A Floristic Survey, Origin and Mycorrhization of Ruderal Plants in Remaining Cerrado Areas Publishing Agreement

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Abstract

This study aimed the floristic survey and to examine the plant origin and mycorrhization of ruderal plants in the urban areas of Três Lagoas-MS, Brazil, specifically in the housing complex Vila Piloto and the surrounding areas. Our intent was to expand knowledge about native and introduced vegetation in environments with anthropogenic changes. The survey occurred over 12 months and 266 species, distributed into 53 botanical families were identified. This flora was composed of native and exotic plants, especially from Americas (82.7%) and Old World and Australia (17.3%). There were 220 species native to the America's, but the highest number (60%) was from Brazil. A small percentage of these Brazilian plant species (28.6%) have originated from Cerrado, suggesting that ruderal vegetation was the high represented by native species. Of the 49 species chosen for root mycorrhization verification, 42 showed colonization in varying degrees. Soil fertility was higher than in the typical Cerrado, and the average number of AMF spores (152 per 100 g of dry soil^{-1}) did not indicated soil degradation.

Keywords: urban vegetation; geographic origin; flora ruderal; arbuscular mycorrhizal; Cerrado.

1. Introduction

Urbanization creates new ecosystems that harbor specialized flora that are adapted to anthropogenic alterations. Since the advent of agriculture and urbanization approximately 9,000 years ago (Tivy, 1993), plant specialization in altered ecosystems has led to accelerated plant population growth and extensive expansion on Earth (Carneiro & Irgan, 2005).

Cities present inherent spatial organization and exhibit distinctive patterns of changes through time. These characteristics results in changes in behavioral patterns and population dynamics of plant species and lead to the establishment of plant communities that are specific to urban environments. Although some urban spaces have remained relatively undisturbed for centuries in the form of parks and gardens, most cities usually have densely populated areas with remnants of agro-ecosystems (“encapsulated countryside”) and parks and nature reserves. Open spaces in urban settings are modifications of previous habitats and the similarity between the former and present habitat conditions likely decreases with time (Sukopp, 2002).

Ruderal species are plants best adapted to environmental conditions altered by humans and commonly grown in urban areas. The temperature where the land is cover with buildings, pavements and urban activity, shows variation and tends to be higher than that in the surrounding areas. Solar radiation and water provision due to land coverage and compaction of soil also reduce percolation and increase superficial drainage. Moreover, artificial illumination from streetlights can significantly alter the photoperiod of plants (Haig, 1980). Despite the anthropogenic effects on plant species in urban areas, human movement may transport propagules from different plant species, resulting in floristic diversity (Rapoport et al., 1983). As well, the existence of microhabitats around or in the cities high positively affects the floristic richness of urban environments. The continuous disorder in urban centers (e.g., human and vehicular movement, cleaning activities, changes in land use, as well as demolition and new constructions) destabilizes the environment. However, altered environmental conditions may allow the survival of species physiologically similar in geographically distant locations (Tivy, 1993). In addition, traveling and the continuous movement of people facilitate the breakdown of geographic barriers, thereby reducing the impediment to species dispersion (Rapoport, 1976).

Ruderal plant species are adapted to different environments and grow spontaneously in vacant lots, sidewalk, wall cracks, and street curbs. These species are often considered as invasive weeds; some have medicinal value while others have no known utility. Regardless of their specific use, the ruderal flora grows rapidly and thus serves as study material for many botanical subareas and provides an opportunity to study the development of vegetation when most plants are annuals. The ecology of ruderal plants also reinforces the importance of these plants because they can vegetate, bloom, and fructify with high efficiency, allowing them to be used for the recovery of degraded areas. One strategy of plant species to overcome biotic and a biotic stressors in soil is to establish mycorrhizal symbiosis (Carneiro & Irgan 2005) formed between the plants roots and certain soil fungi.

Arbuscular mycorrhizal fungi (AMF) have an important role in the uptake of water and nutrients, especially in phosphorus-deficient soils, enabling better plant development (Carneiro et al., 1998). In a nutrient-poor environment, AMF contributes not only to plant nutrition but also to improve soil structure and protect plants from root pathogens (Gemma et al., 1989). These fungal species also help plant establishment and growth in unfavorable environmental conditions (Koske & Polson, 1984). Mycorrhizal plants are highly effective colonizers of disturbed habitats. Little is known about their effects on plant species composition or the diversity of this beneficial symbiosis on ruderal plants. This study aims to identify the floristic composition, origin and mycorrhization of the ruderal plants in remaining Cerrado areas of the city of Três Lagoas-MS (Mato Grosso do Sul state, Brazil). These results will expand and disseminate knowledge of native and introduced vegetation in environments subject to anthropogenic alterations.

Material and Methods

The city of Três Lagoas-MS (urban core: 20°45'04"S and 51°40'42"W), located in the Paraná Sedimentary basin, has an area of 10,235 km^2. Altitude ranges between 315 and 325 m, and the local soils were originated by alluvial material from the Paraná River basin and the sub-basins of the Pardo, Verde, and Sucuriu Rivers. The urban core is located in typical Cerrado. The climate is tropical with two well-defined seasons (humid in the summer and dry in the winter) under the domain of tropical and equatorial air masses. The average temperature is 23.7 °C, but records exist of temperatures above 40 °C, with clear evidence of inflated temperatures (i.e., "heat islands") in the urban area. The annual average precipitation is 1,300 mm. The city is situated in a vast plain with smooth undulation, and Cerrado, grasslands and forests originally covered the region. Railroad construction in the early twentieth century and installation of a hydroelectric power plant in the 1960s has affected local vegetation.

Most of the municipality, after deforested, became pasture. Recently, part of these areas was converted by eucalyptus-crop due to the increase of the growth of pulp and paper industries.

The collection of plant material carried out in the urban areas of Três Lagoas-MS, specifically in the housing complex Vila Piloto and the surrounding areas. Plant observations occurred monthly from August 2007 to July 2008, with systematic collections during plant reproduction.

The vascular plant community, including species found in vacant lots, sidewalks, wall cracks, fences, and street curbs was examined. Plant samples were register by photograph, collected and dried before identification. Specialized literature such as Pio Corrêa (1926-1978), Filgueiras (1995), Andreata (1987), Prance & Mori (1991), Pott & Pott (1994), Ribeiro et al. (1999), Lorenzi (2000), Longhi-Wagner & Bittrich (2001), Lorenzi & Abreu Matos (2002), Durigan et al. (2004) and Pott et al. (2006) were used to aid plant identification. The botanical families Magnoliophyta (Angiopermae) and Pteridophyta were classified based on the Angiosperm Phylogeny Group II (APG II, 2003) and Tryon & Tryon (1982). The spelling of scientific names and the existence of botanical synonyms were verified against the Missouri Botanical Garden database (www.theplantlist.org). Species were classified according to their origin (i.e., geographical position and characteristics of the regional flora).

Plants collected during the floristic survey were evaluated by the presence of the AM colonization. The species selection was based on availability of young plants, because their early flowering, a guarantee that the vegetative stage was at the height of their development. However, young plants were avoided, once the amount of roots could be insufficient. At the end, 44 identified species were in the pre-conditioned state to be collected. Roots were obtain by pulling the whole plants with a hoe, and stored into plastic bags, by species. The number of plants collected by species ranged between three and five, depending on availability. Root systems were washed and, temporarily, preserved in ethanol and water (1:1 ratio) solution. For quantification of AMF colonization, at 45 °C water bath, roots were clarified in 10% KOH solution, acidified with 1% HCl and stained with trypan blue 0.05% (Phillips & Hayman, 1970, Rajapakse & Miller, 1992), and preserved in lactoglycerol. One gram of fine root segments (Toth & Toth, 1982) was used to estimate the total colonization of the roots. Roots were distributed over checkered plates (Giovannetti & Mosse, 1980) and 100 intersections were examinees by fungal structures, for each plant species. Due to environmental differences in the collected area, mycorrhizal colonization was qualitatively addressed according to the classifications proposed by Carneiro et al. (1988). Species were classified as a percentage of colonization, where the categories very high, high, medium, low and absent correspond to > 80 %, 79–50 %, 49–20 %, 19–1 % and 0 % colonization, respectively.

To quantify AMF spores and for soil chemical characterization, soil samples (n=2) consisting of ten sub-samples each, were collected at a depth of 0–0.10 m, at two distinct areas, where on one site was possible to see typical ruderal plants and on the other a mixture of ruderal and Cerrado plants. Samples were air dried, sieved (2 mm mesh), homogenized, and divided into two parts. One hundred grams of each soil samples was used to determine the number of spores, and the samples were processed according to the combination of the wet sieving methods (Gerdemann & Nicolson, 1963), followed by centrifugation and sucrose flotation (Jenkins, 1964). Quantification was determined by enumerating spores placed on acrylic plates with concentric rings and observed under a stereoscopic microscope. A spore average by samples was 152 spores per 100 g de dry soil. The remaining portion of the soil samples was sent for analysis of soil chemical characteristics, according to Raij et al. (2001), and the results are: pH (CaCl2): 5.6; P (mg dm^{-3}): 22; MO (g dm^{-3}): 23; K, Ca, Mg, H+Al, Al, SB and CTC ($mmol_c$ dm^{-3}): 1.2; 16; 10; 20; 2; 26.7; 47.2 and 55, respectively, and V (%), 23.

3. Results and Discussion

3.1. Floristic survey

We recorded the occurrence of 266 species consisting of 57 families and two divisions: of Pteridophyta (three genera and three families) and 263 of Magnoliophyta (173 genera and 53 families). The larger families, (i.e. more than ten species) consisted of the following: Fabaceae (Leguminosae) (54), Asteraceae (Compositae) (28), Poaceae (22), Malvaceae (19), Convolvulaceae (16) and Euphorbiaceae (13). All other families contributed less than 10 species each and 17 families were represented by a single species (Table 1). Among the identified species, 220 were native to the Americas while the other 46 originated from the Old World and Australia. Based on the Brazil geoclimatic position, 157 species are native to Brazil, and of these, 63 originate from the Cerrado. Overall, most of the species found in Três Lagoas-MS are native to Brazil (Table 2). In a similar study conducted in the basin of Merlo stream, Silva & Ferreira (2007) observed that 80% of the collected species came from the Americas and the remaining 20% originated in Europe, Africa and Asia, corroborating the observations made in Três Lagoas-MS. In addition, these authors reported the great sociability and biodiversity of the ruderal plant species found in vacant lots and sidewalks.

Many native species identified are spread throughout the Americas (Table 2), likely due to the lack of barriers between North and South America (Good, 1974). It is difficult to determine the origin of these species, but most were native and residence throughout this area.

It is unclear whether the native species found in our study were present prior to urbanization, or if they were transplanted from another area. Some have efficient dispersion sources, such as *Passiflora foetida*, *Smilax brasiliensis*, *Serjania lethalis,* and *Richardia grandiflora*. The ability of a given species to reach other habitats depends on their distribution in the surrounding areas (Mueller-Dambois & Ellenberg, 1974). In our study area, native environments (i.e. Cerrado) are commonplace throughout the city in many of the unoccupied spaces. These areas are important as the rural Cerrado may disappear in a few decades due to the advance of agriculture. The plants typical of this area such as *Duguetia furfuracea*, *Eschweilera nana* and *Odontadenia lutea* appear to be easily transferable from their natural habitat (Durigan et al., 2004), and the occurrence of such plants in the study area is important and promising for the future.

In the studies areas, most exotic species were transported from Africa and Eurasia (Table 2). One possible explanation for the high occurrence of these species is that they have adapted to centuries of natural or anthropogenic disturbances in their region of origin. Agriculture and urbanization started in the Old World much earlier than in the Americas (except Mexico) (Tivy, 1993); therefore, these plant species had time to adapt to the imposed conditions of the disturbance, and may be competitively superior (Rapoport, 1991). Many species in the present study were identified as pioneers such as *Zinnia elegans*, *Portulaca oleracea* and *Solidago chilensis* (Table 1) are grown as ornamental or medicinal plants and are not considered agronomic crops. Some of these species can be used as food and have become ruderal and cosmopolitan (Asfaw & Tadesse, 2001). Others species, such as *Ricinus communis*, *Jatropha gossypifolia,* and *Argemone Mexicana,* beside be considered toxic and can cause death to children and pets. Species used by our ancestors and their adaptation to urban environments are linked to the history of cultivated plants (Briggs & Walters, 1984).

The introduction of exotic plants over time has caused severe invasions (e.g. mainly brachiarias). They cover the soil and prevent the regeneration of native plants, which may cause a problem during the dry season facilitating the spread and occurrence of fire. The African grasses have greatly expanded in the tropics due to the co-evolution with large herbivores, fact the probably contributed to be finding in disturbed environments (Parsons, 1970). In addition, herbivores may have contributed to changes in vegetation by eliminating palatable species (Burrws, 1990). Cosmopolitanism and homogenization of global biota are making the biological world much simpler. The study area has a high percentage of beneficial native plants compared to introduced, suggesting that this subject deserves special attention (Elton, 1958).

3.2. Mycorrhizal colonization and soil fertility

A ruderal is a plant adapted to disturbed soils and depends heavily on readily available forms of plant nutrients. Ruderal species have fast growth and high reproductive rates that contribute to make ruderals well suited for disturbed areas. However, little is known about the different behaviors of these plants and the mycorrhizal colonization (John, 2014). We collected 49 species that were distributed across 12 families and 31 genera (Table 2). According to the classification scale proposed by Carneiro et al. (1998), 11 species were categorized as high root colonization; 63 species were considered as low colonization, and 8 species did not show root colonization. The ruderal species check for AMF resulted in a high degree of mycorrhizal simbiosis (50%) and may have been a result of high species diversity. This microorganisms and plants relationship is part of the flow of nutrients in the soil (Heijden et al., 1998). Plant species belonging to Commelinaceae, Portulacaceae and Zygophyllaceae families were, previously, reported as non-mycorrhizal (Gerdemann, 1968; Trappe, 1987). The species belonging to the families Amaranthaceae (*Gomphrena celosioides*) and Brassicaceae (*Coronopus didymus*) also showed non-mycorrhizal root colonization, as reported by Moreira & Siqueira (2006) report.

For these authors, species or genera do not behave identically within families, and this difference among genera and species can be observed on mycorrhizal processes. For the family of Fabaceae, we verified 8 species with very high root colonization, 5 with low colonization, and one with zero colonization. The Poaceae family resulted in 4 species with very high colonization and two species as low in the colonization index (Table 3). Our results emphasize the importance of conducting exhaustive studies that screen for the presence of mycorrhizae in roots of ruderal species previously thought to be non-mycorrhizal. This allows better understanding of how mycorrhizal ruderal plants colonize disturbed urban areas.

Ruderal species that establish mycorrhizal interactions may act as temporary hosts of AMF species. This may contribute to the long-term establishment and stability of communities of these symbiotic microorganisms, and may have positive effects on plant growth on areas with disturbed soil.

Variations among species or genera may, also, be related to the degree of degradation of the environment and the consequent partial or total removal of seedlings infected with mycorrhizal fungi (Souza & Silva, 1996). Plant development depends on a number of conditions such as decomposer microorganisms that may be present in places rich in organic matter (Bardgett & Shine, 1999).

The benefits obtained by the interactions among ruderal plants and AMF will depend on factors such as plant and AMF genotype, as well as environmental conditions and the availability of the AMF propagules (Annapurna et al., 1996; Smith & Read, 2008). The degree of plant colonization is related to the amount of spores found in the soil and is critical to the success of re-vegetated areas (Pfleger et al., 1994). Thus, the number of spores and fertility in the area may change revegetation process. The average number of spores encountered in this study was 152 spores per 100 g of dry soil, which is compatible with others the results, obtained in degraded areas.

The AM root colonization may be associated with soil of poor fertility, such as those found in many disturbed urban planting sites (Reis, 1999). However, the colonization percentage in this study was high considering the poor condition. Parts of the study area were highly degraded showing construction debris and boulders, while other parts within the same area had a high content of organic matter. In general, phosphorus, organic matter pH and CEC levels were on average for Cerrado areas. Despite the study area displaying a high visual degradation level, the soil chemical characteristics were not modified and remain characteristic of a typical Cerrado. Thus, the diversity of identified species and the mycorrhizal colonization infers that the ruderal plants are good substitutes to replace maintained lawns. Due to the high diversity of species, ruderal plants have an ecological role for the local fauna, and in many cases have a rare beauty.

In summary, the ruderal flora of Três Lagoas-MS was composed of a diverse set of native and introduced species, originated from different parts of the world. The most representative of the native flora were Brazilian and American (South, Tropical, and Subtropical). Among the evaluated species, at least 25% were typical of the Cerrado and these species were found in preserved natural areas. Although these native species were part of the identified ruderal flora they cannot be considered native of the study area. The exotic species come from different world regions such as Africa, Europe, and Asia. Some of them are cosmopolitan or pantropical and a minority have adapted well to disturbed environments. From the Vila Pilot, at least 50% of the collected ruderal plants showed high percentages of mycorrhizal colonization. The Vila Pilot showed that despite nearly 40 years of human inhabitation the soil was sufficient to maintain urban vegetation that has contributed to environmental preservation.

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Table 1: Ruderal plant species survey their respective botany families, followed by geographical origins. (Três Lagoas-MS, 2007- 2008)

Ruderal plant species	**Botany families**	**Geographical origins**
Abutilon bedfordianum (Hook) A.St.-Hil.	Malvaceae	Cerrado
Abutilon ramiflorum A. St.-Hill.	Malvaceae	Cerrado
Acanthospermum australe (Loefl.) Kuntze	Asteraceae	Cerrado, Cerradão
Acanthospermum hispidum DC.	Asteraceae	Brazilian Native
Adenocalymma peregrinum (Miers) L.G.Lohmann	Bignoniaceae	Cerrado
Aeschynomene histrix Poir	Fabaceae	Cerrado
Aeschynomene paniculata Willd. Ex Vogel	Fabaceae	Eurasia (cosmopolitan)
Aeschynomene rudis Benth.	Fabaceae	Brazilian Native
Albizia lebbeck (L.) Benth.	Fabaceae	Brazilian Native
Alternanthera ficoidea (L.) Sm.	Amaranthaceae	Brazilian Native
Alysicarpus vaginalis (L.) DC.	Fabaceae	Cerrado
Amaranthus deflexus L.	Amaranthaceae	Tropical America
Amaranthus hybridus L.	Amaranthaceae	Tropical America
Andropogon bicornis L.	Poaceae	American Continent
Arachis kuhlmannii Krap. et Greg.	Fabaceae	Cerrado
Argemone mexicana L.	Papaveraceae	American Continent
Aristolochia esperanzae Kuntze.	Aristolochiaceae	Tropical America
Aristolochia gigantea Mart.	Aristolochiaceae	Brazilian Native
Artemisia verlotorum Lamotte	Asteraceae	Cerrado
Astraea lobata (L.) Klotzsch	Euphorbiaceae	Tropical America
Bauhinia pentandra (Bong.) Vog.	Fabaceae	American Continent
Bauhinia rufa (Bong.) Steud.	Fabaceae	Tropical America
Begonia cucullata Willd.	Begoniaceae	Cerrado
Bidens gardneri Baker	Asteraceae	South America
Bidens subalternans DC.	Asteraceae	Brazilian Native
Bixa orellana L.	Bixaceae	Tropical America
Blepharodon bicuspidatum E. Fourn. Mart.	Apocynaceae	Europe
Blepharodon mucronatum (Schltdl.) Decne.	Apocynaceae	Tropical America
Boerhavia diffusa L.	Nictaginaceae	South America
Brachiaria brizantha (A.Rich.) Stapf	Poaceae	Brazilian Native
Brachiaria decumbens Stapf	Poaceae	South America
Brachiaria humidicola (Rendle) Schweick.	Poaceae	Africa
Bredemeyera floribunda Willd.	Polygalaceae	Tropical America
Brosimum gaudichaudii Trécul	Moraceae	South America
Cajanus cajan (L.) Millsp.	Fabaceae	Tropical America
Calopogonium caeruleum (Bth.) Sauv.	Fabaceae	Central America
Calotropis procera (Aiton) Dryand.	Apocynaceae	America (cerrado)
Calyptocarpus biaristatus (DC.) H.Rob.	Asteraceae	Brazilian Native
Campomanesia pubescens Berg.	Myrtaceae	Cerrado
Canavalia brasiliensis Benth.	Fabaceae	Brazilian Native
Cataranthus roseus G.Don	Apocynaceae	Brazilian Native
Cecropia pachystachya Trec.	Urticaceae	Asia
Celosia argentea L.	Amaranthaceae	Cerrado, Cerradão
Celosia cristata L.	Amaranthaceae	Tropical America
Cenchrus echinatus L.	Poaceae	Brazilian Native
Centratherum punctatum Cass.	Asteraceae	Cerrado
Centrosema angustifolium (Kunth) Benth.	Fabaceae	Brazilian Native
Centrosema brasilianum (L.) Bth.	Fabaceae	Cerrado
Chamaecrista campestris (Benth.) H.S.Irwin & Barneby	Fabaceae	Cerrado
Chamaecrista desvauxii (Collad.) Killip	Fabaceae	Cerrado
Chamaecrista flexuosa (L.) Greene	Fabaceae	Tropical America
Chamaecrista nictitans Collad.	Fabaceae	South America
Chamaecrista rotundifolia (Pers.) Greene	Fabaceae	Brazilian Native
Chloris barbata (L.) Sw.	Poaceae	Cerrado
Chloris polydactyla (L.) Sw.	Poaceae	Old world
Chromolaena maximiliani (Schrad. ex DC.) R.M.King & H.Rob.	Asteraceae	Tropical America

Table 1: Ruderal plant species survey with their respective botany families, followed by geographical origins. (Três Lagoas-MS, 2007- 2008)

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Ruderal plant species	**Botany families**	**Geographical origins**
Chromolaena odorata (L.) R.M.King & H.Rob.	Asteraceae	Africa
Cipura paludosa Aubl.	Iridaceae	Brazilian Native
Cissampelos ovalifolia DC.	Menispermaceae	Cerrado
Cissampelos pareira L.	Menispermaceae	Cerrado
Citrullus lanatus (Thunb.) Matsum. & Nakai	Cucurbitaceae	American Continent
Cleome affinis DC	Cleomaceae	Africa
Clitoria guianensis (Aubl.) Benth.	Fabaceae	Asia
Cochlospermum regium (Mart et Schl.) Pilg.	Bixaceae	American Continent
Commelina benghalensis L.	Commelinaceae	Brazilian Native
Commelina erecta L.	Commelinaceae	Cerrado
Corchorus orinocensis Kunth	Malvaceae	Brazilian Native
Cosmos sulphureus Cav.	Asteraceae	Africa
Crotalaria incana L.	Fabaceae	Brazilian Native
Crotalaria micans Link	Fabaceae	Africa
Crotalaria pallida Aiton	Fabaceae	South America
Crotalaria stipularia Desv.	Fabaceae	American Continent
Croton bonplandianus Bail.	Euphorbiaceae	Tropical America
Croton campestris A.St.-Hil.	Euphorbiaceae	Asia (trop. and subt.)
Croton glandulosus L.	Euphorbiaceae	America (trop. and subt.)
Cuphea carthagenensis (Jacq.) J.F.Macbr.	Lythraceae	Brazilian Native
Cyclospermum leptophyllum (Pers.) Eichler	Apiaceae	India
Cymbopogon winterianus Jowitt ex Bor	Poaceae	Cerrado
Cynodon dactylon (L) Pers.	Poaceae	Brazilian Native
Cyperus iria L.	Cyperaceae	Old World (trop. and sub.)
Cyperus meyenianus Kunth	Cyperaceae	Cerrado
Cyperus rotundus L.	Cyperaceae	Brazilian Native
Cyperus sesquiflorus (Torrey) Mattf. & Kük.	Cyperaceae	Tropical America
Dactyloctenium aegyptium (L.) Willd.	Poaceae	Europe
Dalechampia micromeria Baill	Euphorbiaceae	Brazilian Native
Dalechampia scandens L.	Euphorbiaceae	America
Desmodium adscendens (Sw.) DC.	Fabaceae	Africa
Desmodium barbatum (L.) Benth.	Fabaceae	Cerrado
Desmodium incanum DC.	Fabaceae	Brazilian Native
Desmodium tortuosum (Sw.) DC.	Fabaceae	Brazilian Native
Digitaria ciliaris (Restz.) Koel.	Poaceae	Brazilian Native
Digitaria insularis (L.) Mez ex Ekman	Poaceae	America
Dioclea violacea Mart. ex Benth.	Fabaceae	Cerrado
Diodella teres (Walter) Small	Rubiaceae	America
Dorstenia cayapia Vell.	Moraceae	South America
Duguetia furfuracea (A. St.-Hil.) Benth.& Hook.	Annonaceae	Brazilian Native
Dysphania ambrosioides (L.) Mosyakin & Clemants	Amaranthaceae	Brazilian Native
Echinochloa colona (L) Link	Poaceae	Brazilian Native
Eclipta prostrata (L.) L.	Asteraceae	Africa
Elephantopus mollis Kunth	Asteraceae	Cerrado
Eleusine indica (L.) Gaertn.	Poaceae	African Continent
Emilia fosbergii Nicolson	Asteraceae	Cerrado
Eragrostis pilosa (L.) P.Beauv.	Poaceae	Cerrado, Cerradão
Erechtites hieraciifolius (L.) Raf. Ex DC.	Asteraceae	Tropical Africa
Eriosema platycarpum Micheli	Fabaceae	South America
Eugenia pitanga Kiaersk.	Myrtaceae	Brazilian Native (and Am.)

Table 1: Ruderal plant species survey with their respective botany families, followed by geographical origins. (Três Lagoas-MS, 2007- 2008)

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Ruderal plant species	**Botany families**	**Geographical origins**
Eschweilera nana (O.Berg) Miers	Lecythidaceae	Cerrado
Euphorbia heterophylla L.	Euphorbiaceae	Brazilian Native
Euphorbia hirta L.	Euphorbiaceae	Cerrado
Euphorbia hyssopifolia L.	Euphorbiaceae	Tropical America
Euphorbia prostrata Aiton	Euphorbiaceae	Cosmopolitan
Evolvulus pusillus Choisy	Convolvulaceae	Asiatic Continent
Ficus insipida Willd.	Moraceae	Cerrado
Fridericia florida (DC.) L.G.Lohmann	Bignoniaceae	Brazilian Native
Fridericia platyphylla (Cham.) L.G.Lohmann	Bignoniaceae	Brazilian Native
Froelichia interrupta (L.) Moq.	Amaranthaceae	South America
Fuirena umbellata Rottb.	Cyperaceae	Tropical America
Gomphrena celosioides Mart.	Amaranthaceae	Tropical Asia
Gouania latifolia Reiss.	Rhamnaceae	Cerrado
Heliotropium indicum L.	Boraginaceae	Brazilian Native
Herissantia cripa (L.) Brizicky	Malvaceae	Cerrado
Hibiscus sabdariffa L.	Malvaceae	Brazilian Native
Hybanthus calceolaria (L.) Oken	Violaceae	Cerrado
Hydrocotyle bonariensis Lam.	Araliaceae	Asia
Hyparrhenia rufa (Nees) Stapf	Poaceae	Brazilian Native
Hyptis suaveolens (L.) Poit.	Lamiaceae	Brazilian Native
Indigofera hirsuta L.	Fabaceae	South America
Indigofera suffruticosa Mill.	Fabaceae	Brazilian Native
Ipomoea asarifolia (Desr.) Roem. & Schult.	Convolvulaceae	Cerrado
Ipomoea cairica (L.) Sweet.	Convolvulaceae	Brazilian Native
Ipomoea carnea Jacq.	Convolvulaceae	Mexico
Ipomoea chiliantha Hallier	Convolvulaceae	South America
Ipomoea grandifolia (Dammer) O?Donell	Convolvulaceae	Cerrado
Ipomoea nil (L.) Roth.	Convolvulaceae	Africa
Ipomoea procumbens Mart.ex Choisy	Convolvulaceae	Brazilian Native
Ipomoea purpurea (L.) Roth.	Convolvulaceae	Brazilian Native
Ipomoea quamoclit L.	Convolvulaceae	Cerrado
Ipomoea ramosissima (Poir.) Choisy	Convolvulaceae	American Continent
Jatropha gossypiifolia L.	Euphorbiaceae	Asia
Lantana camara L.	Verbenaceae	Africa
Lantana canescens Kunth	Verbenaceae	Cerrado
Lantana trifolia L.	Verbenaceae	Tropical America
Leonotis nepetifolia (L.) R.Br.	Lamiaceae	Brazilian Native
Lepidium virginicum L.	Brassicaceae	Brazilian Native
Leucaena leucocephala (Lam.) de Wit	Fabaceae	South America
Lippia alba (Mill.) N.E.Brown	Verbenaceae	China and Japan
Lonchocarpus negrensis Benth.	Fabaceae	American Continent
Loudetiopsis chrysothrix (Nees) Conert	Poaceae	American Continent
Ludwigia octovalvis (Jacq.) P.H. Raven	Onagraceae	American Continent
Luffa cylindrica (L.) M.Roem.	Cucurbitaceae	Cosmopolitan
Macroptilium atropurpureum (DC.) Urb.	Fabaceae	Cerrado
Macroptilium lathyroides (L.) Urb.	Fabaceae	Tropical America
Matayba elaeagnoides Radlk.	Sapindaceae	Brazilian Native
Melinis minutiflora P. Beauv.	Poaceae	Tropical America
Melinis repens (Willd.) Zizka	Poaceae	Cerrado
Melochia pyramidata L.	Malvaceae	Cerrado
Melochia simplex A. St.-Hil.	Malvaceae	Cerrado
Melochia spicata (L.) Fryxell	Malvaceae	Mexico
Merremia aegyptia (L.) Urb.	Convolvulaceae	Cerrado
Merremia cissoides (Lam.) Hallier f.	Convolvulaceae	Eurasia

Table 1: Ruderal plant species survey with their respective botany families, followed by geographical origins. (Três Lagoas-MS, 2007- 2008)

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Ruderal plant species	**Botany families**	**Geographical origins**
Merremia dissecta (Jacq.) Hallier f.	Convolvulaceae	Tropical Asia
Merremia macrocalyx (Ruiz & Pav.) O'Donell	Convolvulaceae	Tropical Africa (cosmop.)
Merremia umbellata (L.) Hallier f.	Convolvulaceae	Eurasia
Mimosa adenocarpa Benth.	Fabaceae	Tropical America
Mimosa caesalpiniaefolia Benth.	Fabaceae	Tropical America
Mimosa debilis Humb.& Bonpl. ex Willd.	Fabaceae	Tropical America
Mimosa nuda Benth.	Fabaceae	Tropical America
Mimosa pellita Willd.	Fabaceae	South America
Mimosa polycarpa Kunth	Fabaceae	Brazilian Native
Mimosa quadrivalvis L.	Fabaceae	Tropical Africa
Mimosa somnians Willd.	Fabaceae	American Continent
Mimosa xanthocentra (Benth.) Barneby	Fabaceae	Australia
Mirabilis jalapa L.	Nictaginaceae	Brazilian Native
Mollugo verticillata L.	Molluginaceae	Cerrado
Momordica charantia L.	Cucurbitaceae	Pantropical
Ocimum basilicum L.	Lamiaceae	Tropical America
Ocimum carnosum (Spreng.) Link & Otto ex Benth.	Lamiaceae	Cerrado
Ocimum gratissimum L.	Lamiaceae	Tropical America
Odontadenia lutea (Vell.) Marckgr.	Apocynaceae	Tropical America
Oxalis cratensis Hook.	Oxalidaceae	American Continent
Oxypetalum banksii Schult.	Apocynaceae	Brazilian Native
Panicum maximum Jacq.	Poaceae	Brazilian Native
Parthenium hysterophorus L.	Asteraceae	Tropical America
Passiflora cincinnata Mast.	Passifloraceae	Tropical America
Passiflora foetida L.	Passifloraceae	Brazilian Native
Passiflora pohlii Mast.	Passifloraceae	Brazilian Native
Pavonia cancellata (L.) Cav.	Malvaceae	Cerrado
Pavonia communis A.St.-Hil.	Malvaceae	Africa
Pavonia guerkeana R.E.Fr.	Malvaceae	Asia
Pavonia sidifolia Kunth	Malvaceae	Brazilian Native
Peltodon tomentosus Pohl	Lamiaceae	Cerradão
Pennisetum polystachion (L.) Schult.	Poaceae	Cerrado, Cerradão
Pereskia sacharosa Gris.	Cactaceae	Brazilian Native
Phenax sonneratii (Poir) Wedd.	Urticaceae	Brazilian Native
Phyllanthus niruri L.	Phyllanthaceae	Brazilian Native
Phyllanthus orbiculatus Rich.	Phyllanthaceae	India
Phyllanthus tenellus Roxb.	Phyllanthaceae	American Continent
Pilea microphylla (L.) Liebm	Urticaceae	Cerrado
Piriqueta cistoides (L.) Gris.	Turneraceae	Tropical America
Piriqueta corumbensis Moura	Turneraceae	South America
Pityrogramma calomelanos (L.) Link	Adiantaceae	Brazilian Native
Plectranthus barbatus Andrews	Lamiaceae	American Continent
Pluchea sagittalis Less.	Asteraceae	India (probably)
Polygala violacea Aubl	Polygalaceae	Cerrado
Porophyllum ruderale (Jacq.) Cass.	Asteraceae	Brazilian Native
Portulaca fluvialis D. Legrand	Portulacaceae	American Continent
Portulaca oleracea L.	Portulacaceae	Cerrado
Praxelis diffusa (Rich.) Pruski	Asteraceae	Cerrado
Prestonia tomentosa R.Br.	Apocynaceae	Cerrado
Pteris vittata L.	Pteridaceae	Cerrado
Pterocaulon virgatum (L.) DC.	Asteraceae	Brazilian Native
Pyrostegia venusta (Ker Gawl.) Miers	Bignoniaceae	Cosmopolitan
Raphanus raphanistrum L.	Brassicaceae	Cerrado
Rhynchosia minima (L.) DC.	Fabaceae	Brazilian Native

Richardia brasilensis Gomes	Rubiaceae	Brazilian Native

Table 1: Ruderal plant species survey with their respective botany families, followed by geographical origins. (Três Lagoas-MS, 2007- 2008)

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Ruderal plant species	**Botany families**	**Geographical origins**
Richardia grandiflora (Cham. & Schltdl.) Steud.	Rubiaceae	Brazilian Native
Ricinus communis L.	Euphorbiaceae	America
Riedeliella graciliflora Harms	Fabaceae	Brazilian Native
Sapium haematospermum Müll.Arg.	Euphorbiaceae	Old World (tropical)
Senna obtusifolia (L.) H.S. Irwin & Barneby	Fabaceae	Cerrado
Senna occidentalis (L.) Link	Fabaceae	Brazilian Native
Senna rugosa (G. Don) H.S.Irwin & Barneby	Fabaceae	Asia
Serjania caracasana (Jacq.) Willd.	Sapindaceae	Brazilian Native
Serjania erecta Radlk.	Sapindaceae	America
Serjania lethalis A.St.Hil.	Sapindaceae	American Continent
Sida cordifolia L.	Malvaceae	Brazilian Native
Sida linifolia Juss. ex Cav.	Malvaceae	Cerrado
Sidastrum paniculatum (L.) Fryxell	Malvaceae	Brazilian Native
Smilax brasiliensis Spreng	Smilacaceae	Cerrado
Smilax cissoides M.Martens & Galeotti	Smilacaceae	Brazilian Native
Smilax fluminensis Steud.	Smilacaceae	Brazilian Native
Solanum americanum Mill.	Solanaceae	Cerrado
Solanum lycocarpum A. St. Hil.	Solanaceae	South America
Solanum palinacanthum Dunal	Solanaceae	American Continent
Solanum paniculatum L.	Solanaceae	Tropical America
Solanum sisymbriifolium Lam.	Solanaceae	Tropical America
Solidago chilensis Meyen	Asteraceae	Cosmopolitan
Spermacoce latifolia Aubl.	Rubiaceae	Brazilian Native
Spermacoce verticillata L.	Rubiaceae	America
Sporobolus indicus (L.) R. Br.	Poaceae	Cerrado, Cerradão
Stachytarpheta cayenensis (Rich.) Vahl	Verbenaceae	Mexico
Staelia thymoides C.et S.	Rubiaceae	South America
Stylosanthes guianensis (Aubl.) Sw.	Fabaceae	Mexico
Stylosanthes leiocarpa Vogel	Fabaceae	Tropical America
Stylosanthes viscosa (L.) Sw.	Fabaceae	Cerrado, Cerradão
Synedrellopsis grisebachii Hieron. & Kuntze	Asteraceae	American Native
Talinum paniculatum (Jacq.) Gaertn.	Talinaceae	Mexico
Talinum triangulare (Jacq.) Willd.	Talinaceae	Mexico
Thelypteris dentata (Forsrk.) E.P. St. John	Thelypteridaceae	Central America
Tithonia diversifolia A.Gray	Asteraceae	India
Tradescantia pallida (Rose) D.R. Hunt	Commelinaceae	Cerrado
Tridax procumbens(L.) L.	Asteraceae	Tropical America
Trigonia nivea Cambess.	Trigoniaceae	Brazilian Native
Triumfetta rhomboidea Jacq.	Malvaceae	Brazilian Native
Turnera melochioides A. St.-Hil. & Cambess.	Turneraceae	Tropical America
Turnera subulata Sm.	Turneraceae	Brazilian Native
Unxia camphorata L.f.	Asteraceae	America
Urena lobata L.	Malvaceae	Africa
Vernonanthura brasiliana (L.) H.Rob.	Asteraceae	Tropical America
Vernonanthura chamaedrys (Less.) H.Rob.	Asteraceae	Cerrado
Vigna unguiculata (L.) Walp.	Fabaceae	Africa
Waltheria communis A.St.-Hil.	Malvaceae	American Continent
Waltheria indica L.	Malvaceae	Cerrado
Youngia japonica (L.) DC.	Asteraceae	Cerrado
Zinnia elegans Jacq.	Asteraceae	Cerrado
Zornia latifolia Sm.	Fabaceae	Africa

Tabela 2: Families and plant species, percentage of arbuscular mycorrhizal colonization (Col) for Pilot Village and surrounding area.

Family and plant species	Col (%)	Index	Family and plant species	Col (%)	Index
Amaranthaceae			*Crotalaria micans* Link	78	H
Gomphrena celosioides Mart.	0	A	*Desmodium adscendens* (Sw.) DC.	1	L
Asteraceae			*Desmodium tortuosum* (Sw.) DC.	90	VH
Bidens subalternans DC.	92	VH	*Galactia eriosematoides* Harms	1	L
Porophyllum ruderale (Jacq.) Cass.	73	H	*Indigofera hirsuta* L.	98	VH
Tridax procumbens (L.) L.	1	L	*Indigofera microcarpa* Desv.	1	L
Brassicaceae			*Indigofera suffruticosa* Mill.	1	L
Lepidium virginicum L.	0	A	*Mimosa adenocarpa* Benth.	0	A
Cleomaceae			*Mimosa debilis* Willd.	0	A
Cleome affinis DC.	90	VH	*Mimosa nuda* Benth.	0	A
Commelinaceae			*Senna obtusifolia* (L.) H.S. Irwin & Barneby	1	L
Commelina benghalensis L.	88	VH	*Senna occidentalis* (L.) Link	1	L
Commelina erecta L.	92	VH	*Stylosanthes guianensis* (Aubl.) Sw.	1	L
Euphorbiaceae			*Zornia crinita* (Mohlenbr.) Vanni	0	A
Astraea lobata (L.) Klotzsch	82	VH	*Zornia reticulata* Sm.	80	VH
Euphorbia hyssopifolia L.	90	VH	**Lamiaceae**		
Euphorbia heterophylla L.	80	VH	*Hyptis suaveolens* (L.) Poit.	90	VH
Euphorbia hirta L.	88	VH	**Onagraceae**		
Phyllanthus tenellus Roxb.	1	L	*Ludwigia tomentosa* (Cambess.) H. Hara	20	M
Fabaceae			**Poaceae**		
Aeschynomene histrix Poir.	90	VH	*Cenchrus echinatus* L.	96	VH
Aeschynomene paniculata Vogel	99	VH	*Chloris barbata* Sw.	90	VH
Aeschynomene rudis Benth.	99	VH	*Digitaria ciliaris* (Retz.) Koeler	92	VH
Alysicarpus vaginalis (L.) DC.	98	VH	*Eleusine indica* (L.) Gaertn.	1	L
Arachis hypogaea L.	90	VH	*Eragrostis pilosa* (L.) P.Beauv.	10	L
Chamaecrista campestris H.S.Irwin & Barneby	88	VH	*Melinis repens* (Willd.) Zizka	90	VH
Chamaecrista desvauxii (Collad.) Killip	20	M	**Polygalaceae**		
Chamaecrista flexuosa (L.) Greene	0	A	*Polygala violacea* Aubl.	90	VH
Chamaecrista nictitans (L.) Moench	98	VH	**Rubiaceae**		
Chamaecrista rotundifolia (Pers.) Greene	80	VH	*Richardia brasiliensis* Gomes	88	VH
Chamaecrista serpens (L.) Greene	99	VH			

Considering: > 80%= very high (VH); 50-79%= high (H); 20-49%= medium (M); 01-19% low (L) and 0%= absence (A) based on Carneiro et al. (1988).