REPRODUCTIVE BIOLOGY OF TROPICAL PLANTS

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Contents

Summary

The reproduction of tropical plants relies largely on their interaction with animal pollinators and fruit and seed dispersers. Morphological and physiological features of the species involved in the interactions must be adapted in order to permit the fructification and to fit animal interests. The investigation into these interactions is of fundamental importance to the understanding of the spatial distribution of plants in different ecosystems. The agents that perform pollination and dispersal may vary according to the plant species and the environment where it occurs. Even within the same horizontal and vertical stratification of a forest, it is possible to find variation in the plant population and the animals associated with it, both also influenced by seasonality. The identification of the interactions between biological factors, such as animal and plant species, and non-biological factors, like rain and wind, helps us to elaborate management and conservation plans for the ecosystems of the planet, which have become more and more necessary along the last decades.

1. Introduction

1.1 Distribution of Biomes in the Tropics

Weather-related factors are one of the main forces acting upon the distribution of vegetation in our planet, particularly humidity, temperature and light, all essential ingredients to the accomplishment of vital functions in plants and other life forms. In

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regions where rains are more abundant, temperature is high and there is great incidence of light, a wider diversity of life is found, in contrast to the polar areas.

In the tropics resides the larger diversity of vegetal formations in the planet (Figure 1). In this area, there are forests of many types (rainforests, monsoon forests, mountainside forests, mixed tropical forests and mixed subtropical forests), southern-hemisphere groves, meadows, deserts, savannas and alpine tundra (Figures 2A-D).

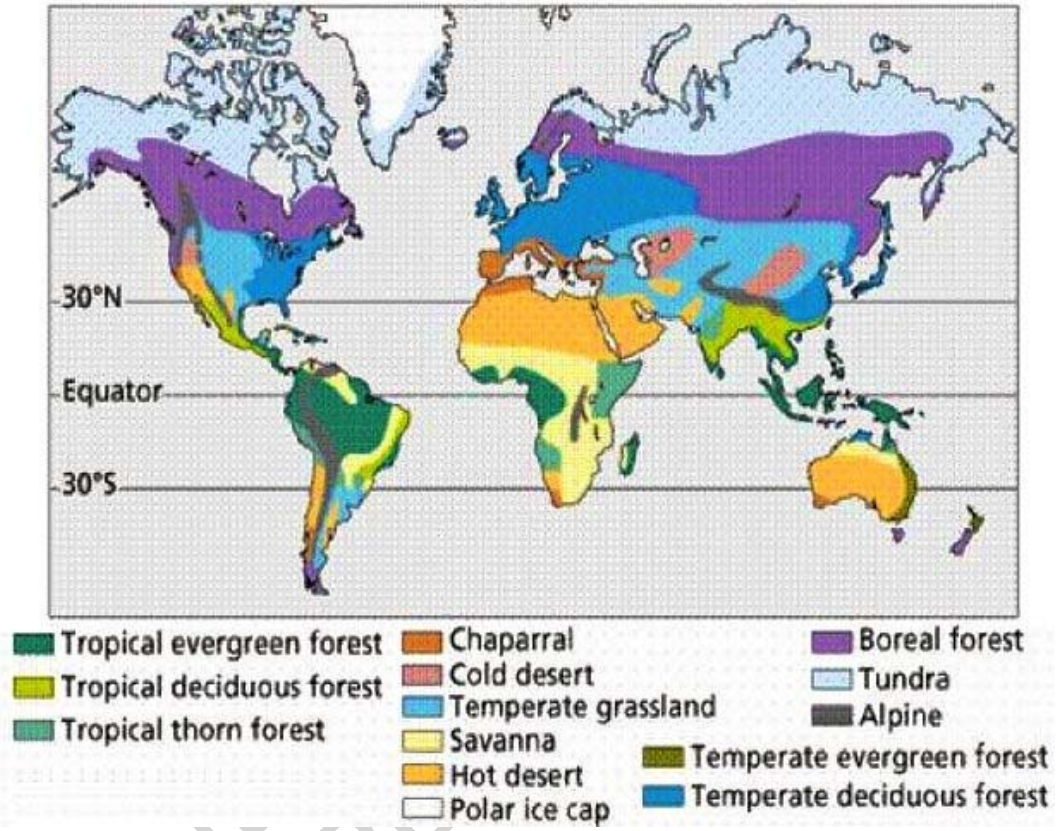

Figure 1 – Distribution map for the biomes on Earth.

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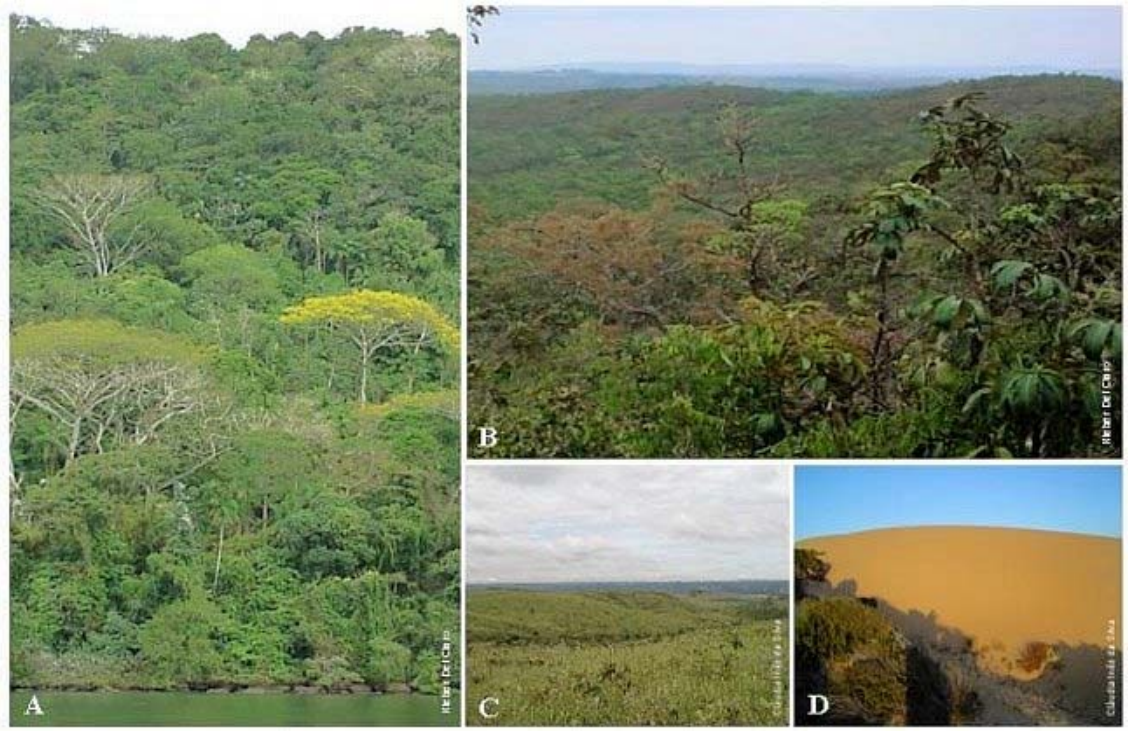

Figure 2 - Types of vegetation found in tropical regions. A: Tropical forest, B: Brazilian Savanna, C: Prairie, D: Deserts.

The forests in the tropics grew in a warm and moist weather, with more than 1,500mm of annual rain and average temperatures ranging from 24° to 30°C. The constant climate favored the development of luxuriant vegetation, presenting leaves and flowers all year long. The forest vegetation appears in different levels, with very tall, isolated trees (Figure 3), whose canopy may reach 60 meters high, with a very dense coverage of leaves. The interior of these forests is always moist, with accumulation of bryophytes on the ground or a covering layer composed of fallen leaves and branches in state of decomposition, associated with fungi and arthropods.

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Figure 3 – Image of the interior of a pluvial forest.

The countries with the larger areas of tropical forests are: Brazil, Democratic Republic of Congo, Peru, Indonesia, Colombia, Papua New Guinea, Venezuela, Bolivia, Mexico and Suriname. Among all these countries which bear tropical vegetation, Brazil possesses one of the richest and more varied vegetal formations in the planet, including the Amazon Forest (Figure 4). These vegetation types are associated to the diversity of weather, terrain and soil existent in the country. Brazilian vegetation, according to its characteristics, can be divided into ten major groups: Amazon forest, Atlantic forest, "Caatinga", the "Pantanal" in Mato Grosso, the "Cerrado" (a type of savanna), meadows, araucaria woods, "mata de cocais", mangrove and the salt marsh. Even within

one single biome, like the Brazilian "Cerrado", there are diverse phytophysionomies, ranging from woods with very tall trees to shallow meadows.

Figure 4 – Distribution map of the Amazon Forest in South America.

The diversity of plants in the tropics is proportional to the different forms of reproduction, which include mechanisms that are highly adapted to pollination and to the dispersal of fruits and seeds. These mechanisms are indispensable to the structuring and the dynamics of vegetal and animal communities and, consequently, responsible for the maintenance of several ecosystems found in tropical regions.

2. Reproductive Biology of Tropical Plants

2.1 Sexual System

The reproduction in angiosperms is performed by the flower. The flower is formed by a set of highly modified leaves, some fertile, some sterile. The sterile leaves are usually formed by two whorls: the outer one is called the calyx and is composed of sepals and the inner one is known as the corolla and is made up of petals. When each element of the calyx and the corolla are so similar amongst each other in a way that they can not be distinguished, as in lilies, they are called tepals and constitute the flower's perianth (Figure 5). The sterile flower whorls serve to protect the fertile leaves that form the male and female reproductive organs, designated as androecium and gynoecium, respectively. Besides the protection, the sterile parts of the flower also serve to signalize and attract flower visitors through visual and scent-related cues. Some plant species do

not have one, or even both, sterile whorls.

Figure 5 – The six tepals present on lilies flower have great similarity, but are clearly separated into two whorls. (Picture by Helena Maura Torezan Silingardi).

Plants may present arrangements with the two sexual organs, the androecium and the gynoecium, in a single flower or in different flowers, in the same individual or in different individuals.

Flower types

Single-gendered flowers are said imperfect and can be male or female, depending on its reproductive function. When the flower presents both genders, it is designated as bisexual or hermaphrodite and is considered perfect.
There are morphologically hermaphrodite flowers which are functionally single-gendered, that is, despite having both types of reproductive organs, only one of them fully develop, becoming apt to execute its function.

The male or staminated flower presents only the androecium, which is formed by a group of stamens. Each stamen is formed by the filament and its anther, in which the pollen grains are produced (Figure 6A).

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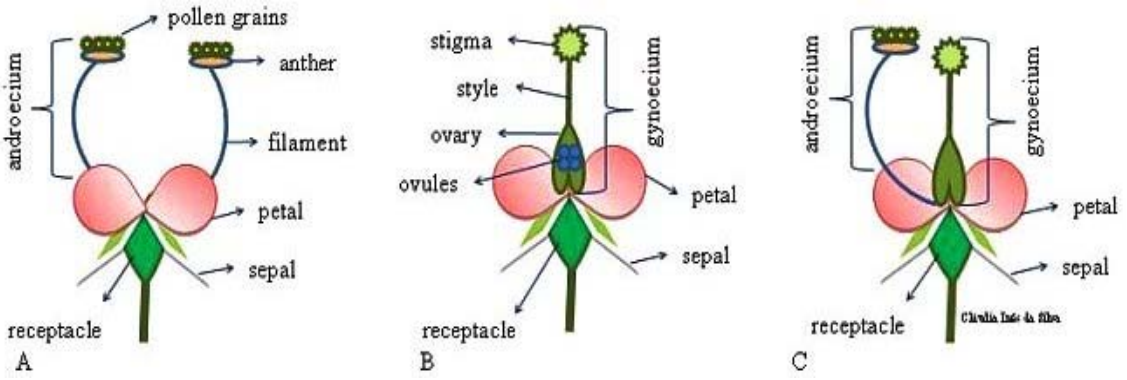

Figure 6 – Basic flower types found in nature. A: Male flower, B: Female flower, C: Hermaphrodite flower.

The female or pistillated flower presents only the gynoecium, constituted by the stigma, style and ovary. Inside the ovary, the ovules are formed and they can later originate the seeds (Figure 6B).

The hermaphrodite flower presents the androecium and the gynoecium in the same flower and both are functional (Figure 6C).

Distribution of flower types among species

- **Monoecious species** present male and female flowers distributed in the same plant or individual (Figure 7A).
- **Dioecious species** have male and female flowers disposed in separated plants or individuals (Figure 7B).
- **Hermaphrodite species** possess hermaphrodite or bisexual flowers.
- **Gynomonoecious species** bear female and bisexual flowers in the same individual.
- **Gynodioecious species** present female and bisexual flowers in separated individuals.
- **Andromonoecious species** have male as well as bisexual flowers distributed along the same plant or individual.
- **Androdioecious species** possess male and bisexual flowers, but in different individuals.
- **Polygamous species** bear male, female and bisexual flowers in the same individual (Figure 7C).

Throughout the vegetal world, around 80% of the species bear hermaphrodite flowers and approximately 10% present individuals with separated genders. The remainder shows a lot of variation and some species have non-functional organs.

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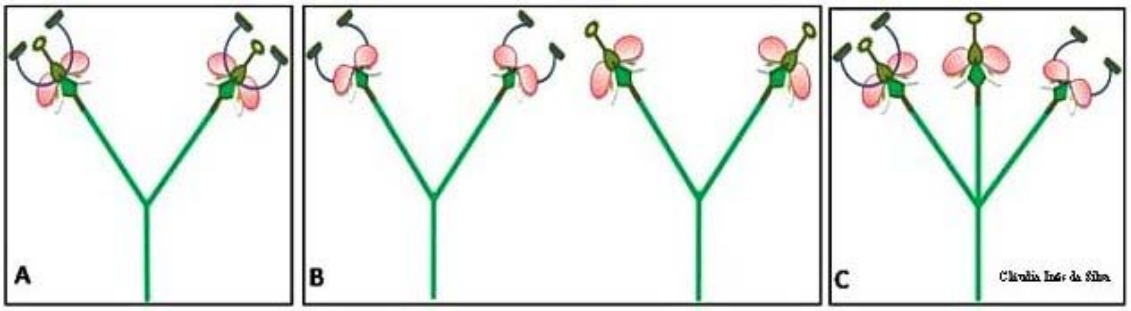

Figure 7 – Basic types of plants found in nature according to the sexual expression of the flowers. A: Monoecious plant, B: Dioecious plant, C: Polygamous plant

As to the expression of gender in plants based on the environment, in wide-leafed tropical forests, for instance, hermaphrodite plants are predominant, while dioecious and monoecious are unusual. Opposedly, in temperate regions, there is a predominance of monoecious species, followed by a small percentage of hermaphrodite and dioecious plants.

Some studies show a comparison between tropical and temperate plants regarding gender expression, as shown on Table 1

Sexual Expression	**Frequency of Species**	
	Tropical forest	Temperate forest
Hermaphrodite	68%	7%
Dioecious	10%	74%
Monoecious	22%	19%

Source: Bawa (1974).

Table 1- Sexual expression in species of tropical and temperate forests.

Although many plants present both reproductive organs in the same flower, most of them have systems to prevent self-pollination and need external agents to conduct cross-pollination.

2.2 Reproductive system

In a general way, plants present asexual, as well as sexual, reproductive systems.

- In the **asexual or agamic reproduction**, plants can be reproduced by vegetative propagation, through any part of the plant, as, for example, cuttings, spores, tubers, bulbs, runners, sprouts and roots. In the vegetative propagation, there is not the formation of seeds. Instead of it, a clone genetically identical to the original individual springs up.
- The **agamospermy or apomixis** is the production of seeds without the fertilization of the ovule, therefore, asexually. It may occur in flowers of species that also form seeds after normal pollination and fecundation, as in *Citrus*, or in species in which sexual reproduction is rare. Apomixis takes

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place in almost 15% of the Angiosperm families. There are two major types of apomixis in Angiosperms: the gametophytic and the sporophytic kind. It is a vegetative propagation with the formation of seeds and the individual formed is a clone, genetically identical to the mother-plant.

- In the **sexual or gamic reproduction**, the union of two single-celled reproductive units happens, namely the male and female **gametes** (syngamy).
- In **autogamy**, the ovule is fertilized by pollen grains produced in the same flower.

If the pollen is originated from other flowers of the same plant, it is called **geitonogamy**.

A classical case of autogamy is the **cleistogamy**, in which the deposition of pollen grains on the stigma takes place inside the flower bud still closed. In this case the petals will not open and no extra pollen will be involved.
Both in autogamy, geitonogamy and cleistogamy, the process of seed formation is considered to be **self-fecundation**, since all the flowers of a single plant have a **gene pool originated from the same seed.**

- In **alogamy**, the fecundation is originated from **cross-pollination** between flowers of different individuals, but within the same species. It is also called **xenogamy**.

In **chasmogamy**, the pollen grains reach the stigma after the opening of the petals and can be originated from self- or cross-pollination. It is the opposite of **cleistogamy**.

Besides the reproductive systems of plants cited above, there is also the **mixed system**, much more common, in which part of the seeds of a population is originated from self-fecundation and the other part, from cross-fertilization.

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