Naturalized Alien Plant as Traditional Medicine Resources: A Study from Cibodas Biosphere Reserve, West Java

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ABSTRACT

Cibodas Biosphere Reserve, with Gunung Gede Pangrango National Park as the core zone area, has an enormous number of naturalized alien species spread within it. There are 88 alien plant species, and more than 50% are utilized for many purposes. This research documented the utilization of these naturalized alien plant species, particularly for traditional medicine. Data were obtained by interviewing 90 respondents in three locations around Cibodas Biosphere Reserve using questionnaire sheets. The questionnaire used the Index Cultural Significance framework to quantify the value of every species for traditional medicine. The results showed that the community used 41 naturalized alien plant species from 15 families. Asteraceae is the family with the most widely used species and has various medicinal benefits. The most frequently treated health problems are anti-inflammatory, dental and oral health, and fever. ICS value showed that the utilization rate is low, yet these plants have promising properties as sources of natural medicine. Moreover, the utilization of these alien plants can be an option in controlling these species to prevent the invasion of Gunung Gede Pangrango National Park.

1. Introduction

Alien plant species are plants introduced into a new area all over the world outside their original range. Alien species successfully naturalized in a new area when the species established self-sustaining populations by reproducing in the wild without human intervention and thus become permanent parts of the flora (Milanović et al. 2020; Richardson and Pyšek 2013). The latest data shows that 13,168 alien plant species have been naturalized worldwide, at least 1,345 in the Malesia region (Holmes et al. 2023; van Kleunen et al. 2015).

Alien plant species become invasive when the species dominate an ecosystem and alter the ecosystem’s function, causing ecological, social, and economic losses (Pyšek et al. 2020; Rai and Singh 2020; Setyawati et al. 2021). Invasive alien species are considered one of the most significant threats to native species diversity and ecosystem function. The spread of invasive plant species in Indonesia caused many adverse impacts on the environment and human well-being. The
most famous is the case of the massive spread of *Vachellia nilotica* in Baluran National Park (van Etten and Sutomo 2016; Zahra et al. 2020). In Sumatra, the invasion of *Merremia peltata* in Bukit Barisan Selatan National Park is also a notable conservation issue due to its negative impact on biodiversity (Duryat et al. 2023).

In Indonesia, the spread of alien plant species has been recorded in a number of conservation areas, especially national park areas. Padmanaba et al. (2017) recorded 67 naturalized alien plant species in several national parks in Java, one of which is the Gunung Gede Pangrango National Park (GGPNP). Gunung Gede Pangrango National Park is a national park that is the core zone of the Cibodas Biosphere Reserve, a pilot area for sustainable development (UNESCO 2011). More than 80 species of naturalized alien plants were recorded in this area, with 50% potentially invasive (Handayani et al. 2021a; Handayani and Hidayati 2020). Cibodas Biosphere Reserve is the site for understanding and managing biodiversity also interactions between social and ecological systems; thus, controlling the spread of alien plant species in the CBC area is challenging. On the other hand, our previous research found many alien plant species used by the community, with the highest utilization in traditional medicine (Handayani et al. 2021b).

Based on this information, this study would like to record the local knowledge about the utilization of these naturalized alien plant species as a traditional medicine from communities around Cibodas Biosphere Reserve. Although the study on ethnomedicine has been widely carried out in many places or communities in Indonesia, the study with the specific object of naturalized alien plant species utilization has not been recently studied. Furthermore, this utilization data is expected as the novelty input in controlling these alien plant species because the approach to managing invasive alien species through utilization has not been widely implemented in Indonesia.

## 2. Materials and Methods

### 2.1. Research site

The study was conducted sampling and data collection from October to December 2020 in three buffer zones of Cibodas Biosphere Reserve (CBR), directly located next to the CBR core zone: Bodogol, Cibodas, and Gekbrong (Fig. 1). The elevation of the sampling location in Bodogol is approximately 600 masl. Sampling locations in the Cibodas area range from 1100–1200 masl. The Gekbrong area sampling location is located at 1200 masl.

### 2.2. Data collections

This research interviewed 90 respondents with a number of questions on questionnaire sheets. Selecting the respondent used a simple random sampling method because all the community members assumed they had an equal chance of utilizing alien plant species. The questionnaire was designed to quantify the value of every species utilization for traditional medicinal purposes using the Index of Cultural Significance by Turner (1988). The questionnaire was made in a mixed structure, with a number of questions regarding the name (local name) of the used species, the parts of the plants used (choice given: leaves, fruits, seeds, bark, flowers, all parts, and other), the type of disease being treated, processing method, the source of the plants (yard, farm, forest edges, or in the forest area), the frequency of utilization (rarely to often; score given 1-5 ), and the level of preference to the used plant species (score given: 0.5, 1, and 2). To ensure that the used plant species are alien plant species, the identification process is carried out to know the scientific name of the used plant species. The identification of these alien plants is
performed by picking the samples of these plants and documenting them for identification process by field assistant. In addition, identification is also strengthened by searching through online databases, accessed on World Flora Online’s database (WFO 2023) and Plants of the World Online by the Royal Botanic Gardens Kew (POWO 2023). Questionnaires with species that have been identified as alien plant species are processed to calculate the ICS value.

Fig. 1. Research site within Cibodas Biosphere Reserve area: Bodogol, Cibodas, and Gekbrong.

2.3. Data analysis

This study used the Index of Cultural Significance (ICS) as the questionnaire framework. ICS is a method to quantify the importance value of utilized species by communities (Turner 1988). The value obtains from species utilization (in this case, category as a medicine given score 3), utilization intensity (score given 1-5), and the exclusivity or preferences of the species (score 0.5, 1, and 2) (Turner 1988). Data from the questionnaire was processed into Microsoft Excel to calculate the ICS value. Calculating ICS value using the following formula:

\[
ICS = \sum_{i=1}^{n} (q \times i \times e)u_i
\]

where \(ICS\) is the Index of Cultural Significance, \(q\) is utilization quality, \(i\) is the intensity of utilization, \(e\) is the level of preference of species utilization, and \(n\) is the utilization category (this study only used the medicine category).

The result of the calculation was classified based on the categorization proposed by Turner (1988): ICS > 100 (very high significance), 50-99 (high significance), 20-49 (medium significance), 5-19 (low significance), 1-4 (very low significance). The ICS value of each species was analyzed based on the practice of its utilization.
3. Results and Discussion

3.1. Naturalized Alien Plant Species for Medicinal Purposes

The results of this study show that the communities utilize 41 naturalized alien plant species (NAPS) from 15 families, with Asteraceae and Solanaceae as the dominant families (Fig. 2). As the largest family number from angiosperms, Asteraceae has about 25,000 species distributed worldwide and is widely known has many potential uses, such as medicinal plants (Fauziana and Susandarini 2019). Unsurprisingly, this family has become dominant in its utilization of traditional medicine. Its abundance around the community makes people easy to gather it for many purposes.

Fig. 2. Health problem categories treated per family.

From three research locations, 39 respondents in Cibodas used as many as 38 species, 29 respondents in Bodogol used 16 species, and 22 respondents used only seven species in Gekbrong. The respondent number difference from each location depends on the community’s voluntary participation in the questionnaire. Then, the difference in utilized species number from each location depends on the respondents’ knowledge. In this utilization activity, the most well-known species by respondents from the three locations were Ageratum conyzoides, Artemisia vulgaris (Asteraceae), Kalanchoe pinnata (Crassulaceae), and Physalis peruviana (Solanaceae). These four species are well known in all research locations, except Artemisia vulgaris, only in Cibodas.
and Bodogol. The practice of using these species is quite common in Indonesia. It was recorded in several ethnobotanical studies, both *Ageratum conyzoides* (Navia et al. 2022; Supiandi et al. 2019), *Artemisia vulgaris* (Rohman et al. 2019), *Kalanchoe pinnata* (Rambev and Lubis 2022), and *Physalis peruviana* (Oktavia et al. 2017) are widely known for their efficacy.

The results showed that Asteraceae is the most widely used to treat a number of diseases. As many as 18 categories of health problems can be treated by species from Asteraceae (Fig. 2), ranging from anti-inflammatory, appetite enhancers, dental and oral health, deodorizers, diabetes, digestive problems, fever, hypertension, leukorrhea, muscle soreness, nosebleed, pain reliever, postpartum treatment, reduce risk of cancer, respiratory problems, skin diseases, urinary tract diseases, and wound. The high diversity of Asteraceae species is in line with the number of health problems that can be treated.

Based on ICS calculation, no species had high ICS scores. Only one species had a moderate ICS score, namely *Fragaria vesca*, while the remaining 23 had low ICS, and 17 had very low ICS scores. Most utilized NAPS have low ICS scores, indicating that NAPS utilization for medicinal purposes is rarely practiced. This means that the community is not dependent on these NAPS for medicinal needs. However, based on the utilization practices of this community, the properties obtained from these NAPS are potentially developed as natural medicine sources.

3.2. Health Benefit, Biological Activities and Future Potential of Naturalized Alien Plant Species as Natural Medicinal Resources

Data from respondents show there are 29 health problem categories treated by these NAPS, such as dental and oral health, eye irritation, wound, skin diseases, and postpartum treatment (Fig. 2). The most efficacy of plant species are to treat inflammation or anti-inflammatory properties, maintain dental and oral health, and relieve fever. Species that are efficacious as anti-inflammatory are *Amaranthus spinosus*, *Bidens pilosa*, *Biophytum intermedium*, *Blainvillea acmela*, *Cosmos caudatus*, *Fragaria vesca*, *Oxalis corniculata*, *Passiflora ligularis*, *Euphorbia hirta*, *Galinsoga parviflora*, *Ageratum conyzoides*, *Austroeupatorium inulifolium*. Species that are used for treating oral and dental health are *Erechtites valerianifolius*, *Mentha arvensis*, *Bidens pilosa*, *Biophytum intermedium*, *Eryngium foetidum*, *Fragaria vesca*, *Oxalis corniculata*, *Passiflora edulis*, *Passiflora ligularis*, *Passiflora suberosa*, *Solanum americanum*, and *S. betaceum*. To relieve fever, the plant species used are *Ageratina riparia*, *Ageratum conyzoides*, *Artemisia vulgaris*, *Cosmos caudatus*, *Galinsoga parviflora*, *Kalanchoe pinnata*, *Oxalis corniculata*, *Passiflora edulis*, *Passiflora suberosa*, *Tithonia rotundifolia*, and *Solanum americanum*.

In addition to the efficacy of these NAPS, a literature search was conducted to find pharmacological effects for each species. Several studies regarding pharmacological studies have revealed the importance of several compounds owned by these NAPS (Table 1). Therefore, these species can be developed as a source of modern natural-based medicine. There is a number of their potential for treating several types of diseases which are major health problems such as diabetes (Puente et al. 2019), hypertension (Ahda et al. 2023; Darkwah et al. 2020), some cancers (Irani et al. 2022; Kumar et al. 2020), as well as antivirals such as those for COVID-19 treatment (Khan 2021; Mekam et al. 2019). In developing countries, plant-derived medicine continues to increase in traditional and modern medicine. For example, *A.conyzoides* has been used as an antiseptic, antihemorrhagic, antileprosy, and wound-healing (Kotta et al. 2020).
Table 1. Summary of the utilization of naturalized alien plant species based on questionnaires

<table>
<thead>
<tr>
<th>No.</th>
<th>Family</th>
<th>Species</th>
<th>Lifeform</th>
<th>Used part</th>
<th>Medicinal use</th>
<th>Formulation</th>
<th>Pharmacological effects</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Amarathaceae</td>
<td>Amaranthus spinosus</td>
<td>Herbs</td>
<td>Leaves, stems</td>
<td>Help to improve digestive health, weight loss, heartburn, sore throat, and source of vitamins for children’s growth</td>
<td>Young leaves and stems are steamed and consumed as a side dish</td>
<td>Anti-inflammatory, antioxidant, antidiabetic, antimicrobial, diuretic, antimarial, anti-ulcer, antipyretic, anti-androgenic, anthelmintic, antigenic, and immunomodulatory activity</td>
<td>(Abir and Ahmad 2021; Ganjare and Raut 2019)</td>
</tr>
<tr>
<td>2</td>
<td>Apiaceae</td>
<td>Eryngium foetidum</td>
<td>Herbs</td>
<td>All parts</td>
<td>Canker sore, muscle soreness, hepatitis</td>
<td>Drink the decoction from boiled parts of the plant</td>
<td>Antimicrobial, antioxidant, anti-inflammatory, and antidiabetic potential</td>
<td>(Paw et al. 2022; Silalahi 2021)</td>
</tr>
<tr>
<td>3</td>
<td>Asteraceae</td>
<td>Cosmos caudatus</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Sore throat, cough, fever (fresh leaves consumed as a side dish), hypertension, diabetes, and reduced risk of cancer (drink the decoction from boiled leaves)</td>
<td>Sore throat, cough, fever (fresh leaves consumed as a side dish), hypertension, diabetes, and reduced risk of cancer (drink the decoction from boiled leaves)</td>
<td>Antidiabetic, antioxidant, anti-inflammation, antibacterial, antifungal, anti-osteoporosis, anti-hyperlipidemic, anticancer, antihypertensive, antihepatoprotective, and to manage fertility problems</td>
<td>(Ahda et al. 2023)</td>
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<tr>
<td>4</td>
<td>Asteraceae</td>
<td>Artemisia vulgaris</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Pain reliever, typhoid fever, rheumatism, itchy skin, reduced body odor</td>
<td>Pain reliever, typhoid fever, rheumatism, itchy skin (drink the decoction from boiled leaves), reduce body odor (crush the leaves for dermal application, and drink the decoction from boiled leaves)</td>
<td>Antioxidant, antispasmyotic, antinociceptive, hepatoprotective, cytotoxic, estrogenic, antibacterial, and antifungal effects</td>
<td>(Eikert et al. 2020)</td>
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<tr>
<td>5</td>
<td>Asteraceae</td>
<td>Ageratina riparia</td>
<td>Herbs</td>
<td>All parts</td>
<td>Fever, diarrhea, wounds, breastmilk booster (drink the decoction from boiled all parts of the plant), wounds (crushed the leaves for dermal application)</td>
<td>Fever, diarrhea, breastmilk booster (drink the decoction from boiled all parts of the plant), wounds (crushed the leaves for dermal application)</td>
<td>Antifungal activity against banana disease by fungus</td>
<td>(Ratnayake et al. 2018)</td>
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<tr>
<td>6</td>
<td>Asteraceae</td>
<td>Ageratum conyzoides</td>
<td>Herbs</td>
<td>All parts</td>
<td>Nosebleed, fever, wounds, gastritis</td>
<td>Wounds, nosebleeds (crushed the leaves for dermal application), fever, gastritis (drink the decoction from boiled all parts of the plant)</td>
<td>Antifungal activity, antioxidant, anticancer, antimicrobial, anti-inflammatory, analgesic, antiprotozoal, antidiabetic, spasmyotic, allelopathy</td>
<td>(Chahal et al. 2021; Yadav et al. 2019)</td>
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<td>No.</td>
<td>Family</td>
<td>Species</td>
<td>Lifeform</td>
<td>Used part</td>
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<td>References</td>
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<td>7</td>
<td>Asteraceae</td>
<td><em>Austroeupatorium inulifolium</em></td>
<td>Shrubs</td>
<td>Leaves, stems</td>
<td>Diabetes, gastritis, itchy skin, treat bee stings</td>
<td>Diabetes, gastritis (drink the decoction from boiled leaves), itchy skin (the decoction water from leaves and stems is used for bathing, and the boiled leaves and stems are used to scrub the itchy skin)</td>
<td>The bactericidal activity of all compounds was evaluated against four bacterial strains: <em>Staphylococcus aureus</em>, <em>Enterococcus faecalis</em>, <em>Escherichia coli</em>, and <em>Pseudomonas aeruginosa</em></td>
<td>(Chacón-Morales et al. 2019)</td>
</tr>
<tr>
<td>8</td>
<td>Asteraceae</td>
<td><em>Bidens pilosa</em></td>
<td>Herbs</td>
<td>Leaves</td>
<td>Sore throat, toothache, postpartum treatment, leukorrhea</td>
<td>Sore throat (fresh leaves consumed as a side dish), toothache, postpartum treatment, leukorrhea (drink the decoction from boiled leaves)</td>
<td>Antimetabolic activities and anticoecidial potency</td>
<td>(Kuo et al. 2021; Yang et al. 2019)</td>
</tr>
<tr>
<td>9</td>
<td>Asteraceae</td>
<td><em>Erechtites valerianifolius</em></td>
<td>Herbs</td>
<td>Leaves</td>
<td>Reduce halitosis, appetite enhancer, and back pain</td>
<td>Fresh leaves are consumed as a side dish, or drink the decoction from boiled leaves</td>
<td>Antioxidant activity and mosquito larvicidal activity</td>
<td>(Hung et al. 2019; Puspaningtyas et al. 2020)</td>
</tr>
<tr>
<td>10</td>
<td>Asteraceae</td>
<td><em>Ageratum houstonianum</em></td>
<td>Herbs</td>
<td>All parts</td>
<td>Diarrhea, wounds</td>
<td>Diarrhea (drink the decoction from boiled all parts of the plant), wounds (crushed the leaves for dermal application)</td>
<td>Repellent, antifeedant, and larvicidal activities</td>
<td>(Hadidy et al. 2022)</td>
</tr>
<tr>
<td>11</td>
<td>Asteraceae</td>
<td><em>Blainvillea acmella</em></td>
<td>Herbs</td>
<td>All parts</td>
<td>Sore throat, muscle soreness</td>
<td>Drink the decoction from all boiled parts of the plant</td>
<td>Antioxidant and anti-osteoporosis agent</td>
<td>(Abdul Rahim et al. 2022)</td>
</tr>
<tr>
<td>13</td>
<td>Asteraceae</td>
<td><em>Sonchus arvensis</em></td>
<td>Herbs</td>
<td>All parts</td>
<td>Nephrolithiasis, laxative</td>
<td>Nephrolithiasis treatment (drink the decoction from boiled leaves), laxative (drink the decoction from boiling all parts of the plant)</td>
<td>Antioxidant activity, anti-fatigue effects, and antiplasmodial activity</td>
<td>(Wahyuni et al. 2021; Yuan et al. 2019)</td>
</tr>
<tr>
<td>No.</td>
<td>Family</td>
<td>Species</td>
<td>Lifeform</td>
<td>Used part</td>
<td>Medicinal use</td>
<td>Formulation</td>
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<td>References</td>
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<tr>
<td>14</td>
<td>Asteraceae</td>
<td>Sonchus oleraceus</td>
<td>Herbs</td>
<td>All parts</td>
<td>Nephrolithiasis, diuretic</td>
<td>Drink the decoction from all boiled parts of the plant</td>
<td>Gastroprotective effects, a natural antioxidant, and anti-cholinesterase</td>
<td>(Aissani et al. 2022; Vecchia et al. 2022)</td>
</tr>
<tr>
<td>15</td>
<td>Asteraceae</td>
<td>Tithonia rotundifolia</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Diabetes, fever</td>
<td>Drink the decoction from boiled leaves</td>
<td>Antimycobacterial treatments</td>
<td>(Omokhua et al. 2019)</td>
</tr>
<tr>
<td>16</td>
<td>Asteraceae</td>
<td>Sonchus asper</td>
<td>Herbs</td>
<td>All parts</td>
<td>Wounds</td>
<td>Drink the decoction from all boiled parts of the plant</td>
<td>Against free-radical-associated oxidative damage</td>
<td>(Khan et al. 2012)</td>
</tr>
<tr>
<td>17</td>
<td>Asteraceae</td>
<td>Sphagneticola trilobata</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Wounds</td>
<td>Crushed the leaves for dermal application</td>
<td>Antidiabetic, antioxidant, antitumor, anti-inflammatory, and cytotoxic activity</td>
<td>(Buddhakala and Talubmook 2020; Mardina et al. 2020; Sun et al. 2020)</td>
</tr>
<tr>
<td>18</td>
<td>Asteraceae</td>
<td>Taraxacum officinale</td>
<td>Herbs</td>
<td>All parts</td>
<td>Diuretic</td>
<td>Drink the decoction from all boiled parts of the plant</td>
<td>Hepatoprotective, antioxidant, anticancer, anticoagulant, and anti-platelet activities</td>
<td>(Jedrejek et al. 2019; Di Napoli and Zucchetti 2021)</td>
</tr>
<tr>
<td>19</td>
<td>Caryophyllaceae</td>
<td>Stellaria media</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Flatulence</td>
<td>Crushed the leaves for dermal (belly skin) application</td>
<td>Anti-obesity, antifungal, antibacterial, antioxidant, anti-proliferative, anti-inflammatory, antioxidative, wound-healing, analgesic, antiinflammatory, and anti-inflammatory activity</td>
<td>(Miere (Groza) et al. 2021; Oladeji and Oyebamiji 2020)</td>
</tr>
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<td>20</td>
<td>Crassulaceae</td>
<td>Kalanchoe pinnata</td>
<td>Herbs</td>
<td>leaves</td>
<td>Fever</td>
<td>Crushed the leaves for dermal (forehead) application</td>
<td>Anti-inflammatory activity and adjuvant in cancer treatment</td>
<td>(de Araújo et al. 2019; Hernández-Caballero et al. 2022)</td>
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<td>21</td>
<td>Euphorbiaceae</td>
<td>Euphorbia hirta</td>
<td>Herbs</td>
<td>All parts</td>
<td>Dyspnea, prevent stroke, gastritis</td>
<td>Dyspnea (drink the decoction from boiled leaves), prevent stroke (drink the decoction from boiled all parts of the plant), gastritis (drink the decoction from boiled leaves and stems)</td>
<td>Antimicrobial, antimalarial, anti-asthmatic, antioxidant, anticancer, antifungal, and antiviral. Antiviral agents are possible as an application to control COVID-19</td>
<td>(Khursheed et al. 2022; Mekam et al. 2019)</td>
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<td>No.</td>
<td>Family</td>
<td>Species</td>
<td>Lifeform</td>
<td>Used part</td>
<td>Medicinal use</td>
<td>Formulation</td>
<td>Pharmacological effects</td>
<td>References</td>
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<tr>
<td>22</td>
<td>Lamiaceae</td>
<td>Mentha arvensis</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Reduce halitosis, headache, warm up the body/maintain stamina, flatulence, cough</td>
<td>Reduce halitosis (fresh leaves consumed as a side dish), headache (crushed the leaves for dermal application, warm up the body/maintain stamina, flatulence, cough (drink the decoction from boiled leaves).</td>
<td>Antibacterial, antifungal, and natural larvicide and repellent against Aedes aegypti</td>
<td>(Ahmad et al. 2020; Manh and Tuyet 2020)</td>
</tr>
<tr>
<td>23</td>
<td>Melastomataceae</td>
<td>Clidemia hirta</td>
<td>Shrubs</td>
<td>Leaves</td>
<td>Diarrhea, muscle soreness, nosebleed, ulceration, wounds</td>
<td>Diarrhea, muscle soreness (drink the decoction from boiled leaves), nosebleed (roughly crush the leaves, and apply them to the bleeding nose), ulceration, wounds (crush the leaves for dermal application)</td>
<td>Antibacterial activity against Staphylococcus aureus and S. typhi</td>
<td>(Pratami et al. 2021)</td>
</tr>
<tr>
<td>24</td>
<td>Oxalidaceae</td>
<td>Oxalis corniculata</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Fever, canker sore, sore throat</td>
<td>Fresh leaves consumed as a side dish, or drink the decoction from boiled leaves.</td>
<td>Antioxidant, anticancer, antihelmintic, anti-inflammatory, antimicrobial, astringent, diuretic, febrifuge, cardio-relaxant, and wound healing potential</td>
<td>(Sarfraz et al. 2022; Sarkar et al. 2020)</td>
</tr>
<tr>
<td>25</td>
<td>Oxalidaceae</td>
<td>Biophytum intermedium</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Canker sore, sore throat</td>
<td>Fresh leaves consumed as a side dish, or drink the decoction from boiled leaves.</td>
<td>Bacteriostatic, anti-diarrheal, and reduces damages caused to intestinal mucosa barrier by pathogenic mechanisms of Shigella.</td>
<td>(Fokam Tagne et al. 2018)</td>
</tr>
<tr>
<td>26</td>
<td>Oxalidaceae</td>
<td>Oxalis barrelieri</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Remove the fishy smell</td>
<td>Fresh leaves are consumed as a side dish</td>
<td>Anti-oxidants and good inhibition of the tyrosinase enzyme</td>
<td>(Wiliantari et al. 2022)</td>
</tr>
<tr>
<td>27</td>
<td>Passifloraceae</td>
<td>Passiflora edulis</td>
<td>Vines</td>
<td>Fruit</td>
<td>Canker sore, reduce cholesterol levels, hypertension, fever</td>
<td>Consume the fruit</td>
<td>Antioxidant, anticancer against various tumor cell lines, and antibacterial on meat as a food preservative</td>
<td>(He et al. 2020; Ramli et al. 2020)</td>
</tr>
<tr>
<td>28</td>
<td>Passifloraceae</td>
<td>Passiflora ligularis</td>
<td>Vines</td>
<td>Fruit</td>
<td>Canker sore, reduce cholesterol levels, sore throat, source of vitamin C</td>
<td>Consume the fruit</td>
<td>Antioxidants and good inhibition of the tyrosinase enzyme</td>
<td>(Wiliantari et al. 2022)</td>
</tr>
<tr>
<td>No.</td>
<td>Family</td>
<td>Species</td>
<td>Lifeform</td>
<td>Used part</td>
<td>Medicinal use</td>
<td>Formulation</td>
<td>Pharmacological effects</td>
<td>References</td>
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<tr>
<td>29</td>
<td>Passifloraceae</td>
<td><em>Passiflora suberosa</em></td>
<td>Vines</td>
<td>Fruit</td>
<td>A canker sore, reduce cholesterol levels, hypertension, fever</td>
<td>Consume the fruit</td>
<td>Antibacterial activities against all the strains of gram-negative and gram-positive bacterial Insecticide, acaricide and antiparasitic</td>
<td>(Bandara et al. 2018)</td>
</tr>
<tr>
<td>30</td>
<td>Piperaceae</td>
<td><em>Piper aduncum</em></td>
<td>Small tree</td>
<td>Leaves</td>
<td>Eye irritation, antiseptic</td>
<td>The decoction from boiled leaves used as eye drops or antiseptic</td>
<td></td>
<td>(Durofil et al. 2021)</td>
</tr>
<tr>
<td>31</td>
<td>Rosaceae</td>
<td><em>Fragaria vesca</em></td>
<td>Herbs</td>
<td>Fruit</td>
<td>Source of vitamin C, canker sore, sore throat</td>
<td>Consume the fruit</td>
<td>Antioxidant activity</td>
<td>(Couto et al. 2020)</td>
</tr>
<tr>
<td>32</td>
<td>Rubiaceae</td>
<td><em>Cinchona pubescens</em></td>
<td>Tree</td>
<td>Bark</td>
<td>Malaria</td>
<td>Drink the decoction from brewed crushed bark</td>
<td>Quinine for antimalaria</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Solanaceae</td>
<td><em>Solanum americanum</em></td>
<td>Herbs</td>
<td>Leaves, fruit</td>
<td>Maintain stamina, canker sore, common cold, flatulence, fever</td>
<td>Maintain stamina and canker sore (consume mature fruit), common cold, flatulence (crushed the leaves for dermal application, fever (drink the decoction from boiled leaves)</td>
<td>Hepatoprotective, antitumor, immunomodulatory, anti-ulcer, calming, hostile to convulsant, cardio-defensive, antibacterial, antiinflammatory, pain-relieving, antioxidant, and antiradical scavenging activity</td>
<td>(McCarthy and Price 2020; Nair 2021; Campisi et al. 2019; Mani et al. 2022; Ogundola et al. 2022)</td>
</tr>
<tr>
<td>34</td>
<td>Solanaceae</td>
<td><em>Physalis peruviana</em></td>
<td>Herbs</td>
<td>All parts</td>
<td>Diabetes, muscle soreness, postpartum treatment, hemorrhoid</td>
<td>Diabetes (drink the decoction from boiled leaves and stems), muscle soreness, postpartum treatment, hemorrhoid (drink the decoction from boiling all parts of the plant or consume the fruit)</td>
<td>Antioxidant and antimicrobial</td>
<td>(El-Beltagi et al. 2019)</td>
</tr>
<tr>
<td>35</td>
<td>Solanaceae</td>
<td><em>Solanum betaceum</em></td>
<td>Small tree</td>
<td>Fruit</td>
<td>A canker sore, diabetes, hypertension, laxative</td>
<td>Consume the fruit</td>
<td>Possesses higher antioxidant activity than apples and kiwifruit, antimicrobial, antifungal, and antibacterial activity against <em>E. coli</em>, <em>P. aeruginosa</em>, and <em>S. aureus</em></td>
<td>(Diep et al. 2020, 2021, 2022)</td>
</tr>
<tr>
<td>No.</td>
<td>Family</td>
<td>Species</td>
<td>Lifeform</td>
<td>Used part</td>
<td>Medicinal use</td>
<td>Formulation</td>
<td>Pharmacological effects</td>
<td>References</td>
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<tr>
<td>36</td>
<td>Solanaceae</td>
<td>Solanum torvum</td>
<td>Shrubs</td>
<td>Fruit</td>
<td>Back pain, diuretic, maintaining stamina, hypertension</td>
<td>Back pain, diuretic, maintaining stamina (drink the decoction from boiled mature fruits and consume the boiled fruits), hypertension (consume boiled fruits or fresh fruits)</td>
<td>Antibiotics, cardio, and nephro protection, antihypertensive, analgesic, anti-inflammatory, anti-ulcer, antimicrobial activities</td>
<td>(Darkwah et al. 2020; Khunbutrsi et al. 2022)</td>
</tr>
<tr>
<td>37</td>
<td>Solanaceae</td>
<td>Brugmansia candida</td>
<td>Small tree</td>
<td>Flower</td>
<td>Eye irritation</td>
<td>Water from a bud flower is used as eye drops</td>
<td>Anti-inflammatory, cytotoxic, antioxidant, antibacterial, antispasmodic, anti-asthmatic, antinociceptive, antiprotozoal, and larvicidal activity against Aedes aegypti and C. quinquefasciatus</td>
<td>(Algradi et al. 2021; Himmi et al. 2020)</td>
</tr>
<tr>
<td>38</td>
<td>Solanaceae</td>
<td>Brugmansia suaveolens</td>
<td>Small tree</td>
<td>Flower</td>
<td>Eye irritation</td>
<td>Water from a bud flower is used as eye drops</td>
<td>Analgesic, antimicrobial antinociceptive, wound healing, nematicidal, and immunomodulation-mediated anticancer activity</td>
<td>(Kumar et al. 2020; Petricevich et al. 2020; Pundir et al. 2022)</td>
</tr>
<tr>
<td>39</td>
<td>Solanaceae</td>
<td>Cestrum aurantiacum</td>
<td>Shrubs</td>
<td>Leaves</td>
<td>Itchy skin</td>
<td>Crushed the leaves for dermal (itchy skin) application</td>
<td>Antimicrobial</td>
<td>(Sivaraj et al. 2015)</td>
</tr>
<tr>
<td>40</td>
<td>Solanaceae</td>
<td>Cestrum elegans</td>
<td>Shrubs</td>
<td>Leaves</td>
<td>Itchy skin</td>
<td>Crushed the leaves for dermal (itchy skin) application</td>
<td>Antifungal and antiviral</td>
<td>(Nasr et al. 2021)</td>
</tr>
<tr>
<td>41</td>
<td>Verbenaceae</td>
<td>Stachyta orphanis</td>
<td>Herbs</td>
<td>Leaves</td>
<td>Wounds</td>
<td>Crushed the leaves for dermal application</td>
<td>Anti-inflammatory, antioxidant, antidiabetic, and antibacterial activities against gram-positive bacteria only</td>
<td>(Eskander et al. 2021; Idu et al. 2021; Khan et al. 2020)</td>
</tr>
</tbody>
</table>
3.3. Utilization of Naturalized Alien Plant Species as a Management Option

Plant invasions are a complex social-ecological phenomenon (Vaz et al. 2017). Invasive plants were introduced and cultivated intentionally in the past, intended to fulfill socioeconomic and cultural value for communities (Arrington 2021). The use of alien plant species as shortcuts to create “ideal” conditions for an area is also often used, in the case of parks or urban forests, because they are easier to obtain and usually are fast-growing species (Heriyanto et al. 2023). This causes the use of these NAPS could be commonly practiced considering the original purpose of their introduction. In this study, the NAPS utilization as medicine is not a high activity rate in the community around Cibodas Biosphere Reserve. However, considering the medicinal potential possessed by the properties of these NAPS, this utilization activity should still be practiced. The results of interviews showed the use of NAPS as medicine to treat a number of minor ailments such as wounds, flatulence, toothache, canker sores, fever, common cold, or diarrhea. Thus, the use of NAPS can be consistently practiced as first aid for minor ailments in the community. The utilization of these species, especially if harvesting the parts of the plant related to their reproduction, can indirectly reduce or control the spread of the species. Thus, the spread of these NAPS can be controlled and minimize invasion risk, especially in Gunung Gede Pangrango National Park area.

These NAPS can also be made as medicinal plant simplicia for long-lasting storage. Harvesting large amounts of NAPS for drying can also be processed into jamu, a form of herbal medicine. Furthermore, the community can commercialize herbal medicine as one of the local products of Cibodas Biosphere Reserve’s community. This practice, along with studies on plant species and their phytochemical content comprehensively, considers their use as medicine which needs precaution. In the end, the activity of utilizing NAPS is not only useful for controlling the NAPS population but also as the form of preserving traditional knowledge owned by the community.

The utilization of NAPS as the management option has been carried out in several sites. The other study on NAPS as traditional medicine was also carried out in South Africa, which recorded 89 invasive plant species (McGaw et al. 2022). In Indonesia, Merremia peltata, an invasive species in Bukit Barisan Selatan National Park, Sumatra, is used as animal feed to control its spread (Garsetiasih et al. 2019), and its biomass can be processed as organic fertilizer or soil enhancer (Duryat et al. 2023). Apart from medicine, the utilization of NAPS also includes the production of biochar from Ragweed and horseweed to efficiently adsorb Cd (II) and Pb (II) (Lian et al. 2020), charcoal production from Prosopis juliflora (Tabe-Ojong 2023), also animal feed and organic fertilizer from water hyacinth (Yan et al. 2017). Centrosema pubescens, known as an invasive weed species, also has the potential as forage under pine stands at Forest Area with Special Purpose in Mount Bromo (Zaki et al. 2022). Another utilization comes from the aquatic ecosystem in the Mediterranean basin, which harvests invasive fish species to use their poison for cosmetic industry purposes (Papadaki et al. 2022).

Consideration about the invasive risk, there is a critical stage between naturalized species into invasive species. Many factors play a role in making a species invasive. However, the main factor that causes the spread of an alien species to a location to become uncontrollable is associated with traits of the species, traits of recipient communities, and species-community interactions (Catford et al. 2019). Some traits associated with plant invasiveness are specific leaf area, growth
rate, flowering phenology, higher fecundity, and seed dispersal mechanism (Milanović et al. 2020).

Search results of the invasive status of these used NAPS showed that 39 species are included in the invasive species list in the CABI Compendium (CABI 2022), and 14 species of them are invasive species in Indonesia (KLHK 2016; Tjitrosoedirdjo et al. 2016a). The 14 invasive species in Indonesia are Ageratina riparia, Bidens pilosa, Brugmansia suaveolens, Erechtites valerianifolius, Stachytarpheta jamaicensis, Astroleeuropatorium inulifolium, Cestrum aurantiacum, Cinchona pubescens, Clidemia hirta, Passiflora edulis, Passiflora ligularis, Piper aduncum, Sphagneticola trilobata, and Tithonia rotundifolia. However, these invasive plant characteristics may not be the same as the condition of the species in the Cibodas Biosphere Reserve.

Therefore, it is necessary to have a risk analysis to assess the invasive risk of each species. The number of species traits and different environmental conditions resulted in different risks for each species in different locations. It causes a species can be invasive in one location while not in another. However, through a risk assessment, it can be known which species have a high risk of invasiveness and which are not at risk of being invasive so that the utilization of their populations can still be controlled, especially those in forest areas. There are two invasive risk analyses in the form of pre-border and post-border in Indonesia (Tjitrosoedirdjo et al. 2016a; Tjitrosoedirjo et al. 2016b). This risk analysis scheme is by scoring some questions and statements regarding the traits of the species and its environmental conditions. In the pre-border analysis, the result score determines whether the species is potentially invasive. In contrast, in the post-border analysis, the score will determine the management for handling the species in the field.

In this case, because most of the species used come from the environment around the community’s settlement, such as yards and gardens, the risk analysis that can be applied is pre-border analysis. The results will indicate which species have high or low invasive potential. Species with low risk can be utilized optimally for the community’s needs. In contrast, high-risk species need precaution in their utilization so that these species do not spread widely, especially into TNGGP forest areas. In the end, the community still practices the NAPS utilization as a medicinal plant to fulfill their healthcare need. At least, regular use of NAPS for medicinal purposes is expected to control the spread of NAPS while preserving the community’s traditional knowledge.

4. Conclusions

Utilizing naturalized alien plant species as a source of raw materials for natural medicines benefits the community. Most of the used species have proven to have pharmacological effects that benefit health needs. Nevertheless, the precautional principle is needed in this utilization, especially for species declared invasive in Indonesia. Thus, it is necessary to have a risk analysis for each used species to determine the risk of invasiveness. Furthermore, harvesting these species can be a management option to control the spread of these species to avoid invasion risk into the Gunung Gede Pangrango National Park area. This utilization also to preserves the traditional knowledge of the community around Cibodas Biosphere Reserve.
Acknowledgments

The authors thank LPDP for the research funding support. The authors also thank Mr. Muslim from Cibodas, Mr. Jamaludin from Bodogol, and Mr. Uden from Gekbrong, who supported all fieldwork activities and the questionnaire survey data collection.

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