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Phyto-morphological diversity and distribution of the Genus *Ixora* L. (Rubiaceae) in Bangladesh Agricultural University Botanical Garden

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ABSTRACT

The genus *Ixora* L. (Rubiaceae) is the largest in the tribe Ixoreae, which consists of various shrubs and tree species from humid rainforest. *Ixora* spp. is mainly distributed in Asia and the Pacific, although little is known about the ecology, taxonomy and distribution of the endemic species. The present study aimed to make primary documentation through a taxonomic study of the species available in the Bangladesh Agricultural University Botanical Garden (BAUBG). There were fifteen species (including 9 varieties of two species) recorded at BAUBG based on the morphological observations of taxonomically significant characteristics. The maximum leaf size (450.49 cm²) was reported in *I. superba*, followed by *I. nigricans* 'White' (83.13 cm²) and *Ixora polyantha* (81.54 cm²). However, minimum leaf size was noticed in *Ixora pavetta* (1.97 cm²) and *Ixora chinensis* 'Red' (2.158 cm²). A table showing their nomenclature with the conservation status has been presented in the text. Photographs of all available species and some graphs showing variations in leaves are provided as well. The current study is a pioneer study that offers a glimpse of the enormous species diversity of single genera from BAUBG. It will serve as a benchmark for future conservation and management study on these wild species.

Keywords: *Ixora*, Rubiaceae, Diversity, Medicinal Uses, BAUBG, Bangladesh

1. INTRODUCTION

Rubiaceae, the madder family (Order: Gentianales), consists of 611 genera with more than 13,150 species of herbs, shrubs, and trees, distributed primarily in tropical areas of the world (Davis et al., 2009). The family Rubiaceae is represented by a total of 165 species in Bangladesh (Das, 2014). Apart from the recorded species, there are some specimens of this family enlisted in different Herbaria of Bangladesh that remain unidentified (Das and Rahman, 2011).

Ixora L. is a genus of flowering plants in the family Rubiaceae, the only genus in the tribe Ixoreae, comprising about 530 species of shrubs and trees (Davis et al., 2009), is the third-largest genus in the family. Though the genus is native to the tropical and subtropical regions, it is widely distributed all over the globe, especially in Tropical Asia. Its greatest species density is found in the Malaysian Archipelago with its maximum in Borneo (Bremekamp, 1937a). *Ixora* is also found commonly in subtropical climates in the United States, where it is locally known as West Indian Jasmine. Other common names include “Jungle flame” and “Jungle geranium” among others. *Ixora* can be a suitable choice for bonsai making. It is a popular choice for hedges in parts of South East Asia as well. In tropical climates, they flower year-round and are commonly used in Hindu worship, as well as in Indian folk medicine and Ayurveda (Dontha et al., 2015).

The present study was designed to carry out phyto-diversity and distribution of *Ixora* L. (Rubiaceae) in the Bangladesh Agricultural University Botanical Garden (BAUBG), investigate niche partitioning of prevalent *Ixora* species at the BAUBG and update the database of *Ixora* L. (Rubiaceae) based on morpho-taxonomic characteristics including inflorescence, floral and leaf characteristics. This primary research may seem beneficial to a large number of people interested to collect, conserve or research *Ixora*. Photographs of each species were included in the paper for better identification.

2. MATERIALS AND METHODS

Study Area

Bangladesh Agricultural University is one of the well-equipped and largest universities in Bangladesh which has a well-established Botanical Garden, situated on the west bank of the old Brahmaputra River. The garden conserves about 1800 plant species under 168 families and 287 genera (<https://bg.bau.edu.bd/>). The geographic location of the garden is E90°26'29.6" and N24°43'26.8" with dominating Tropical Monsoon climates that have relative humidity between 80-84% and an average rainfall of about 2000mm at BAU and its surrounding area (Jone et al., 2022).

Survey, Data collection and Processing

The present study has been planned to prepare primary documentation through a taxonomic study of all the *Ixora* spp. available in the Bangladesh Agricultural University Botanical Garden (BAUBG). All the data were generated through field visits in the garden and those were cross-checked with The Plant List (<http://www.theplantlist.org/>) and the Encyclopedia of Flora and Fauna of Bangladesh (Siddiqui et al., 2007) for taxonomical study. Leaf samples were collected on July 03, 2022; the average temperature of the lab area was about 32 °C and the relative humidity was 72%. These samples were kept in an electric oven at 65°C for 72 hours. After that, on July 06, 2022, the final and constant dry weights were measured. The average temperature of the lab area at the time of weight measurement was about 33°C and relative humidity was 65%. Microsoft Excel 2019 spreadsheet was used to process and analyze collected data.

3. RESULTS AND DISCUSSIONS

Around 15 species with 9 varieties of two species of the genus *Ixora* L. (Rubiaceae) have been documented in the Bangladesh Agricultural University Botanical Garden (BAUBG). The species are arranged in a linear way around the Medicinal zone, Cactus zone, Cycas zone and Chittagong zone as a hedge plant. *Ixora* is a dense, multi-branched evergreen shrub of 2-3 meters in height. They have glossy, leathery, oblong/acuminate leaves sometimes with a wavy margin. In the case of *Ixora* Small, tubular, scarlet flowers in dense rounded clusters are blooms generally rainy season in Bangladesh. The documentation found that due to the amount of sunlight the color of the flowers may be light or deep. Fruits formed after the blooming of flowers. The following species are identified from the *Ixora* group from BAUBG.

Among 15 species with 9 varieties of 2 species, the conservation status of about 11 species is not available anywhere, seven (7) species were categorized as Conservation Dependent according to IUCN Conservation Status. Rest two (2) species are categorized as Least Concerned and one (1) as Vulnerable and one (1) as Data Deficient (Table 1).

Diversity among different species of the genus *Ixora* is not limited to the characteristics of its inflorescence. The morphological characteristics of leaves show a great variation from each other. From Figure 1 to Figure 3 it is obvious that anyone can differentiate *Ixora* species by studying their leaves only. *Ixora superba* has the highest leaf area and weight among all other available species (Figure 01), while *I. pavetta* has the lowest (Figure 02). Again, the leaf area, weight and specific leaf area change continuously with different growth stages as the leaf produces and stores maximum food materials in younger stages while minimum in adults specifically before senescence.

Table 1 List of *Ixora* with their scientific name and conservation status (CS)

SL	Common Name	Scientific Name	CS
1	Nata Rangan	<i>Ixora acuminata</i> Roxb	CD
2	Shurovi Rangan	<i>Ixora arborea</i> Roxb. Ex Sm.	NA
3	Lal China Rangan	<i>Ixora chinensis</i> 'Nana Red'	CD
4	China Rangan	<i>Ixora chinensis</i> 'Nana Lutea'	CD
5	Komola China Rangan	<i>Ixora chinensis</i> 'Prince of Orange'	CD
6	Lal China Rangan	<i>Ixora chinensis</i> 'Red'	CD
7	Jhumka Phul	<i>Ixora coccinea</i> L.	LC
8	Rangan Phul	<i>Ixora coccinea</i> 'Lancasteri'	NA
9	Lal Rangan	<i>Ixora coccinea</i> 'Magnifica'	NA
10	Gulapi Jhumka Phul	<i>Ixora coccinea</i> New Pink	NA
11	Lal Jhumka Phul	<i>Ixora coccinea</i> Red	NA
12	Java Rangan	<i>Ixora javanica</i> (Blume) DC.	DD
13	Shada Rangan	<i>Ixora lanceolata</i> Lam.	NA
14	Rangan	<i>Ixora macrothyrsa</i> (Teijsm. & Binn.) T. Moore	NA
15	Dikranga	<i>Ixora nigricans</i> 'White' R. Br. ex Wight & Arn.	CD
16	Variegated Rangan	<i>Ixora parviflora</i> 'variegated' Lam.	NA
17	Rangan	<i>Ixora pavetta</i> Andr.	VU
18	Chuang Giri	<i>Ixora polyantha</i> Wight	NA
19	Holud Rangan	<i>Ixora singaporensis</i> hort.	NA
20	Boro Rangan	<i>Ixora superba</i>	NA
21	Polok Jui	<i>Ixora undulata</i> Roxb.	CD
22	Bonno Rangan	<i>Ixora sp.</i>	LC

CS=Conservation status: LC= Least Concerned, CD= Conservation dependents, NA=Not Available, DD= Data Deficient, VU= Vulnerable

Twenty leaves of each species were collected for the assessment of leaf characteristics such as leaf area, fresh weight and dry weight. Among all these species, the maximum leaf size (450.49 cm²) was reported in *I. superba*, followed by *I. nigricans* 'White' (83.13 cm²) and *Ixora polyantha* (81.54 cm²). However, minimum leaf size was noticed in *Ixora pavetta* (1.974 cm²) and *Ixora chinensis* 'Red' (2.158 cm²) (Figure 1).

Again, the maximum dry weight (6.948 g) was reported in *I. superba*, followed by *I. nigricans* 'White' (0.716 g), and *Ixora arborea* (0.56 g). However, minimum dry weight was noticed in *Ixora pavetta* (0.0028 g) and *Ixora chinensis* 'Red' (0.028 g) (Figure 2). The leaf area and the weight of the leaf are directly related to each other. Figure 3 indicates the relative succulence or relative density of a plant the lower the value, the higher the succulence. Here, it is evident that *I. superba* has the maximum succulence and *I. pavetta* has the minimum succulence.

Therapeutic Properties of *Ixora*

Though *Ixora* spp. Is widely distributed and commonly available in every natural habitat of Bangladesh, local people are quite unaware of its uses other than its ornamental values. Previous research based on a few *Ixora* spp. stated that they are great sources of medicine precursors as most of them are used by some ethnic tribes worldwide. Pharmacological studies suggest that *Ixora coccinea* L. possesses some antioxidative, antibacterial, gastroprotective, hepatoprotective, antidiarrheal and chemo-preventive effects (Dontha et al., 2015). Besides this, they have anti-inflammatory (Ratnasooriya et al., 2005), anti-thelmic (Surana et al., 2011), anti-asthmatic (Naskar et al., 2013) and wound healing activities (Nayak et al., 1999). Other species like *Ixora chinensis*, *Ixora finlaysoniana*, *Ixora macrothyrsa*, *Ixora javanica*, etc. have similar properties to *Ixora coccinea* L. *Ixora* extracts have the potential to develop antimicrobial agents, particularly against *Staphylococcus aureus* and *Staphylococcus flexneri* (Marimuthu et al., 2014).

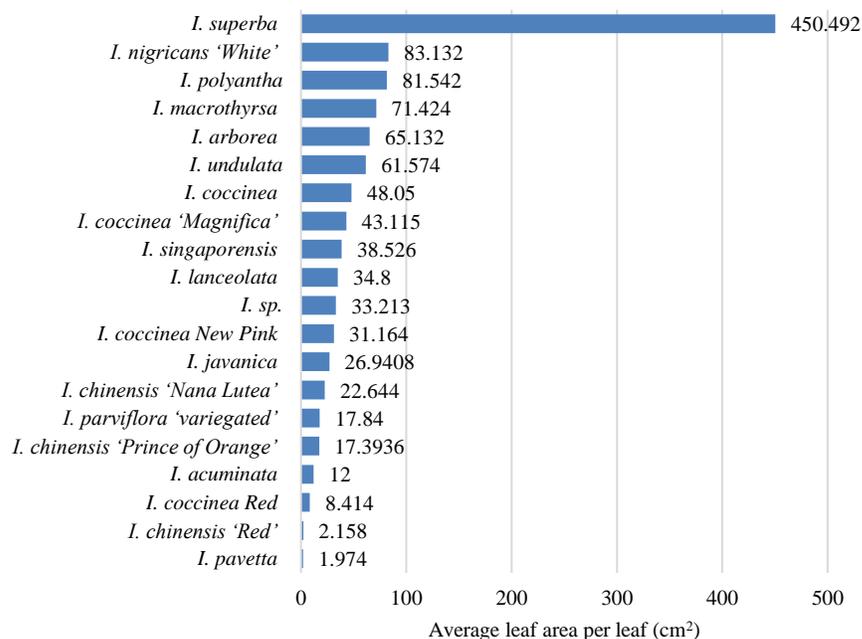


Figure 1 Variations of average leaf area (cm²) of Ixora species

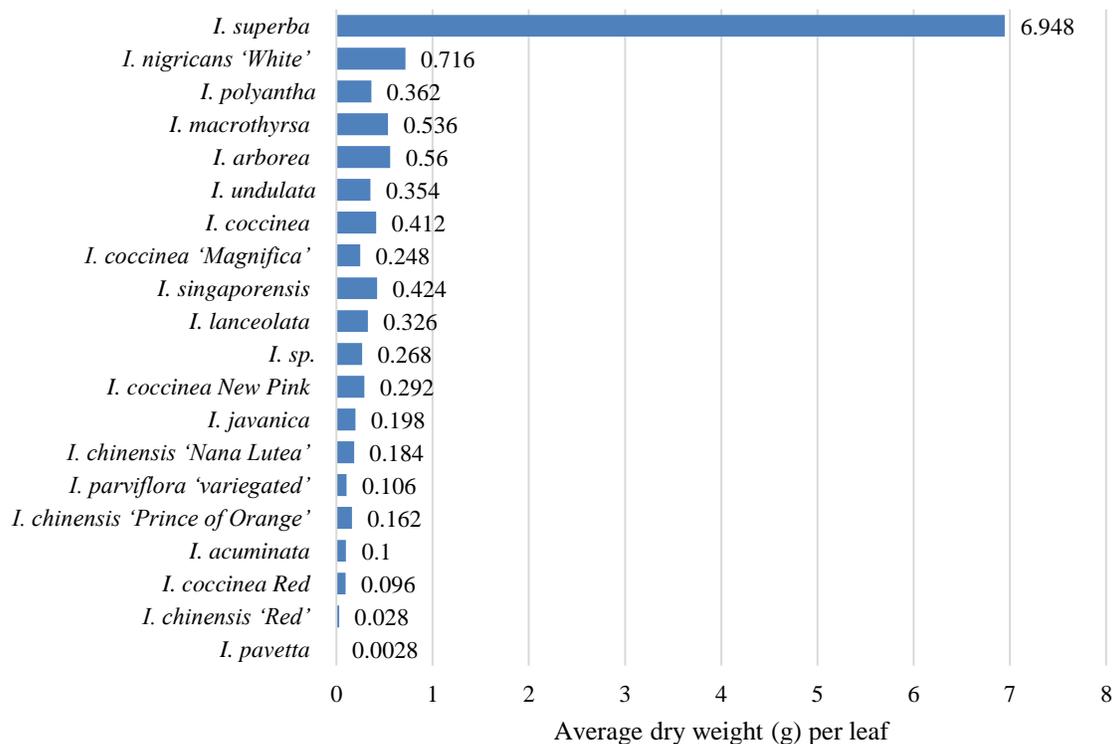


Figure 2 Variations of average dry weight (g) of Ixora species

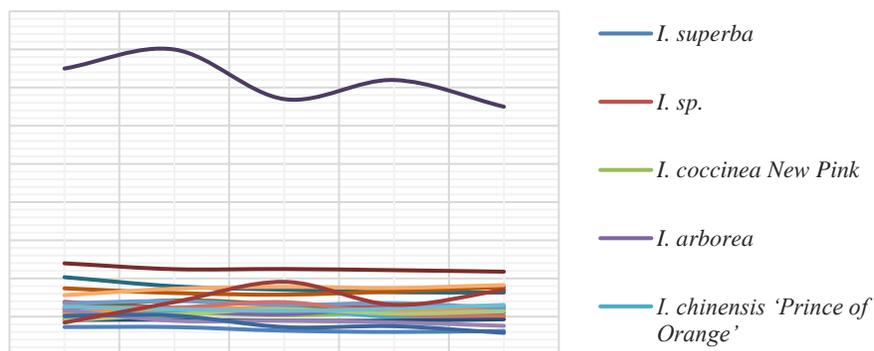


Figure 3 Variations of Specific leaf area (cm²/g) of Ixora species



Figure 4 A. *Ixora acuminata* Roxb. B. *Ixora arborea* C. *Ixora chinensis* 'Nana Red' D. *Ixora chinensis* 'Nana Lutea' E. *Ixora chinensis* 'Prince of Orange' F. *Ixora chinensis* 'Red' G. *Ixora coccinea* L. H. *Ixora coccinea* 'Lancasteri' I. *Ixora coccinea* 'Magnifica' J. *Ixora coccinea* 'New Pink' K. *Ixora coccinea* 'Red' L. *Ixora javanica* (Blume) DC.

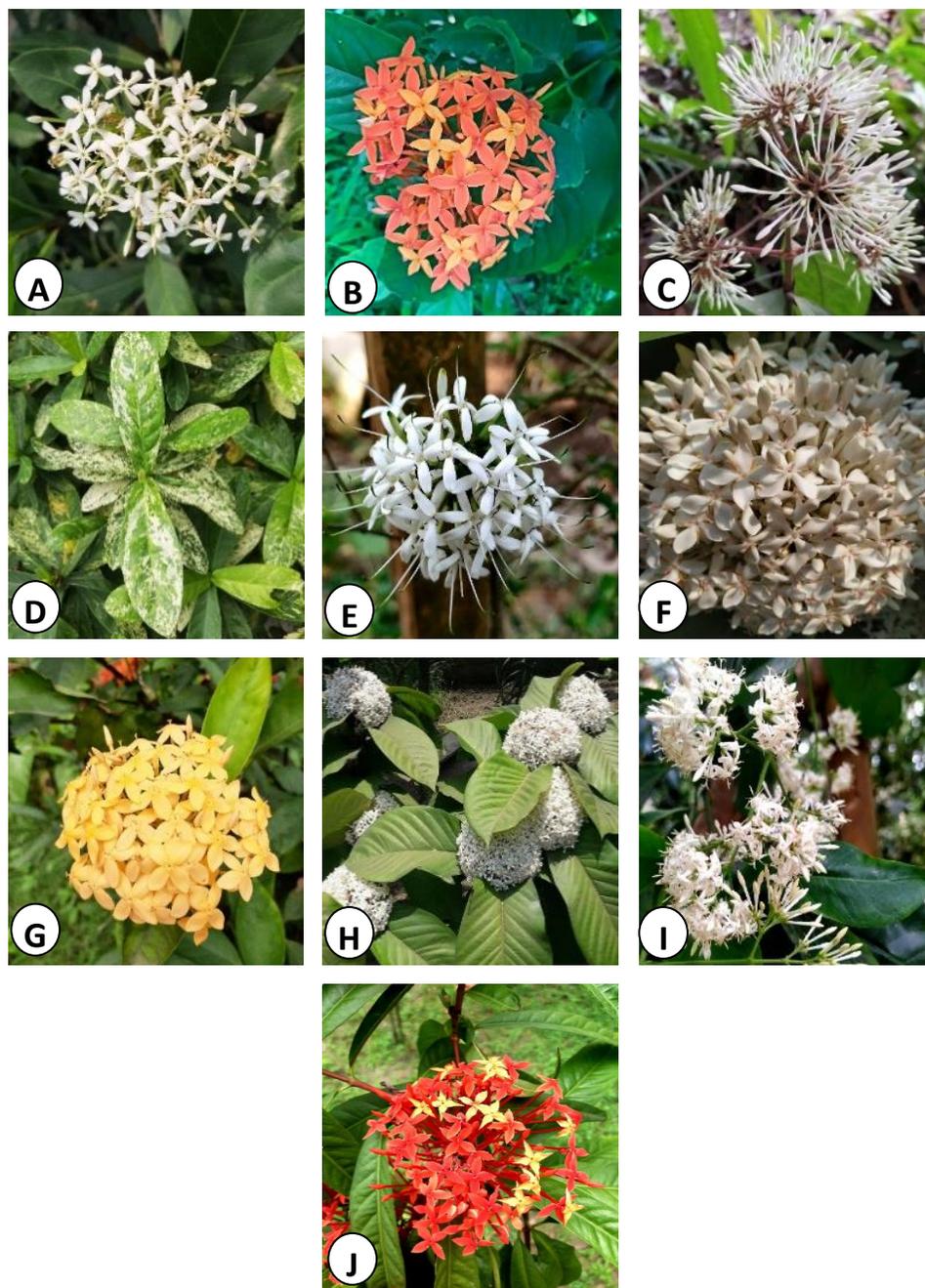


Figure 5 A. *Ixora lanceolata* Lam. B. *Ixora macrothyrsa* (Teijsm. & Binn.) T. Moore C. *Ixora nigricans* 'White' R. Br. ex Wight & Arn. D. *Ixora parviflora* 'variegated' Lam. E. *Ixora pavetta* Andr. F. *Ixora polyantha* Wight G. *Ixora singaporensis* Hort. H. *Ixora superba* I. *Ixora undulata* Roxb. J. *Ixora* sp

4. CONCLUSIONS

The findings of this study confirm the general understanding that BAUBG has very divergent species of *Ixora*. According to De Block (1998), the complexity of *Ixora* in Asia and the Pacific is the result of diversification in the genus' inflorescence structures. Most species have very similar inflorescence structures but few differences, for instance, in the arrangement of lateral axes branching of inflorescence or the ultimate flower triads may separate them. This was reflected in the present study that reproductive traits (inflorescence, floral and fruits) were important in explaining the diversity within species. Although some of the total variations were observed, it may not truly reflect the inherent diversity in the genus as well as not to mention the genus as a whole, because the study was limited to a particular area. However, much work is recommended to elucidate the extent of its morphological diversity, identity and taxonomic alignment to possibly reveal the exact number of *Ixora* species in Bangladesh, especially in the Mymensingh region.

Authors' contributions

U.S. Ruba, M.J.H. Jone and M. Ashrafuzzaman identified the research problem and designed the research outlines. U.S. Ruba and M.J.H. Jone surveyed the study area and collect all the required data and all three authors contributed to taking photographs. U.S. Ruba identified all the species documented and the other two authors rechecked and confirmed the botanical name. U.S. Ruba collected leaf samples and took morphological data; M.J.H. Jone documented the first draft and prepared all the graphs added. M. Ashrafuzzaman reviewed, revised and modified the drafts. And finally, all three authors revised and approved the final paper.

Ethical approval

Genus Ixora L. (Rubiaceae) was observed from Bangladesh Agricultural University Botanical Garden. The ethical guidelines for plants & plant materials are followed in the study for sample collection & identification.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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