Diversity and distribution of figs (Ficus: Moraceae) in Gianyar District, Bali, Indonesia

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Abstract. Wijaya IDS, Defiani MR. 2021. Diversity and distribution of figs (Ficus: Moraceae) in Gianyar District, Bali, Indonesia. Biodiversitas 22: 233-246. Fig (Ficus) is an important species in tropical regions, but there is a lack of updated data on fig diversity in Bali. This study of fig diversity and distribution in Gianyar District, Bali, Indonesia was conducted to record the alpha-diversity of figs. The intensive exploration method was applied at seven locations representing the seven sub-districts of Gianyar. Habitats and coordinates were recorded, and the appropriate samples were preserved as dried or spirit specimens. The results showed that there were 23 identified species of figs from six subgenera: Ficus (1), Pharmacosyceae (2), Sycidium (5), Sycomorus (5), Synoece (2), and Urostigma (9). Based on location, three species had restricted distribution: F. fulva, F. tinctoria ssp. globosa, F. vires, and F. subcordata, whereas six species were adapted in every location: F. montana, F. hispida, F. septica, F. punila, F. benjamina, and F. superba. The figs were primarily distributed near bodies of water, especially riverbanks.

Keywords: Ara, fig, hemi-epiphyte, keystone species, syconium

INTRODUCTION

Indonesia is a tropical country which biogeographically comprised of the Sundaland and Wallacea regions. Those regions are biodiversity hotspots with conservation priority that had more than 1,500 endemic plants and animals, but have lost 75% of their primary vegetation (Myers et al. 2000). Forest is a terrestrial ecosystem that preserves the biodiversity in Indonesia, however, it was the area with highest loss by deforestation. As an ecosystem, the forest had complex interactions among its organisms, but this complexity could be simplified by studying the keystone species. Keystone species maintain the ecosystem’s stability by altering the species composition. It could be a top predator, a dispersal agent, or a tree whose importance is rarely noticed, such as the fig (Ficus).

Fig (Ficus: Moraceae) is abundant in tropical regions and around 367 out of 735 species were growing in Malesia (Berg and Corner 2005). The high diversity among figs includes their various growth forms. Trees or shrubs were the most dominant growth forms (also called the forest-type), whereas the other growth forms were lianas or creeping figs (about 100 species) and hemi-epiphytes (about 300 species) (Berg and Corner 2005). Hemi-epiphytes are epiphytic plants that require host plants to attach to. When they grow, the roots would reach the soil through the surface stem of the host tree and then gradually grow bigger until the host tree is strangled (van Steenis 1972; Harrison et al. 2003). A hemi-epiphyte is also known as an intricate growth form because its successional rate depends on many factors, such as the species’ ability, the size of the host tree, and the position in the canopy in terms of access to light (Harrison et al. 2003).

Figs can be distinguished from other plants by their syconium. There has been some confusion because the term “fig” could refer to either the fig as an entire plant or its syconium. The fig’s syconium is a hollow, fleshy receptacle with only one hole at the tip called ostiole or orifice, which is enclosed by multiple inner bracteae. Inside the syconium, there are unisexual apetal flowers. Each female flower bears one ovule. During pollination periods, the syconium will release a species-specific compound to attract certain pollinators (Harrison and Rasplus 2006; Wang et al. 2013), and then the inner-bractea will stretch to form a small path for the pollinator (Harrison and Rasplus 2006).

Ficus is an important genus in tropical forests because it maintains the ecosystem’s stability by providing food for many types of frugivores (Shanahan et al. 2001; Harrison 2005; Sreekar et al. 2010; Kuaraksa et al. 2012). Figs are capable of producing a large number of fruits, and most of the species can bear fruit throughout the year, making them a potential resource for frugivores in periods of scarcity (Shanahan et al. 2001; Wang et al. 2005; Walther et al. 2017). Most of the bats in the subfamily Stenodermatinae are fig specialists because they rely on figs as a keystone resource (Bravo et al. 2012). The more figs are eaten, the wider the distribution of their seeds, whether by endo-zoochory, dys-zoochory, or exo-zoochory that related to the frugivores dispersal (Harrison 2005). Ultimately, this seed dispersal has played a key role in defining the forest’s composition and accelerating colonization in a phase of succession by transferring seeds from the nearby island (Wandrag et al. 2017). There is evidence that the dispersal and ecological factors were the keys to establishing the current fig distribution (Xu et al. 2015). Ficus species were
recorded in a serie of succession on Krakatau Island (after the massive explosion in 1883) as a keystone species in forest diversification through fig-frugivore interaction (Thornton and Rasplus, 2006; Cruaud et al. 2012; Suleman et al. 2014). Gall flowers in figs are useful for Aganoidae insect to oviposit their eggs as a reciprocal reward for pollination (Suleman et al. 2014). If the pollinator community dropped excessively, it would affect the interaction patterns of figs/fig-pollinating wasps interaction to host/parasite interaction by non-pollinator insects (Wang et al. 2005; Zhang et al. 2020), or it could cause the occurrence of a host shifting phenomenon by non-pollinator insects, leading to hybridization (Tsai et al. 2015; Zhang et al. 2020. Cruaud et al. (2012) published comprehensive work on fig/fig-pollinating wasp interaction and found that if the mutualistic interaction was a long-term codiversification that spread from Eurasia. The codiversification might be included in major evolutionary events in figs. Zhang et al. (2019) hypothesized that the fig/fig-wasp interaction might be one of the factors that led to several fluctuations in the evolution of monoeocious and dioeocious figs, which is connected with the fig’s recent biogeographical range. Biogeographical range correlated with gene flow could be mismatching some characters or strengthening the co-adaptation pattern (Medeiros et al. 2018).

Figs have proven to be an essential part of the tropical ecosystem, but there has been a lack of updated data on fig diversity in Bali. The latest data only show the fig diversity of Lesser Sunda with 34 species (Berg and Corner 2005). Harrison (2005) stated that diversity (alpha-diversity) of the fig should be re-assessed because it might be underestimated due to the sampling protocol. Fig diversity was derived from a tree plot, however, there were not many figs with the tree growth form in the lowland forest (Harrison 2005).

The Balinese culture mostly integrated with Hinduism used many species of plants in religious offerings which is indirectly lead to local-based conservation (Suwarjo et al. 2020). The use of figs in Balinese culture is not the only factor that causes the existence of figs in Bali. A more influential factor is the natural environment conditions that suit the figs’ habitat, one of which is in Gianyar District. This district has various altitudes from 0-950 m asl. (BPS-Statistics of Gianyar 2019) with diverse types of landscapes such as coasts, estuaries, lowland areas, and highland areas. This district also has many permanent rivers that flow throughout the year (Hadisusanto et al. 2018). Watersheds, especially riparian vegetation or riverbanks are the habitat preference for figs. Based on those factors, this study aimed to assess the diversity and distribution of figs in Gianyar.

**MATERIALS AND METHODS**

**Study area**

Research was conducted from March to September 2020 in Gianyar District, Bali, Indonesia. This district is located at S: 08°11'48"-08°38'58" and E: 115°13'29"-115°22'23", covers 36,800 ha area, and has an altitude varying from 0-950 m asl. (BPS-Statistics of Gianyar 2019). Gianyar District consists of 7 sub-districts which were used as the 7 main exploration areas: I (Bhahbatuh), II (Gianyar), III (Sukawati), IV (Ubud), V (Payangan), VI (Tampaksiring), and VII (Tegalalang), as shown in Figure 1.

**Data collection, preparation of specimens, and identification**

Morphological characterization was carried out by describing the characteristics of figs such as roots, stems, leaves, flowers, and fruits. Each characteristic was photographed/document, particularly the fruit (syconium), which is known as the main feature of the fig. The syconium was split longitudinally in order to obtain the structure of the orifice, flower arrangement, color, and characteristics of the fleshy receptacle. Fruit characteristics could indicate the preferences of frugivores based on size, color, and fruit location (Shanahan et al. 2001). Supporting descriptions were also added, such as their habitat, habitus or growth form, and interactions with other organisms were included as supplementary taxonomical data.

The fruit (syconium) is the most important organ of the fig species, and it should be prioritized in sample collection (Rugayah et al. 2004). The fruit was preserved as a spirit specimen by putting it in a jar and adding 70% alcohol, closing the jar tightly, and labelling it. Other samples such as leafy twigs with or without fruit, were preserved as dry specimens according to Womersley (1981). Samples were washed in running water, placed in papers, and sprayed with 70% alcohol for sterilization. Samples were stacked in group of 5-10, then pressed with plywood to dry in an oven for about 7 days. After being dried, samples were arranged on 420 x 297 cm paper, labeled, and covered with transparent plastic. Labels consisted of much information, such as the collection number, collector, collection date, family, scientific name, local name, determinator, date of identification, location, habitat, and annotations composed of description of characteristics that could not be collected or probably change during preservation (Womersley 1981; Rugayah et al. 2004). The collected spirit and dried specimens (voucher specimens) were stored at the Biology Study Program, Faculty of Mathematics and Natural Sciences, Udayana University, Bali, and not yet deposited in any herbarium.
Figur[73x485]e 1. Exploration area for figs (Ficus) in Gianyar, Bali, Indonesia

Photos, spirit specimens, and dried specimens that collected were important materials for identification. The books Flora of Java vol. 2 (Backer and van den Brink, 1965) and Flora Malesiana series 1 Spermatophyta, Moraceae: Ficeae (Berg and Corner 2005) were used as the two main references for identification, while for nomenclature status was accessed using The Plant List (https://www.theplantlist.org/), The International Plant Name Index Collaborators (https://www.gbif.org/), Plant of the World Online (https://www.plantsoftheworldonline.org/), and cross-referenced with Flora Malesiana series 1 Spermatophyta, Moraceae: Ficeae (Berg and Corner, 2005) to obtain the accepted name. The figs’ conservation statuses were assessed via the International Union of Conservation of Nature (IUCN) Red List of Threatened Species™ (https://iucnredlist.org/) and then compared with Indonesia’s Ministry of Environment and Forestry regulation (Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia Nomor P.106/Menhk/Setjen/Kum.1/12/2018 tentang Perubahan Kedua Atas Peraturan Menteri Lingkungan Hidup dan Kehutanan Nomor P.20/Menhk/Setjen/Kum.1/6/2018 tentang Jenis Tumbuhan dan Satwa yang Dilindungi) to assess their national conservation statuses.

RESULTS AND DISCUSSION

Figs diversity in Gianyar, Bali

The fig (Ficus) is the largest genus in the Moraceae family with a more complex classification. Taxonomically, the genus of Ficus has three infrageneric classifications: subgenus, section, and subsection. In this study, 23 species composed of six subgenera were obtained (Table 1) with some documentation shown in Figure 2. The subgenus Urostigma was the most highly represented, with nine species, whereas the others were five species in the subgenus Sycidium, five species in the subgenus Sycomorus, two species in the subgenus Synoecia, and one species each in the subgenera Pharmacosycea and Ficus. Table 1 is also comprised of the habitus and fruit of the fig. Terrestrial trees or shrubs were the dominant habitus, followed by hemi-epiphytes and creeping figs. Some species could have more than one habitus, such as Ficus elastica and F. Superba, which are commonly found as trees, but could also appear as hemi-epiphytes. Fruit characteristics were added to provide an overview of potential frugivores. Large fruits, pale colors (usually greenish when mature), and cauliflorous/ramiflorous or flagelliflorous characteristics were commonly preferred by volant mammals, whereas fruits with bright color (contrasted with leaves) and placed axillarily or at the tips of branches were preferred by birds (Thornton et al. 1996). Among the 23 figs in Gianyar, 17 species had axillary figs, three species had cauliflorous/ramiflorous figs, two species had short flagelliflorous figs, and one species had long flagelliflorous figs. The IUCN Red List (2020) was accessed to derive the global conservation status of the figs. All fig species in this study were classified as Least Concern (LC), but categorized as an object of conservation ex-situ.
Figure 2. Fig species found in Gianyar, Bali. A. Ficus fulva; B. Ficus callosa; C. Ficus ampelox; D. Ficus montana; E. Ficus subulata; F. Ficus tinctoria ssp. gibbosa; G. Ficus fistulosa brownish-purple fig variation; H. Ficus hispida; I. Ficus racemosa; J. Ficus variegata; K. Ficus pumila; L. Ficus trichocarpa; M. Ficus drupacea; N. Ficus rumphii; O. Ficus subcordata; and P. Ficus superba

Table 1. List of figs (Ficus: Moraceae) in Gianyar, Bali, Indonesia. The scientific names were derived from Berg & Corner (2005) and https://www.plantsoftheworldonline.org/ with synonyms

| Subgenus Ficus | Scientific name | Common names | Habitus | Fruit |
|----------------|----------------|--------------|---------|-------|
| Ficus fulva Reinw. ex Blume | Ficus fulva Reinw. ex Blume | Stinging fig (English); hamerang badak, kuyang, kebeg (Indonesia); - (Bali) | Terrestrial tree. | Pale green with hairy surface; Axillary, solitary or in pairs. |
| Synonyms: | Ficus apiculata Miq. | | | |
| Ficus chlorocarpa Miq. | | | | |
| Ficus chrysocarpa Reinw. ex Blume | | | | |
| Ficus discolor Miq. | | | | |
| Ficus patens Ridl. | | | | |
| Ficus reinwardtii Link & Otto | | | | |
| Ficus suborbicularis Miq. | | | | |
| Pogonotrophe flavidula Miq. | | | | |

| Subgenus Pharmacosycea | Scientific name | Common names | Habitus | Fruit |
|-----------------------|----------------|--------------|---------|-------|
| Ficus callosa Wild. | Ficus callosa Wild. | Calloused fig (English); ilat-ilatan, lasi (Indonesia); - (Bali) | Terrestrial tree. | Pale green with pubescent surface; Axillary, solitary or in pairs. |
| Synonyms: | Ficus basidentula Miq. | | | |
| Ficus cinerascens Thwaites | | | | |
| Ficus cardifolia Elmer | | | | |
| Ficus longespallalata Sata | | | | |
Subgenus Sycidium

**Ficus amplexa** Burm.f.
- Rough-leaf fig (English); amplas-amplas, rampelas, hampelas (Indonesia); amplas-amplas (Bali)
- Terrestrial tree or shrub.
- Green, gradually turn orange/yellow at maturity; Axillary, solitary.

**Ficus gul** Lauterb. & K. Schum
- Terrestrial tree or shrub.
- Green; Cauliflorous.

**Ficus montana** Burm.f.
- Oakleaf fig (English); uyahan, amis mata (Indonesia); uyah-uyah (Bali)
- Terrestrial small shrub with lack of branches.
- Green, gradually turn red at maturity; Axillary with 1—5 figs.

**Ficus subulata** Blume
- Terrestrial climber or creeping fig. Could form dense branches at the base.
- Orange; Axillary, solitary or in pairs.

**Ficus tinctoria** ssp. gibbosa (Blume) Corner
- Dye fig, humped fig (English); kresek, kroya (Bali)
- Hemiepiphyte or strangler fig which slowly replaced its host.
- Green, gradually turn orange or reddish at maturity; Axillary, solitary figs which clustered at the tip of branches.

Subgenus Sycomorus

**Ficus fistulosa** Reinw. ex Blume
- Yellow-stem fig (English); beunying (Indonesia); dadem (Bali)
- Terrestrial tree.
- Green, pale green, or brownish-purple; Cauliflorous or axillary at the leafy twigs.
| **Ficus hispida** L.f. | Synonyms: | Hairy fig, rough-leaved stem fig | Terrestrial tree or shrub. | Green or pale green with hairy surface and sticky sap; Long flagelliflorous (commonly short flagelliflorous when young). |
|------------------------|-----------|-------------------------------|---------------------------|------------------------------------------------------------------|
| **Covellia assamica** Miq. | **Covellia courtallensis** Miq. | **Covellia daenonom (L.Koenig ex Vahl)** Miq. | **Covellia dasyarpa** Miq. | **Ficus compressa** S.S.Chang |
| **Ficus daemonum** J.Koenig ex Vahl | **Ficus fecunda** Blume | **Ficus hispidoides** S.Moore |
| **Ficus hauilii** Blanco | **Ficus kaukauensis** Hayata | **Ficus leucocarpa** (Miq.) Miq. |
| **Ficus letaqui** H.Lév. & Vaniot | **Ficus leucosticta** (Spreng.) Gasp. | **Ficus mollis** (Mcq.) Miq. |
| **Ficus lima** Royen ex Miq. | **Ficus scabra** Jacq. | **Ficus sambucixylon** H.Lév. |
| **Ficus oppositifolia** Willd. | **Ficus symphytifolia** Lam. | **Ficus venosa** Miq. |
| **Ficus poillanei** Gagnep. | **Gonosuke daemonum** Raf. | **Cystogyne leucosticta** (Spreng.) Gasp. |
| **Ficus poillanei** Gagnep. | **Gonosuke hispida** (L.f.) Raf. | **Ficus browneana** Merr. |
| **Ficus prunifolia** King | **Urostigma leucocarpum** Miq. | **Ficus casearia** F.Muell. ex Benth. |
| **Ficus racemosa** L. | **Urostigma lucescens** (Blume) Miq. | **Ficus didymophylla** Warth. |
| **Ficus septica** Burm.f. | **Ficus septica** (Blume) Miq. | **Ficus guminifolia** Miq. |
| **Ficus semicosta** F.M.Bailey | **Cystogyne leucosticta** (Spreng.) Gasp. | **Ficus hauilii** Blanco |
| **Ficus scabra** Jacq. | **Ficus leucocarpa** (Blume) Miq. | **Ficus laxiramea** Elmer |
| **Ficus symphytifolia** Lam. | **Ficus leucotoma** Roem. & Schult. | **Ficus leucotoma** Poir. |
| **Ficus leucotoma** Roem. & Schult. | **Ficus leucotoma** Roem. & Schult. | **Ficus leucotoma** Roem. & Schult. |
Ficus linearis Merr.
Ficus oldhamii Hance
Ficus paludosa Perr.
Ficus philippense Hérincq
Ficus radiata Decne.
Ficus rapiformis Roxb.
Ficus stictocarpa (Miq.) Miq.
Ficus verrucosa Vahl

Ficus variegata Blume

Synonyms:
Ficus agusanensis Elmer
Ficus amboinensis Kostel
Ficus cerifera Blume
Ficus ceriflua Jungh.
Ficus chlorocarpa Benth.
Ficus compressitora Elmer
Ficus cordifolia Blume
Ficus domesticz Zipp. ex Miq.
Ficus ehretoides F.Muell. ex Benth.
Ficus garciæ Elmer
Ficus glochidiifolia Hayata
Ficus gummiflua Miq.
Ficus ilangoides Elmer
Ficus integrifolia Elmer
Ficus konishii Hayata
Ficus latsonii Elmer
Ficus paucinervia Merr.
Ficus subopaca Miq.
Ficus subrecessosa Blume
Ficus sum Gagnep.
Ficus sycomoroides Miq.
Sycomorus gummiflua Miq.
Urostigma cordifolium (Blume) Gasp.
Urostigma javanicum Miq.

Subgenus Synoecia
Ficus pumila L.

Synonyms:
Ficus hanceana Maxim.
Ficus longipedicellata H.Perrier
Ficus scandens Lam.
Ficus stipulata Thunb.
Ficus stipulata Lam.
Ficus vestita Desf.
Tenorea heterophylla Gasp.
Urostigma scandens Liebm.
Varinga repens Raf.
Plagiostigma pumila (L.) Zucc.
Plagiostigma stipulata Zucc.

Ficus trichocarpa Blume

Synonyms:
Ficus ahernii Merr.
Ficus filiformis Blume
Ficus nodulosa Zipp. ex Miq.
Ficus obtusa Hassk.
Ficus phaeopoda (Miq.) Miq.
Ficus piperifolia (Miq.) Miq.
Ficus platycalyx Miq.
Ficus tawaensis Merr.
Pogonotrophe bornensis Miq.
Pogonotrophe javana Miq.
Pogonotrophe phaeopoda Miq.
Pogonotrophe piperifolia Miq.
Pogonotrophe pyrrhospoda Miq.
Urostigma trichocarpum Miq.

Red-stem fig; green-fruited fig; variegated fig (English); ara, nyawai, labo (Indonesia); aa (Bali)
Terrestrial tree. Pale green, gradually turn red at maturity; Short flagelliflorous.

Ficus cerifera Blume

Creeping fig. Epiphyte. Green or pale green, gradually turn purple at maturity; Axillary, solitary.
Climbing fig (English); dolar rambat (Indonesia); dolar mini (Bali)
### Subgenus Urostigma

**Ficus benjamina** L.  
**Synonyms:**  
- *Ficus comosa* Roxb.  
- *Ficus cuspidata* Hayata  
- *Ficus dictyophylla* Wall.  
- *Ficus haematocarpa* Blume ex Decne.  
- *Ficus neglecta* Decne.  
- *Ficus nepalensis* Blanco  
- *Ficus nitida* Thunb.  
- *Ficus notobor* Buch.-Ham. ex Wall.  
- *Ficus papyrifera* Griff.  
- *Ficus parvifolia* Oken  
- *Ficus pendula* Link  
- *Ficus pyrifolia* Salisb.  
- *Ficus reclinata* Desf.  
- *Ficus striata* Roth  
- *Ficus umbrina* Elmer  
- *Urostigma benjaminum* (L.) Miq.  
- *Urostigma haematocarpum* Miq.  
- *Urostigma neglectum* Miq.  
- *Urostigma nitidum* (Thunb.) Miq.  
- *Urostigma nitidum* Gasp.  
- *Urostigma nudum* Miq.

**Benjamin fig.**  
Weeping fig (English); beringin (Indonesia); beringin, bingin (Bali)  
Hemiepiphyte or strangler fig which slowly replaced its host.  
Green, gradually turn pink or red at maturity; Axillary, solitary fig but commonly in pairs.

**Ficus drupacea** Thunb.  
**Synonyms:**  
- *Ficus aurantiicarpa* Elmer  
- *Ficus chrysochlamys* K.Schum. & Lauterb.  
- *Ficus chrysocoma* Blume  
- *Ficus citrifolia* Willd.  
- *Ficus ellipsoidea* F.Muell. ex Benth.  
- *Ficus gonia* Buch.-Ham.  
- *Ficus mysorensis* B.Heyne ex Roth  
- *Ficus payapa* Blanco  
- *Ficus pilosa* Reinw. ex Blume  
- *Ficus rupestris* Buch.-Ham.  
- *Ficus vidaliana* Warb.  
- *Urostigma bicorne* Miq.  
- *Urostigma chrysotrix* Miq.  
- *Urostigma dasyccarpum* Miq.  
- *Urostigma drupaceum* (Thunb.) Miq.  
- *Urostigma mysorense* (B.Heyne ex Roth) Miq.  
- *Urostigma pilosum* (Reinw. ex Blume) Miq.  
- *Urostigma subcuspidatum* Miq.

**Mysore fig.**  
Brown-wolly fig (English); bingin bulu (Bali)  
Hemiepiphyte or strangler fig which slowly replaced its host.  
Green, gradually turn yellow or orange at maturity. Had white or green dot at the surface; Axillary, in pairs or solitary.

**Ficus elastica** Roxb. ex Hornem.  
**Synonyms:**  
- *Ficus clusiifolia* Summerh.  
- *Ficus cordata* Kunth & C.D.Bouché  
- *Ficus skytinodermis* Summerh.  
- *Ficus taeda* Kunth & C.D.Bouché  
- *Stilpnophyllum elasticum* (Roxb. ex Hornem.) Drury  
- *Urostigma circumscissum* Miq.  
- *Urostigma elasticum* (Roxb. ex Hornem.) Miq.  
- *Urostigma karet* Miq.  
- *Urostigma odoratum* Miq.  
- *Visiania elastica* (Roxb. ex Hornem.) Gasp.  
- *Macrophthalma elastica* (Roxb. ex Hornem.) Gasp.

**Rubber tree.**  
Rubber bush (English); pohon karet, karet kebo (Indonesia); karet kebo, bunut (Bali)  
Terrestrial tree, rarely a strangler.  
Yellow at maturity; Axillary, solitary but commonly in pairs.

**Ficus microcarpa** L.f.  
**Synonyms:**  
- *Ficus amblyphylla* (Miq.) Miq.  
- *Ficus cairnsii* Warb.  
- *Ficus condaravia* Buch.-Ham.  

Chinese banyan, Malayan banyan, curtain fig (English); dolar (Indonesia); beringin dolar (Bali)  
Terrestrial tree, rarely hemiepiphyte or strangler.  
Green, gradually turn red or purplish at maturity; Axillary, solitary.
Ficus dahlia K.Schum.
Ficus dilatata Miq.
Ficus dyctiophleba F.Muell. ex Miq.
Ficus littoralis Blume
Ficus naumannii Engl.
Ficus regnans Diels
Ficus retusiformis H.Lév.
Ficus rubra Roth
Ficus thyneana F.M.Bailey
Urostigma amblyphyllum Miq.
Urostigma littorale (Blume) Miq.
Urostigma microcarpum (L.f.) Miq.
Urostigma pisiferum Miq.

Ficus religiosa L.
Synonyms:
Ficus caudata Stokes
Ficus peepul Griff.
Ficus superstitiosa Link
Urostigma affine Miq.
Urostigma religiosum (L.) Gasp.

Bodhi, sacred fig, peepul tree (English); Bodhi (Indonesia); Bodhi (Bali)
Terrestrial. Greenish yellow, gradually turn red or purplish at maturity;
Axillary, solitary but commonly in pairs.

Ficus rumphii Blume
Synonyms:
Ficus affinior Griff.
Ficus conciliorum Oken
Ficus cordifolia Roxb.
Ficus damit Gagnep.
Ficus populiformis Schott ex Miq.
Ficus populnea Kunth & C.D.Bouché
Urostigma cordifolium Miq.
Urostigma rumphii (Blume) Miq.

Rumph’s fig (English); ancak (Bali)
Terrestrial tree, rarely hemiepiphyte or strangler. Pinkish, gradually turn purple or black at maturity; Axillary, solitary but commonly in pairs and densely at the tip of branches.

Ficus subcordata Blume
Synonyms:
Ficus acrorrhyncha Summerh.
Ficus balica (Miq.) Boerl.
Ficus calophylloides Elmer
Ficus fairchildii Backer
Ficus gartcinifolia Miq.
Ficus polygramma Corner
Urostigma balicum Miq.
Urostigma subcordatum Miq.

- Terrestrial tree, rarely hemiepiphyte or strangler. Green or pale green, gradually turn yellow or orange at maturity; Axillary, solitary or in pairs.

Ficus superba (Miq.) Miq.
Synonyms:
Ficus petiolata Reinw. ex Miq.
Ficus tenuipes S.Moore
Ficus timorensis Decne.
Urostigma accedens Miq.
Urostigma superbum Miq.

Deciduous fig, sea fig (English); krasak, kresek (Indonesia); kresek (Bali)
Terrestrial tree, rarely hemiepiphyte or strangler. Green or pale green; Cauliflorous.

Ficus virens Aiton
Synonyms:
Ficus ampla Kunth & C.D.Bouché
Ficus carolinensis Warb.
Ficus cunninghamii (Miq.) Miq.
Ficus fraseri (Miq.) F.Muell.
Ficus glabella Blume
Ficus infrafoliacea Buch.-Ham. ex Sm.
Ficus lambertiana (Miq.) Miq.
Ficus monticola Miq.
Ficus nesophila (Miq.) F.Muell.
Ficus nitentifolia S.Moore
Ficus psychotritfolia (Miq.) Miq.
Ficus racemosa Wild.
Ficus scandens Buch.-Ham.
Ficus terminalioides Griff.
Ficus terminalis B.Heine ex Roth

White fig, grey fig (English); ampulu (Indonesia)
Hemiepiphyte or strangler fig which slowly replaced its host. Pinkish white; Axillary, solitary.
Table 2. Distribution of figs (Ficus: Moraceae) in Gianyar, Bali. Note: I: Blahbatuh; II: Gianyar; III: Sukawati; IV: Ubud; V: Payangan; VI: Tampaksiring; VII: Tegallalang

| Species                         | Distribution Area |
|--------------------------------|-------------------|
| Ficus fulva Reinw. ex Blume    | +                 |
| Ficus callosa Willd.           | +                 |
| Ficus ampelac Burm.f.          | +                 |
| Ficus gal Lauterb. & K. Schum  | +                 |
| Ficus montana Burm.f.          | + + + + + + +     |
| Ficus subalata Blume           | +                 |
| Ficus tinctoria ssp. gibbosa (Blume) Corner | + |
| Ficus fistulosa Reinw. ex Blume | + + + + + +      |
| Ficus hispida L.f.             | + + + + + + +     |
| Ficus racemosa L.              | +                 |
| Ficus septica Burm.f.          | + + + + + + +     |
| Ficus variegata Blume          | + + + + + + +     |
| Ficus pumila L.                | + + + + + + +     |
| Ficus trichocarpa Blume        | +                 |
| Ficus benjamina L.             | + + + + + + +     |
| Ficus drupacea Thurnb.         | +                 |
| Ficus elastica Roxb. ex Hornem. | + + + + + +     |
| Ficus microcarpa L.f.          | +                 |
| Ficus religiosa L.             | + + + + + + +     |
| Ficus ramphii Blume            | +                 |
| Ficus subcordata Blume         | +                 |
| Ficus superba (Miq.) Miq.      | + + + + + + +     |
| Ficus viridens Aiton           | +                 |
| Total                          | 9 18 11 14 11 14 13 |

Discussion

Figs (Ficus) are pantropical plants consisting of approximately consist of 735 species, 367 of which are distributed in the East-Australasian region (Berg & Corner 2005). Indonesia has among the highest fig diversity, with Borneo as its center of diversity. Berg and Corner (2005) reported 138-141 species in Borneo, 94-97 species in Sumatera, 79-81 species in Moluccas (Maluku), 78-81 species in Celebes (Sulawesi), 74-77 species in Java, and 34 species on Lesser Sunda Island (Bali and Nusa Tenggara). Ficus is also known as a highly dispersed genus because of its extreme range of growth forms, thus making it more adaptable in various types of ecosystems. This genus could be found as trees, shrubs, climbers and scramblers, epiphytes, or semi-epiphytes (stranglers).

Ficus is composed of 6 subgenera: Urostigma, Pharmacosyceae, Ficus, Synoeoia, Sydidiurn, and Sycomorus. On Lesser Sunda Island, Urostigma was the subgenus with the highest diversity relative to the others (Berg & Corner 2005), which correlated with this research. Berg and Corner (2005) found that of the 34 species on Lesser Sunda Island, 12 species were from the subgenus Urostigma, four species from Pharmacosyceae, one species from Ficus, three species from Synoeoia, eight species from Sydidiurn, and six species from Sycomorus. Urostigma is also a subgenus with many semi-epiphyte species. Both large and small semi-epiphyte Urostigma figs attract many frugivorous birds and mammals (Seekar et al. 2010). Hemi-epiphyte figs do not depend on water resources or water bodies because of their adaptability to dehydration, however, they depend on their host tree (Pothasin et al. 2014). Because these hemi-epiphytes need large trees as proper hosts, logging could affect the diversity of hemi-epiphytes, sequentially impacting the frugivore diversity (Harrison et al. 2003).

All species in the subgenus Urostigma were monoecious (Berg & Corner 2005; Cruaud et al. 2012) with a wide variety of pollinating insects (Cruaud et al. 2012). The monoecious dioecious traits in figs were the results of reciprocal evolution in mutualistic fig/fig-pollinating wasp interactions that affected the diversity of figs (Cruaud et al. 2012; Zhang et al. 2019). A high variety of pollinating insects made monoecious figs occur more areas than dioecious figs, but in terms of local abundance,
dioecious figs are more abundant (Harrison 2003; Dev et al. 2011). Complex interactions between insects and monoecious figs in *Urostigma* affect the morphological character divergence. Chantarasuwan et al. (2015) used a molecular approach to solve the taxonomic uncertainties within *Urostigma* because of its high morphological variability and exhibit overlapping distribution.

Not only were all the *Urostigma* species in this study monoecious, they were also all strangler figs: *F. benjamina, F. drupacea, F. elastica, F. microcarpa, F. religiosa, F. rumphi, F. subcordata, F. superba, and F. virens*. Monoecious strangler figs have wider geographical distribution (Harrison et al. 2003; Chantarasuwan et al. 2015) caused by animal dispersal and human introduction. *Ficus benjamina, F. drupacea, F. elastica, F. microcarpa,* and *F. religiosa* are Asian figs that were heavily introduced to other countries as cultivated plants (Berg and Corner 2005). In the view of Hindu culture in Bali, figs are also an integrated part of religion. The banyan tree (*F. benjamina*) plays the main part in the ceremony of the *ngangget don bingin* phase, which is one of the phases in the cremation ceremony or *ngaben* (Figure 3A-B). That is why at least one banyan tree is always found in every village. The banyan tree is also considered a plant with a mystical ambiance and is associated with fertility; thus, its existence has been venerated in many traditional cultures (Harrison et al. 2003). This is also the case for *F. religiosa*, which is globally known as the *bodhi* or holy fig. *Ficus religiosa* is mainly found at the temple (*pura*) or vihara, and is believed to give a serene ambiance. Although this fig is popular in Malesia, its native distribution in Asia did not reach the Malesian region without human introduction (Berg and Corner 2005).

The culturally associated banyan tree in Bali indirectly supports the ecosystem. Shanahan et al. (2001) compiled data on frugivores and found out that the banyan tree (*F. benjamina*) can support 84 species of frugivores. Other strangler fig species also supported remarkable numbers of frugivores. *Ficus virens* could support 90 species of frugivores, and *F. drupacea* up to 63 species of frugivores (Shanahan et al. 2001). The number of frugivores for *F. drupacea* might vary due to its intraspecific variations. *Ficus drupacea* had two major variations (forms) based on its biogeographical distribution: the stipitate receptacles form, which is found in eastern New Guinea, and the hairy (twigs, petioles, and laminas) form, which is found in the western New Guinea (Berg and Corner 2005). Corresponding with the prior research, the hairy form of *F. drupacea* was found in this study. There was also a variation in its fruit surface. Some fruit could have a glabrous surface, whereas others could be coarser. This variation might be correlated with fig/fig-pollinating wasp interaction. Wang et al. (2013) hypothesized that the pollinator specificity in figs could be a result of a combination of the scent and surface texture of the fruit to prevent misleading pollinators.

The five species of the subgenus *Sycidium* in this study were *F. ampelas, F. gul, F. montana, F. subulata,* and *F. tinctoria*. The species in this subgenus are relatively common around the world, mainly distributed on riverbanks and in humid areas, and a few species are found on the beaches or in grasslands (Berg and Corner 2005). All *Sycidium* species are dioecious. Dioecious figs are more abundant than monoecious figs in tropical regions, usually in the forms of small trees, shrubs, or climbers (Bain et al. 2014). *Ficus ampelas* is known as *amplas-amplas* because of its rough leaves. This species is widespread in Indonesia except for Borneo (Berg and Corner 2005). *Ficus tinctoria* and *F. subulata* also have a wide distribution in Indonesia. *Ficus tinctoria* has two subspecies: *F. tinctoria ssp. tinctoria,* which is distributed in eastern Bali, and *F. tinctoria ssp. gibbosa,* which is distributed in western Bali (Berg and Corner 2005). Some people in Bali distinguish *F. tinctoria* from *F. benjamina* by its leaves. The leaf vein in *F. tinctoria* is more obvious than in *F. benjamina.* This is necessary because those two species could appear on the same host tree, such as in Gianyar, where an *Alstonia scholaris* tree is strangled with *F. benjamina* and *F. tinctoria.*

![Figure 3. Traditional culture is associated with figs. A. *Ficus benjamina* in Ubud with massive roots; B. *Ngangget don bingin* phase in the cremation ceremony sequence showing people collecting *F. benjamina* leaves using a particular tool; C. The culturally protected *F. racemosa* at Tegallalang supports many forms of plant and animal life.](image-url)
Ficus subulata is a climber fig that shares a unique interaction with its host. The lower parts of the plant, usually in a shaded area, form small canopy by formation of its dense branches below the host’s canopy. The canopy of F. subulata could act as protection for frugivores or create a specific niche for ground animals. Some of the branches climb the host tree with loose branches until reaching a suitable height. Both the upper and lower parts can produce a massive amount of axillary fruit. Even though its mature stage is similar to hemi-epiphytes, a molecular study showed that climber figs developed from a shrub form (Zhang et al. 2020).

Ficus montana is a small shrub fig commonly found in pastureland, rice fields, or abandoned areas. This species is very adaptable to unfavorable and unpredictable conditions (Bain et al. 2014) and is mostly recognized as a weed. In Bali and Java, it is known as uyah-uyah or uyahan and used as food for ruminants. Ficus montana has varied leaf morphology in terms of shape (oval, obovate, oblong), margin (entire, sparsely dentate, serrated, lobed as oak leaf), apex (acute, acuminate, rarely caudate). Generally, the leaf color is green, except for the F. montana var. purpurascens, which is purple on the underside of the leaf (Tarachai et al. 2012). The amount of fruit (syconia) is also variable, usually 1-2, but sometimes more than five. Ficus montana is often used for studying the relationship between the fig and its pollinator (Kradibia tentacularis: Aganoidae). Suleman et al. (2015) reported interaction between F. montana and its pollinator while studying the floral ratio of active and passive pollination.

The subgenus Sycomorus consists of tree, small tree, and shrub figs, such as F. hispida, F. septica, F. racemosa, F. variegata, and F. fistulosa. Most Sycomorus species are dioecious. Dioecious figs produce massive fruit all year round (Bain et al. 2014), but they have short-range pollinators because their fruits grow under the canopy (Harrison 2003; Harrison and Rasplus 2006). This could increase the local extinction risk due to pollinator disappearance (Harrison and Rasplus 2006). Some species are fast-growing figs with quickly maturing fruits and are common in disturbed areas, such as F. septica and F. hispida. Ficus is a notable genus for forest restoration in disturbed landscapes (Cottee-Jones et al. 2016), and these two species appeared at the early stage of succession on Krakatau Island as pioneer trees or pioneer figs (Thornton et al., 1996). Although both species were adaptable in various types of habitats, those species have different colonization strategies. Ficus septica tends to produce fruit as soon as possible. It is common to see 1.5 m F. septica plants producing fruit. In contrast, F. hispida tends to produce fruit only under certain conditions, but in massive quantities. For example, a 4 m F. hispida plant could produce many fruits in short and long flagelliferous forms (Figure 2.H). In forest restoration, F. hispida is an excellently ranked species (Kuarakra et al. 2012).

Ficus fistulosa is locally known as dadem. In Tegallalang, young leaves of the F. fistulosa could be processed as vegetables or used as a forage plant for ruminants. This species is abundant at the roadside in Tegallalang, Tampak Siring, and Payangan, with a height < 3 m because it is regularly trimmed. There are two variations of F. fistulosa based on its fruit color, green (green to greenish-yellow when mature) and brownish-red (red to brownish-red when mature). The brownish-red fruit is rarer than the green; at lower altitudes (below 300 m ASL), only green fruit was found. Ficus fistulosa also bears fruit in axillary and cauliflorous form. The axillary fruits have a depressed-globose shape and are larger than the cauliflorous fruits, whereas the cauliflorous fruits are globose. The cauliflorous fruits only appear on adult trees, but the axillary fruits appear in both the juvenile and adult/mature stages of growth.

Some of the figs are widespread species that were found in many geographical areas, such as F. racemosa and F. variegata (Berg and Corner 2005). These species can grow up to 20 m high or more and are characterized by producing contrast red fruit. Among the mature red fruit, groups of pale green or yellow fruit were also found. The pale green group, known as gall fruit, are believed to have a correlation with primates’ vision evolution (Berg and Corner 2005). Ficus variegata has variations in fruiting times between male and female plants. Male F. variegata trees are semi-deciduous with 4-month fruiting periods, whereas the female trees are deciduous with fruiting periods throughout the year (Kuarakra et al. 2012). Even though F. variegata and F. racemosa have similar habitus types, F. racemosa has its own value for elderly people in Gianyar. When there was a large eruption of Mount Agung in 1963, people in Gianyar lacked a food source and started to consume the fruit of F. racemosa as a substitute for rice. In some areas in Bali, F. racemosa is also protected because of a belief that the plant has contributed to protecting water sources. Soejono et al. (2013) stated that the fig tree is a perfect plant for restoration and water source protection because of its broad and deep root system that increases water infiltration and its dense and wide canopy, which can reduce the speed of raindrops. The dense branching in F. racemosa that supports many epiphyte plants (Figure 3.C) also contributing in the reduction of the speed of raindrops.

Ficus pumila and F. trichocarpa are classified in the subgenus Synoeia, which is dominated by climbing figs (Zang et al. 2020). Ficus pumila is an introduced species that is frequently cultivated in Indonesia as an ornamental plant (Backer and van den Brink 1965; Berg and Corner 2005), especially as a wall-creeping plant. In Bali, the fruiting phase of F. pumila is rare because periodically trimming the plant affects its growth and development. The fruiting F. pumila is commonly found in neglected places, where it grows uncontrollably, climbs the nearest tree, and then produces many fruits. Ficus pumila is not only used for ornamental plant, but also has special taxonomic characteristics. The taxonomic position of the cultivated F. pumila excites many discussions regarding the possibility of interspecific hybridization between F. pumila and F. deltoidea (Zhang et al. 2020) or between F. pumila and F. thunbergii (Tsai et al. 2015).
As opposed to *F. pumila*, *F. trichocarpa* is not an ornamental plant. This plant is usually found creeping on other tall trees near a body of water, such as a river, or in a foggy area. The polymorphism of *F. trichocarpa* leaves can be separated into bathyphylls and acrophylls (Berg and Corner 2005). Bathyphylls are sterile leafy twigs that creep on the stem host, have smaller leaves, and have many hairs, whereas acrophylls are fertile twigs that form fruits and have larger leaves. The leaf shape also varies. Bathyphylls of *F. trichocarpa* are commonly spear-shaped, oval, obovate, or oblong, and acrophylls are usually obovate and thicker.

*Ficus callosa* and *F. fulva* were the only species in the subgenera *Pharmacosycea* and *Ficus* in this study. Both of those species are abundant on riverbanks. The fig is an important plant in riparian zones as a means of stream stabilization, flood reduction, shade for animals, and as a food source (Pothasin et al. 2014). *Ficus callosa* reach > 25 m in height and produce small butresses, whereas *F. fulva* does not reach more than 15 m in height. Seedlings of *F. callosa* are easy to find, dispersed along the water’s edge to drier areas. *Ficus callosa* has leaf variations between the juvenile and adult plants. The juvenile leaf of *F. callosa* is oblong-lanceolate with a spinulose-dentate base, whereas the adult leaf is oval-shaped, which matches with the annotations of Berg and Corner (2005). *Ficus fulva* also has leaf variations. The shape of the juvenile *F. fulva* leaf is subpalmate with 3-5 lobes and turns oval, obovate, or pandurate when it matures.

In conclusion, 23 species of figs were found in Gianyar District and were identified and classified into six subgenera. The subgenus *Urostigma* had the highest species diversity with nine species, followed by *Sycomidium* with five species, *Syconcia* with two species, *Pharmacosycea* with one species, and *Ficus* with one species. Some species in *Urostigma* and *Sycomidium* had strong relationships with Balinese culture, such as *F. benjamina*, *F. rumphii*, *F. religiosa*, and *F. racemosa*.

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