 ± 10.9	−3.231	0.002
Area (km^2)	1980 ± 264	1801 ± 230	−0.017	0.987
Forest area (km^2)	635 ± 106	417 ± 111	2.103	0.039
Forest cover (%)	31.2 ± 17.3	18.1 ± 2.8	3.104	0.003

military was involved in some of the larger seizures, when all seizures were considered there was little difference between agencies. There were clear differences between regencies where seizures were made and where they were not in that the former were the economically less strong regencies (as expressed by a lower recommended minimum wage) with more forest, both in absolute and relative terms. We assume that these are also the regencies with the largest areas of managed forest. Judging from seizure data, the locations of seizures, and those who are arrested and successfully prosecuted, the trade in rosewood in Indonesia is largely a domestic affair. We found no evidence of foreign nationals being involved in this trade, even though the vast majority of Indonesia's rosewood harvest is exported to China. Seizures were made over the entire distribution range of Indian rosewood in Indonesia. There was no evidence of a preponderance of seizures or illegal activities closer to the main centres of export, which are the ports of Surabaya (Tanjung Perak) and Semarang (Tanjung Emas) both on Java's north coast. Truck drivers were twice singled out in the judgements, once through an acquittal and once by the judge not imposing a fine. These acquittals most likely reflect the recognition that not all that participate in the rosewood trade are aware of its (potential) illegality. The jurisprudence of truck drivers transporting illegally logged timber in Indonesia is discussed by Ridwan and Irawansyah (2022).

4.2. Forestry, law enforcement and prosecutions

As noted by Linkie et al. (2014) protected area management in the tropics is underpinned by a law enforcement strategy that is aimed at safeguarding forests and their wildlife. This strategy typically follows a system of monitoring, patrolling and reporting forest offences that are then verified by on-the-ground checks by government rangers and/or other law enforcement officers. Few studies have assessed the effectiveness of this approach beyond monitoring and information on arrests and successful prosecutions is lacking (Akella & Canon, 2004; Linkie et al., 2014). As such, there are only a few cases involving the illegal timber trade in Indonesia where details are reported on successful prosecution rates, length of prison sentences and fines, but some are available for the illegal trade in animals and their parts. Linkie et al. (2014) followed 45 cases where judicial action was taken following illegal logging in the Indonesian province of Aceh and found a successful prosecution rate of between 31% and 38%. No detailed data on fines were given and concerning the length of prison sentencing, this was stated as between 4 months and 4 years. It is unclear what legislation was used to convict loggers and or traders. Focussing on Indonesian protected animals only, Adhiasto et al. (2023) followed 376 illegal wildlife trade cases proceeding to courts and their verdicts and found that 60% of these resulted in prison time, a fine, or both. The mean prison time for these offences was low compared to what is reported here for rosewood, i.e., 1.0 year and, once corrected for inflation to 2024 values, a fine of US$1834. Most of the prosecutorial cases seem to be related to violation of protected species legislation (Law 5 of 1990). Shepherd et al. (2020) focussed on seizures of pig-nosed turtles *Carettochelys insculpta* in Indonesia and found a successful prosecution rate of 41%, with a mean prison sentence of 1.4 years and a mean fine of US $3337. Most of the prosecutions centred on protected species legislation and less often quarantine legislation (Law 16 of 1992). Nijman (2017) focussing on orangutan *Pongo* spp seizures, reported a low successful prosecution rate of 3% with an average prison sentence, when handed out, of 1.6 years and mean fines of US$2895. These were all based on protected species legislation (Law 5 of 1990). Finally, Nijman et al. (2024) reported on sentencing of those involved in the trade in chambered nautilus *Nautilus pompilus* shells in Indonesia over the period 2010 to 2023. Sentencing, based on protected species legislation, was a mean of 7 months and a fine of US$149; no information on the successful prosecution rate was presented. Compared to these five studies, the successful prosecution rate for rosewood (21–28%) is average to low, the length of prison sentences (2.0 years) is similar, but the fines (US$29, 769) were considerably higher. This was because when prosecuting for the illegal trade in rosewood, prosecutors resorted to Law 18, which, compared to protected species legislation, carries higher maximum sentences (e.g., for corporations this is a maximum of 15 years imprisonment and a fine of US$941,000) and, crucially, has minimum sentences (e.g., 1 year and US$31,000 for individuals and 5 years and US $31,000 for corporations). Protected species legislation (Law 5 of 1990) does not carry a minimum sentence and the maximum is 5 years imprisonment and a maximum fine of US$6274. These differences in legislation underpinning the protection and management of trees vs animals, and the emphasis on economic losses when considering timber, allows for greater safeguarding of the forest where rosewoods grow.

4.3. Seizure data and green criminology

With Indonesia being the largest exporter of Indian rosewood globally, the domestic organisation of the illegal side of this trade warrants continued scrutiny. Taken out of context, these findings would point to a relatively unsophisticated criminal structure. However, more sophisticated methods and practices are known to occur to capitalise on this lucrative trade (Siriwat & Nijman, 2023). These practices include intentionally damaging trees such that felling can be justified (Chouvy, 2013), procuring fraudulent logging permits (Humphreys, 2016), inserting illegal logs into legitimate stockpiles (Carry and Maihold, 2022), creating artificial plantations which only exist on paper (Pokorny, 2016), and forging duplicate documents to mask true harvest quantities (Stanovsky, 2021), to name a few. Additionally, the illegal rosewood trade is known to occur in conjunction with other illegal activities (Boekhout van Solinge, 2014) but extracting the full extent of subsequent criminality is not the aim of this research.

As such, the findings and data extracted here (specifically that more men between ages 40–49 were arrested than anticipated, seizures occurred more in regencies with lower purchasing power per capita, and no foreign nationals were involved) can deliver two conclusions. First, the persons apprehended are likely to engage in illegal trade out of necessity (as areas with lower purchasing power restrict avenues of strictly legal income and males in the 40–49 age range are more likely to have dependants than younger males), this fits within the 'resource curse' paradox (Sachs & Warner, 2001) experienced by countries with ample high-value natural resources. The second conclusion is that the efficacy of police intervention is moderately successful in the disruption of vehicle-based illegal trafficking of rosewood at this specific operational level (as opposed to military or forestry officials). However, the absence of foreign nationals at this operational level of illegal rosewood trade is an interesting result as rosewood is more valuable when it is exported abroad, specifically to China (Nijman, 2024). The operational structures domestically appear to be able to function autonomously without direct international oversight at this particular stage. Until recently, for most foreign business activities required an Indonesian partner holding a majority share in the company, and timber exporting companies were not able to be in foreign hands. In 2021 Indonesia opened most of its sectors to foreign investment allowing foreign ownership of companies (Hawin et al., 2024). In case of the rosewood exporters active in Java we expect most of them to be established, often family-owned, companies, where the form of foreign involvement (e.g., rosewood importer or rosewood user) is in the form of financial backing, guarantees or investment. This foreign involvement may influence the rosewood harvest. These findings then, highlight and more clearly define the composition of this particular stage of the trade network of illegal rosewood.

Our study also shows how seizure data can be used to provide quantitative assessments of rosewood criminal networks. While the end destination for much of Indonesia's rosewood is China, our results support the argument that the rosewood trade network in Indonesia is domestically organized rather than internationally orchestrated, raising important questions about the importance of domestic legalization and the effectiveness of international regulations, including CITES, to protect rosewood species. In terms of forest management and protection of Indian rosewood it is also clear that solutions have to be found within Indonesia's forestry policies and regulations. Finally, to what extent the illegal logging of rosewood in Indonesia's forest have of an effect on the ecology and intactness of the forest is yet to be assessed.

4.4. Limitations and avenues for further research

As noted by Siriwat and Nijman (2018a) given cautious and systematic data collection, online media can be a highly useful sources of alternative seizure data, as there it offers a high degree of flexibility, reflecting real-time trends, independent of government or monitoring agencies. Indonesia scores low on both the World Press Freedom Index (111 out of 180 countries) and the Corruption Perception Index (115/180 countries) (RFS, 2024; TI, 2024). While making this challenging to collect unbiased data from both the media and government agencies, from our reading of seizure reports we did not get the impression that there were any serious obstacles in reporting on these seizures. In Indonesia, timber crime is not viewed as negatively as other illegal wildlife crime, which on the one hand may encourage authorities to report seizures and outcomes of criminal procedures but on the other hand, given the low profile the illegal rosewood trade has, compared to say the trade in tigers or ivory, seizures may go undetected if not deemed important enough to be made public. In our study this may have an effect on assessing the real levels of Indian rosewood seizures in especially in the eastern part of its range. Here we obtained data on large seizures only leaving open the possibility that smaller seizures remain unreported. Our study covered a relatively short three-year period. Our earlier work showed that there had been an increase in seizures since Indian rosewood was listed on CITES Appendix II (Nijman, 2024). It may be worthwhile in future research to expand our analysis to include a longer period, thus allowing to explore temporal and spatial changes, and crucially spatial-temporal interactions, to gain a deeper understanding of what drives this trade.

Some further limitations of our research that need to be acknowledged encompass a few areas pertinent to understanding the results and conclusions of its findings. A significant limitation was our inability to conduct primary research on how the different administrative bodies function in Indonesia between the police, forestry officials, and the military, as access to these groups is limited or restricted. Our sources and data originate from official statistic releases which are cross-checked against available sources (See Fig. 2); however, without direct interviews across these agencies (and in each of the regencies where data was observed), a clearer understanding is not possible at the time of writing. This segways into a potential bias that we sought to avoid, which is an assumption of why there was very little observed overlap between the law enforcement agencies (speaking to those with the ability to intervene in illegal rosewood harvesting in Indonesia). In many Western countries, law enforcement divisions, much like military branches, are intentionally cordoned off from one another. The reasons for this include information sensitivity, bureaucratic competition, and matters concerning irregularities in terms of how efficacy is measured by each group respectively; leading to instances where multi-agency cooperation potentially becomes cumbersome, ineffectual, and costly. Indonesia's law enforcement and military structure is comparable to many Western countries in this respect, however, it is also incompatible in other ways, specifically concerning the proliferation of bribery and corruption at most administrative levels (Dick & Mulholland, 2016; Zandi et al., 2019).

This is not to say that cross-agency cooperation doesn't exist despite these hurdles (See section 3.2). For example, the police may measure efficacy by operation costs vs. apprehension/prosecution rates but may request military assistance on larger operations where the police don't have the resources to execute their duties safely. In such an instance, the military will not gain anything from assisting in the operation (and the military cannot arrest civilians), but it is in the military's interest to promote cooperation with local authorities in anticipation of future collaborative work for purposes of the military's aim of ensuring the integrity of the nation's borders, particularly in regencies with ports or international transportation hubs. The legal treatment of those apprehended for illegal logging or the transport of illegally obtained rosewood will typically depend on which agency or group makes first contact (this standard practice limits the potential for evidence contamination, simplifies hierarchy in multi-jurisdictional spaces, and decreases the chance of suspects claiming mistreatment due to diffusion of responsibility concerning their care in custody). However, a limitation of our research is that there is no way of knowing what the police, forestry officials, or military of Indonesia during this specific period of time have planned in

advance of arrests or apprehensions (in the events where they can pre-plan), and in the case of forestry officials, there are frequent instances of random detection and interference where officials are simply responding to events to the best of their abilities. Protocols for each type of encounter vary widely depending on who (police, forestry official, or military branch) encounters the offenders first and what other circumstantial considerations (weapons/other contraband) are present; as such the potential prosecutorial sequence for each figure we acquired had the potential to vary significantly from the next. This information (anticipated or random arrests and how each enforcement group strategically manages their respective responses) was not available at the time of writing, as each case would require extensive primary research and such details were not within the purview of this investigation. This investigation aimed to determine who was perpetrating illegal rosewood harvesting at the source of the trade in Indonesia. The intricacies of methodical detection, prevention contingencies, and collaboration practices by law enforcement agencies concerning the illegal Indonesian rosewood trade represent a significant area of research potential should access to said agencies and their respective training/operation guidelines become available.

5. Conclusion

The figures and data we collected yielded significant information. First, while the global trade of Indonesian rosewood is driven by demand in China, the domestic side of the supply chain is run exclusively by Indonesian nationals. Foreign involvement, either in the form of financial backing or guarantees or through direct investment in rosewood exporting companies cannot be ruled out, and if this is the case, targeting companies with foreign links may allow for better regulation of the rosewood trade. This highlights the ability of the trade to run in semi-autonomous links, which can assist those involved in preventing detection, by keeping the activities (and awareness of them) restricted to those in local communities who are known and trusted by one another.

This result is further supported when we consider the age ranges and socioeconomic status of the majority of those arrested (see section 3.5 and Table 3). The prevalence of males between 40 and 49 of lower socioeconomic means speaks to known examples of the 'resource curse' paradox (Brunnschweiler & Bulte, 2008), where crime is perpetrated out of necessity by members of the local community who typically have familial obligations and are less likely to travel/work beyond their local communities; but commit crimes for the sake of survival rather than greed. The outlying youths identified (See section 3.1), while anonymous to us, could as easily be family members of the older males as they could be recruits learning the trade from the older generation.

Second, based on the data, protective measures such as restricted forestry areas were not found to significantly impact illegal logging or exploitation practices. This finding suggests that contemporary protective measures were not effective enough to deter opportunistic felling. Concerning further research, a deeper understanding of how these communities and criminal infrastructures function daily, including how new members are assimilated, could yield further insights into the rosewood trade, which could then be used to make recommendations for prevention in the future. The seizure data presented here has substantiated our original aim, to provide a quantitative assessment of the rosewood criminal networks in Indonesia, and has made a substantial preliminary assessment of their contemporary relationship with forest presence and authority management.

CRediT authorship contribution statement

Vincent Nijman: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Jessica Chavez:** Writing – review & editing, Investigation, Funding acquisition. **Devon Simons:** Writing – review & editing, Validation, Investigation. **Penthai Siriwat:** Writing – review & editing, Resources, Methodology, Investigation, Conceptualization. **Ratna Ayu Widiaswari:** Writing – review & editing, Project administration, Investigation. **Magdalena S. Svensson:** Writing – review & editing, Supervision, Project administration, Investigation.

Data availability

CITES trade data are available from cites.org; outcomes of prosecutions are available from putusan3.mahkamahagung.go.id; all other data are available from the corresponding author upon any reasonable request.

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Declaration of competing interest

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