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Inventory of Invasive Alien Plant Species (IAPs) in Bali Botanic Garden and the Adjacent Areas

Inventarisasi Tumbuhan Asing Invasif di Kebun Raya Bali dan Wilayah Sekitarnya

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ABSTRACT

Similar to other botanic gardens, Bali Botanic Garden (BBG) is also prone to the spread of Invasive Alien Plant (IAP) species. Unfortunately, research about IAP species in BBG is still very limited. Thus, the study aims to update the list of IAP species in BBG and its adjacent areas as well as to provide a garden manager with data of the most important IAP species. This study was conducted by using sampling plots that were purposively established in three areas of BBG, namely the Ekor Burung (EB), VIP, and Kepala Burung (KB). Data analysis was performed to calculate the Relative Frequency (RF), Important Value Index (IVI), Clustering analysis, and NMDS ordination. The study was able to document 18 IAP species. Ageratina riparia and Bidens pilosa have the highest RF in EB, while the former also has the highest RF in VIP and KB. Similarly, the highest IVI was acquired by A. riparia in VIP and KB, as well as by Sida rhombifolia in EB. Cluster analysis revealed two subsets. NMDS ordination suggested that VIP and KB have more similar IAPs than the EB. This study suggested that A. riparia is the most important IAP species in BBG and its surrounding areas.

KATA KUNCI
inventarisasi, tumbuhan asing infasif,
Ageratina riparia, Bali, Kebun Raya

INTISARI

Sepertihalnya Kebun Raya lain, Kebun Raya Bali (BBG) juga rentan terhadap penyebaran Tumbuhan Asing Invasif (IAP). Sayangnya, penelitian tentang IAP di BBG dan daerah sekitarnya masih sangat terbatas. Karena itu, penelitian ini bertujuan untuk memperbarui daftar jenis IAP di BBG dan daerah sekitarnya serta menyediakan data jenis IAP paling penting bagi pengelola Kebun Raya. Penelitian ini dilakukan dengan menggunakan *plot* sampel yang secara *purposive* diletakan pada tiga wilayah BBG yaitu Ekor Burung (EB), VIP dan Kepala burung (KB). Analisis data dilakukan untuk menghitung Frekuensi Relatif (RF), Indeks Nilai Penting (IVI), analisis klaster dan ordinasi NMDS. Penelitian ini mampu mendokumentasikan 18 spesies IAP. *Ageratina riparia* dan *Bidens pilosa* memiliki nilai RF tertinggi di EB, sementara yang disebutkan pertama juga memiliki RF tertinggi di VIP dan KB. Demikian pula, nilai IVI tertinggi di VIP dan KB diperoleh oleh *A. riparia* serta oleh *Sida rhombifolia* di EB. Analisis klaster mengungkapkan dua *subset*.

Ordinasi NMDS menunjukan bahwa VIP dan KB memiliki jenis-jenis IAP yang lebih mirip daripada EB. Studi ini juga menunjukkan bahwa *A. riparia* adalah jenis invasif paling penting di BBG dan daerah sekitarnya.

Introduction

Invasive Alien Plant Species (IAPs) is a major problem in many countries, including Indonesia. Tjitrosoedirdjo (2005) reported the presence of more than a thousand alien plant species in Indonesia with five and 20 species were considered as aquatic and terrestrial important alien plant species. The list was then updated by Setyawati et al. (2015), which listed 357 species of IAPs of Indonesia. Furthermore, Tjitrosoedirdjo et al. (2016) listed 75 plant species as important IAPs in Indonesia. Bali Botanic Garden (BBG) is an ex-situ plant conservation agency, authorized by LIPI, focused on eastern Indonesia mountainous plants with thousands of living plant species, herbarium vouchers, and seed collections. BBG is also serving research activities in the field of botanical and ecological sciences, environmental education, and as a tourist destination with more than half-million visitors annually. As a botanic garden, BBG is very concerned about the spread of IAPs. Hulme (2011) suggested that botanic gardens might have a role in global plant invasion, and Hulme (2015) furthermore reported that 99% of worst IAPs were found in at least one of the botanic gardens living collection across the globe.

In order to mitigate the potential spread of IAPs, the European Code of Conduct for Botanic Garden on Invasive Alien Species suggested that botanic gardens must be aware of both IAPs in their country and region and the danger that its posed (Heywood & Sharrock 2013). Several research have been conducted to understand the spread of IAPs from the Indonesian Botanic Garden. Santosa et al. (2014) reported seven species of invasive weeds in Bogor Botanic Garden was also found outside the garden. One of the seven species, namely *Mikania micrantha,* is considered as IAPs in Indonesia by Setyawati et al. (2015). Zuhri and Mutaqien (2013) reported possible escape of *Cinchona pubescens, Calliandra calothyrsus* and *Cestrum auratiacum* from Cibodas Botanic Garden into Mt. Gede Pangrango National Park. Another IAPs that was spread out from Cibodas Botanic Garden was a bamboo species of *Chimonobambusa quadrangularis* (Damayanto & Muhaimin 2017).

Back to BBG's case, previous floristic inventories, i.e. Sutomo et al. (2012); Fardila and Sutomo (2013); Sutomo (2015) and Mukaromah (2015) were mainly conducted in the forest area of Batukaru Nature Reserves adjacent to the BBG. To the best of our knowledge, studies of IAPs inside and in the adjacent areas of BBG are very limited. No previous study tried to document all IAPs present in BGG. Instead, studies such as by Sutomo and Peneng (2013) and Sutomo and van Etten (2014) focused only on specific IAP species, namely *Ageratina riparia*. *A. riparia* is important IAP species in BBG and its surrounding area as the species invasion in the area was well documented in studies such as Sutomo and Peneng (2013); Sutomo and van Etten (2014) and Mukaromah (2016).

In order to fill the absence of IAPs inventories effort in BBG and its adjacent area, we propose this study as the first attempt to listed all present IAPs in BBG and its adjacent areas. The adjacent areas in this study were the human settlement areas bordered with the garden. The study aims to provide recent data of

IAPs in both BBG and the adjacent areas. IAPs inventory in BBG is important to documented the current presence of IAPs in the garden as well as to raise the awareness of botanic garden stakeholders to the IAPs issues present in the garden. This study result will also enable a garden manager to come up with research-based policies to prevent further spread of IAPs in, into, and from the Botanic Garden.

Methods

Study area

The study was conducted in January-February 2018 at the edges of the BBG area and the adjacent areas, i.e. settlements, farms. BBG is located in Candikuning Baturiti, Tabanan Regency, Bali, and situated about 1200-1300 meters above sea level in the Bedugul Basin. BBG occupies an area of about 157.5 hectares. Parts of the garden are adjacent to Batukaru Nature Reserve, while some other parts of the garden are adjacent to the human settlement. Part of Batukaru that bordered with BBG is a natural forest in the slope of Mt. Tapak, while human settlement near BBG is mainly composed of houses and some farms.

Three areas were sampled in this study, namely Kepala Burung (KB), VIP, and Ekor Burung (EB) (Figure 1). KB is directly bordered with Batukaru Nature Reserve. KB was the most natural site of the three-site sampled in this study as the site does not serve as a tourism spot and not contain BBG plant collections. VIP and EB, on the other hand, were bordered with human settlements, both sites also contain BBG plant collections. However, as the VIP area serves as a tourism spot and contains the VIP accommodation, the maintenance effort and humans present in this area are more intensive than in the EB, which not serve as a tourism spot.

Data collection

A total of 25 plots were purposively placed. 1 x 1 m plots were used in this research as we focused on the understorey plant species. Used of 1 x 1 m to measure understorey plant species was in correspondence with Kent (2011); Windusari et al. (2012) and Nahdi and Darsikin (2014). Ten plots were established in VIP and EB with five plots inside the garden, and the rest were outside (settlements). Also, five plots were established inside the garden in the KB area. We did not establish plots in the nature reserve since the study is focused on IAPs that occur both in the garden and the adjacent settlements. Plots outside the garden were purposively placed, regardless of their distance from the garden.

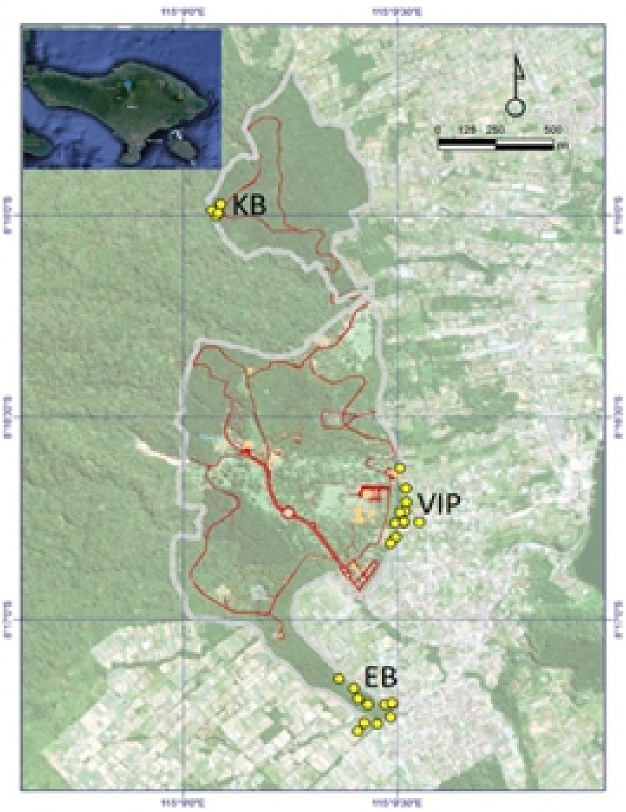

Figure 1. Study area (©Google Earth and Bali Botanic Garden)
Gambar 1. Area studi (©Google Earth dan Bali Botanic Garden)

Recorded data included the names and number of all plant species in each plot. Plant identification was conducted in the field. Unidentified species were made into herbarium vouchers and then analyzed in Herbarium Hortus Botanicus Balinese (THBB). All specimen names and families were verified using an online source, The Plantlist (2013). Checklists of IAPs in Indonesia, i.e. Setyawati et al. (2015) and Tjitrosoedirdjo et al. (2016), were applied to this study to acquired data of invasive status and origin of the IAPs.

Data analysis

Importance Value Index (IVI) was calculated to determine the most important IAPs in each site. Understanding IVI value was important to determine which IAPs needed the most attention in order to prevent its further spread. The IVI was analyzed, according to Ismaini et al. (2015) and Sujarwo and Darma (2011), by summing the value of Relative Density (RD) with the Relative Frequency (RF). The RD and RF were calculated as follow (Sujarwo & Darma 2011; Ismaini et al. 2015) :

$$Relative\ Density\ (RD) = \frac{Density\ of\ X\ species}{\Sigma\ Density} x\ 100 \quad ....(1)$$

$$Relative\ Frequency\ (RF) = \frac{Frequency\ of\ X\ species}{\Sigma\ Frequency}\ x\ 100 \quad ....(2)$$

While the Species Density and Species Frequency were calculated as follow (Sujarwo & Darma 2011; Ismaini et al. 2015) :

$$Species\ Density = \frac{\Sigma\ speciment\ of\ X\ species}{plot\ size} \quad ....(3)$$

$$Species\ Frequency = \frac{number\ of\ plot\ X\ species\ was\ found}{\Sigma\ Plots} \quad ....(4)$$

NMDS ordination and Clustering Analysis were then analyzed according to the *Bray-Curtis similarity algorithm* (Bray & Curtis 1957), and performed using PAST package ver. 3.21 (Hammer et al. 2001). NMDS and Clustering Analysis were conducted to analyze the similarity of the IAPs species between the sites. This data was important to understand how the IAPs were distributed in BBG.

Results and discussion

This study recorded 18 IAPs belonging to 10 families and 16 genera (Table 1). The number of IAPs obtained in this study is higher than the number of alien plant species recorded by Mutaqien et al. (2011) in which they studied the Wornojiwo forest, one of the remnant forests of Cibodas Botanic Garden, with 15 IAPs. However, this study is less than Junaedi (2014), which recorded 26 exotic plant species in all remnant forests of Cibodas Botanic Garden, including the Wornojiwo forest. The differences with previous studies are probably due to the habitat. Two previous studies were focused on the remnant forest within the botanic garden, while this study focused on the maintained areas of the botanic garden and its adjacent settlements. Also, a different understanding of IAPs should be taken into account to understand the different number of IAPs listed in every study. This study only listed the species, which defined as IAPs of Indonesia by Setyawati et al. (2015) and Tjitrosoedirdjo et al. (2016). Meanwhile, two previous studies were listed all exotic alien plant species obtained in the respective study areas, including some species which are not mentioned in the checklist of IAPs of Indonesia cited in this study.

Member of Compositae was the most common species, comprising 33% of all species in the list, followed by Convolvulaceae (11%), Euphorbiaceae (11%), and Poaceae (11%) (Figure 2). This result is following Pysek (1997), which suggested that Compositae was the second most represented plant taxa in the world IAP community after the Graminae. This result is also in correspondence with Tjitrosoedirdjo (2005), which stated that members of Asteraceae, the former name of Compositae, was the most introduced plant taxa in Indonesia with 162 plants species.

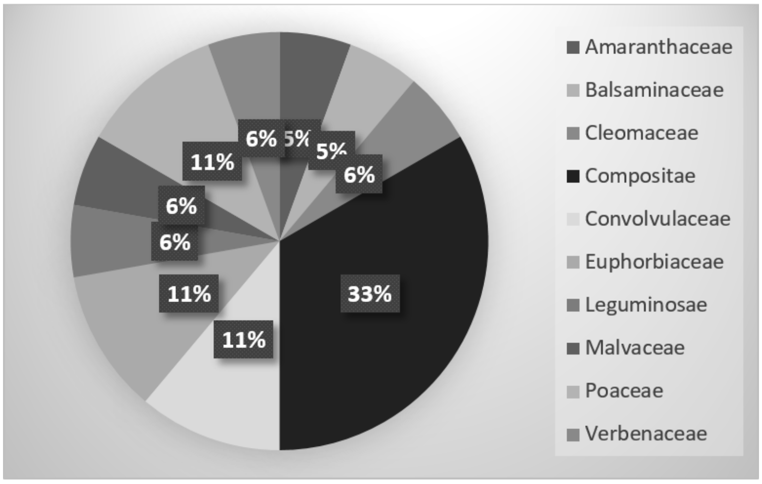

Figure 2. Families of IAPs in BBG and adjacent areas
Gambar 2. Famili-famili IAPs di BBG dan wilayah sekitarnya

Tropical America was the most common origin of the IAPs obtained in this study, with 17%, followed by Mexico and Central America with 13%, respectively (Figure 3.). This result is once again in correspondence with Tjitrosoedirdjo (2005), which mentioned that tropical parts of the American continent are the second most common origin of introduced plant species in Indonesia. We thought that since the Central and Tropical America share the same tropical climate as Indonesia, the plant species originated from these regions were also thriving in Indonesia. A similar climate eases the adaptation process of the alien plant species. Eased adaptation will then enhance the invasive species establishment and thus, made them invasive. This suggestion was supported by the fact that Central and Tropical America originated IAPs, namely, *S. trilobata*, *A. inulifolium*, and *L. camara* are listed as important IAPs in Indonesia by Tjitrosoedirdjo et al. (2016).

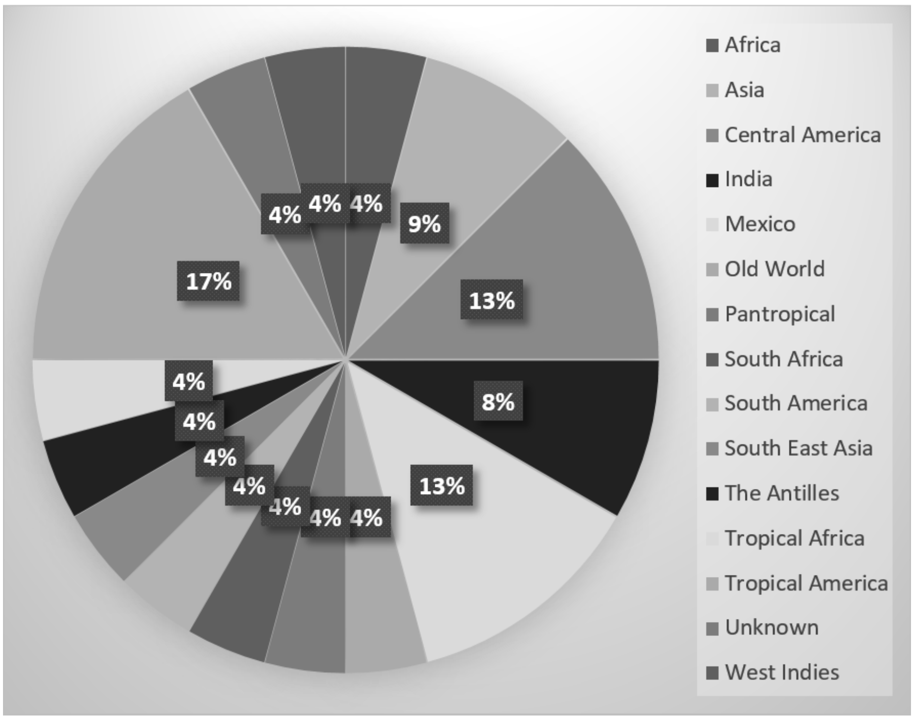

Figure 3. Origin of IAPs in BBG and adjacent areas
Gambar 3. Asal IAPs di BBG dan wilayah sekitarnya

This study showed that the VIP area has the highest diversity of IAPs with 14 species, which is equal to 77,8% of all IAPs obtained in this study, while the KB area has the lowest diversity of IAPs with eight species (Figure 4.). The different number of IAPs is probably due to the difference in anthropological disturbances received by each area. Lozon and MacIsaac (1997) stated that human-associated mechanism is important for the establishment of disturbance-dependent exotic plant species. In Borneo, for example, logging road establishment was helping the spread of *Piper aduncum* (Padmanaba & Sheil 2014).

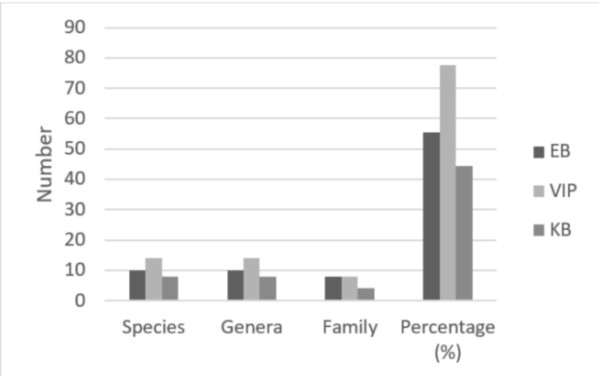

Figure 4. Number of species, genera, families, and percentages of IAPs
Gambar 4. Jumlah spesies, genus, family, dan persentase dari IAPs

Of all areas sampled in this study, VIP received most anthropological disturbance. The VIP is located on the edge of BBG that directly bordered with the settlements. The area contains plant collection and is a favorite tourist spot so that maintenance efforts in this area must be very intensively conducted. The anthropological disturbance that occurred in this area was also due to a lack of fences that allow the free movement of the villagers to the garden. Similar to the VIP, the EB is also situated on the edge of BBG that directly bordered with the settlements. Lack of fences also occurred in the EB, and the area also contains plant collections. Fortunately, there is an absence of tourist activities in the EB, so that anthropological disturbance might be less than the VIP. The KB is completely different from the previous two areas. The KB is located on the edge of BBG that bordered with the Batukaru Nature Reserve. The area is restricted for tourists due to difficult and dangerous access so that it received the least anthropological disturbance.

Setterfield et al. (2005) stated that the establishment of invasive *Andropogon gayanus* was increased by the presence of canopy and ground cover disturbance. The statement is somehow in correspondence with the result of this study, which suggests that the highest number of IAPs is found in the area with most canopy and ground cover disturbances, like VIP, followed by a lesser disturbed area of EB, and a least disturbed area of KB. Intensive maintenance effort in the VIP made this area has a least canopy and ground cover of all area sampled in this study. The canopy and ground cover of EB is better than in VIP since there are many big 'reforestation' trees and fewer maintenance efforts. KB is an area with the best canopy and ground cover sampled in this study. The area is dominated by the big and old existing trees that made a dense canopy. The ground cover is also denser than the other two areas since the maintenance efforts in this area are very limited and only focused on cleaning up the trails. In the KB, we purposively established sampling plots in the trails-sides, which seem the only place that harbors IAPs in this area.

Table 1. List of invasive alien plant species in BBG and the adjacent areas recorded during the sampling.
Tabel 1. Daftar tumbuhan asing infasif di BBG dan wilayah sekitarnya yang di data selama pengambilan sampel.

	Species Name	Family	Origin	Occurring	Literatures
1	*Amaranthus hybridus* L.	Amaranthaceae	Unknown	VIP	Setyawati et al. (2015)
2	*Impatiens balsamina* L.	Balsaminaceae	India & South East Asia	EB, KB	Setyawati et al. (2015)
3	*Cleome viscosa* L.	Cleomaceae	Old World	EB	Setyawati et al. (2015)
4	*Ageratina riparia* (Regel) R.M.King & H.Rob.	Compositae	Mexico & West Indies	EB, VIP, KB	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
5	*Ageratum conyzoides* (L.) L.	Compositae	Tropical America/Central & South America	VIP	Setyawati et al. (2015)
6	*Bidens pilosa* L.	Compositae	South Africa	EB, VIP, KB	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
7	*Austroeupatorium inulifolium* (Kunth.) R.M.King & H.Rob.	Compositae	Central & South America	EB, VIP, KB	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
8	*Crassocephalum crepidioides* (Benth.) S.Moore	Compositae	Tropical Africa	VIP, KB	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
9	*Sphagneticola trilobata* (L.) Pruski	Compositae	Tropical America	VIP, KB	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
10	*Ipomoea cairica* (L.) Sweet	Convolvulaceae	Africa & Asia	VIP, KB	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
11	*Ipomoea indica* (Burm.) Merr.	Convolvulaceae	Pantropical	EB	Tjitrosoedirdjo et al. (2016)
12	*Euphorbia heterophylla* L.	Euphorbiaceae	Mexico & The Antilles	EB	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
13	*Euphorbia hirta* L.	Euphorbiaceae	Tropical America/Central America	VIP	Setyawati et al. (2015)
14	*Calliandra calothyrsus* Meisn.	Leguminosae	Central America and Mexico	VIP	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)
15	*Sida rhombifolia* L.	Malvaceae	Asia	VIP, KB , EB	Setyawati et al. (2015)
16	*Eleusine indica* (L.) Gaertn.	Poaceae	India	VIP	Setyawati et al. (2015)
17	*Pennisetum purpureum* Schumach.	Poaceae	Tropical Africa	EB, VIP	Setyawati et al. (2015)
18	*Lantana camara* L.	Verbenaceae	Tropical America	EB, VIP	Setyawati et al. (2015); Tjitrosoedirdjo et al. (2016)

Remarks : VIP=VIP Guest House; EB=Ekor Burung; KB=Kepala Burung
Keterangan : VIP=VIP Guest House; EB=Ekor Burung; KB=Kepala Burung

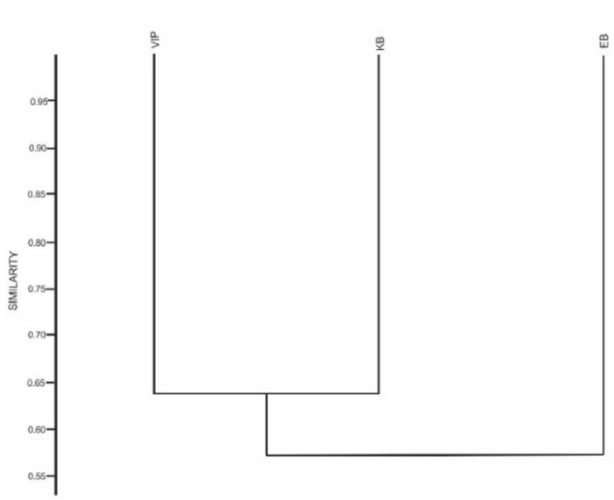

Figure 5. Cluster analysis of IAPs in BBG and adjacent areas
Gambar 5. Analisis cluster IAPs di BBG dan wilayah sekitarnya

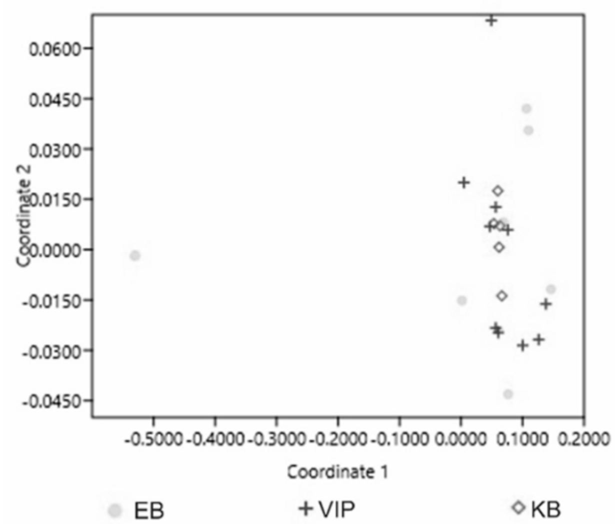

Figure 6. NMDS ordination of IAPs in BBG and the adjacent areas
Gambar 6. Ordinasi NMDS IAPs di BBG dan wilayah sekitarnya

Cluster analysis showed two subsets of IAPs (Figure 5). VIP and KB have a similarity of about 0.65, while EB similarity to those two areas is about 0.57. The analysis suggested that there are more common species obtained in VIP-KB than in other areas. There are seven IAPs obtained in both VIP and KB, such as *A. riparia*, *B. pilosa*, *A. inulifolium*, *C. crepidioides*, *S. trilobata*, *I. cairica*, and *S. rhombifolia*.

NMDS ordination showed a difference in the IAPs community obtained in this study (Figure 6). Round figures in the graphic represent the plots in EB, cross figure represent plots in VIP, and square figures represent plots in KB. Three plots in the EB are placed outside the cluster since there are no IAPs obtained in these plots. The NMDS result also showed that VIP and KB plots look more clustered than the EB, this means that IAPs composition in VIP and KB was more similar than with the EB. This NMDS result was in correspondence with the Clustering Analysis. Information regarding the different IAPs community in each site acquired from the clustering and NMDS analysis in this study is important to IAPs management attempt in BBG. Different IAPs communities might need different ways to manage. VIP and EB, which have more similarity in its IAPs community, might need a similar method of management. This information will also help if there is a need to conduct further assessment of IAPs in BBG.

The IVI value of IAPs in each area sampled this study was quite different. Mawazin and Subiakto (2013) stated that IVI value showed the dominance of a certain plant species to its plant community, with higher IVI value plant species seem to have a higher chance to grow and survive in the respective area. *Sida rhombifolia*, *A. riparia,* and *B. pilosa* have the highest IVI in the EB (Table 2). The absence of other IAPs with comparable IVI value than these three species suggested that these species are the most dominant IAPs in the area and will likely be able to survive in the future. *Ageratina riparia* is also IAPs with the highest IVI value in both VIP and KB areas with an IVI value of 0.38 and 1.11, respectively (Table 3 and Table 4). The high IVI value of *A. riparia* means that the species is very dominant in both areas. According to the IVI value obtained in this study, we supposed that *A. riparia* would be the most successful IAPs in BBG, especially in the KB area where its IVI value is significantly higher than other IAP species.

Table 2. Ecological parameter of IAPs in Ekor Burung (EB)
Tabel 2. Parameter ekologi IAPs di Ekor Burung (EB)

No	Species Name	D	RD	F	RF	IVI
1	*Sida rhombifolia* L.	9.30	0.18	0.10	0.02	0.21
2	*Ageratina riparia* (Regel) R.M.King & H.Rob.	6.10	0.12	0.30	0.07	0.19
3	*Bidens pilosa* L.	5.50	0.11	0.30	0.07	0.18
4	*Austroeupatorium inulifolium* (Kunth.) R.M.King & H.Rob.	1.50	0.03	0.10	0.02	0.05
5	*Euphorbia heterophylla* L.	1.20	0.02	0.10	0.02	0.05
6	*Cleome viscosa* L.	0.20	0.00	0.10	0.02	0.03
7	*Impatiens balsamina* L.	0.10	0.00	0.10	0.02	0.02
8	*Ipomoea indica* (Burm.) Merr.	0.10	0.00	0.10	0.02	0.02
9	*Lantana camara* L.	0.10	0.00	0.10	0.02	0.02
10	*Pennisetum purpureum* Schumach.	0.10	0.00	0.10	0.02	0.02

Remarks : D=Density; RD=Relative Density; F=Frequency; RF=Relative Frequency; IVI=Important Value Index.
Keterangan: D=Density; RD=Relative Density; F=Frequency; RF=Relative Frequency; IVI=Important Value Index.

Table 3. Ecological parameter of IAPs in VIP
Tabel 3. Parameter ekologi IAPs di VIP

No	Species Name	D	RD	F	RF	IVI
1	*Ageratina riparia* (Regel) R.M.King & H.Rob.	23.10	0.28	0.70	0.10	0.38
2	*Sphagneticola trilobata* (L.) Pruski	5.10	0.06	0.20	0.03	0.09
3	*Bidens pilosa* L.	2.30	0.03	0.40	0.06	0.08
4	*Pennisetum purpureum* Schumach.	2.60	0.03	0.30	0.04	0.07
5	*Sida rhombifolia* L.	3.40	0.04	0.20	0.03	0.07
6	*Ageratum conyzoides* (L.) L.	3.30	0.04	0.20	0.03	0.07
7	*Lantana camara* L.	0.80	0.01	0.30	0.04	0.05
8	*Amaranthus hybridus* L.	2.20	0.03	0.10	0.01	0.04
9	*Calliandra calothyrsus* Meisn.	1.50	0.02	0.10	0.01	0.03
10	*Crassocephalum crepidioides* (Benth.) S. Moore	0.30	0.00	0.20	0.03	0.03
11	*Eleusine indica* (L.) Gaertn.	0.60	0.01	0.10	0.01	0.02
12	*Austroeupatorium inulifolium* (Kunth.) R.M.King & H.Rob.	0.50	0.01	0.10	0.01	0.02
13	*Euphorbia hirta* L.	0.30	0.00	0.10	0.01	0.02
14	*Ipomoea cairica* (L.) Sweet	0.10	0.00	0.10	0.01	0.02

Remarks : D=Density; RD=Relative Density; F=Frequency; RF=Relative Frequency; IVI=Important Value Index.
Keterangan: D=Density; RD=Relative Density; F=Frequency; RF=Relative Frequency; IVI=Important Value Index.

Table 4. Ecological parameter of IAP species in Kepala Burung (KB)
Tabel 4. Parameter ekologi IAPs di Kepala Burung (KB)

No	Species Name	D	RD	F	RF	IVI
1	*Ageratina riparia* (Regel) R.M.King & H.Rob.	80.00	0.79	1.00	0.31	1.11
2	*Bidens pilosa* L.	0.20	0.00	0.10	0.03	0.03
3	*Austroeupatorium inulifolium* (Kunth.) R.M.King & H.Rob.	2.60	0.03	0.20	0.06	0.09
4	*Crassocephalum crepidioides* (Benth.) S.Moore	0.10	0.00	0.10	0.03	0.03
5	*Impatiens balsamina* L.	0.60	0.01	0.20	0.06	0.07
6	*Ipomoea cairica* (L.) Sweet	0.60	0.01	0.20	0.06	0.07
7	*Sida rhombifolia* L.	0.10	0.00	0.10	0.03	0.03
8	*Sphagneticola trilobata* (L.) Pruski	0.80	0.01	0.10	0.03	0.04

Remarks : D=Density; RD=Relative Density; F=Frequency; RF=Relative Frequency; IVI=Important Value Index.
Keterangan: D=Density; RD=Relative Density; F=Frequency; RF=Relative Frequency; IVI=Important Value Index.

Junaedi (2014) mentioned that relative frequency (RF) reflects the distribution of plant species in respective sites. Higher RF means a broader distribution of IAPs in the respective areas. The study revealed that *A. riparia* and *B. pilosa* with an RF value of 0.07, respectively, are the most common IAPs obtained in the EB (Table 2). *Ageratina riparia* is also IAPs with the highest RF value in both VIP and KB areas. RF values of *A. riparia* in VIP and KB areas are significantly higher than other IAPs and revealed that *A. riparia* is the most widely distributed IAPs in both areas. Junaedi and Dodo (2014) also stated that an exotic plant is defined as an invasive if the RF is above 10%. Based on that statement, this study showed that there is no defined IAPs in the EB area. However, this study also revealed that *A. riparia* is a defined IAPs in both VIP and KB areas.

The high RD, RF, and IVI values of IAPs such as *A. riparia* in VIP and KB indicated the species' invasive behavior. Significantly higher RD value of *A. riparia* in both sites indicated that the species was almost producing a uniform community, suppressing all other plant species in respective sites. Significantly higher RF value of the species, on the other hand, indicated that *A. riparia* could be found in the majority of the plots placed on the respective sites, indicating that the species can be live in almost all places within the sites. Finally, the significantly higher IVI value of *A. riparia* indicates that the species used most of the resources available in respective sites, suppressed other plant species in competition for resources. All of these treads indicated the invasive behavior of IAP species documented in this study, especially the *A. riparia*.

Our study suggested that *A. riparia* is the most important IAPs species in BBG and its adjacent areas. Other than having high IVI and RF values, *A. riparia* alongside *B. pilosa, S. rhombifolia,* and *A. inulifolium* (Figure 7.) are obtained in all areas sampled in this study. Our concern toward *A. riparia* was also based on a previous study by Mukaromah (2016) that reported *A. riparia* invasion to the top of Mt. Pohen, part of the Batukaru Nature Reserve, as well as studies by Sutomo and Peneng (2013) and Sutomo and van Etten (2014) that reported *A. riparia* as the dominant understorey plant species in both Vak VII C and the Tropical Forest Walk-Guiding Track of BBG. Thus, immediate control attempts should be made to prevent a further spread of *A. riparia* in BBG and the adjacent areas, especially in the KB and VIP area where the invasive weed was significantly dominated the IAPs community.

Figure 7. a. *Ageratina riparia* b. *Austroeupatorium inulifolium* in BBG during the survey
Gambar 7. a. *Ageratina riparia* b. *Austroeupatorium inulifolium* di BBG saat survey

Conclusion

This study was able to document 18 IAPs in BBG and its adjacent areas. Cluster analysis and NMDS ordination result suggested that VIP and KB IAPs community was more similar than EB. The *A. riparia* was the most important IAPs in this study, evidenced by the species IVI value, which highest in both VIP and KB while also second highest in EB. Thus, we suggest a control attempt is conducted for the IAP species, especially *A. riparia.* Study of IAPs in other parts of BBG was also needed fully to understand the spread of IAPs in the garden and determine the best control attempt.

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